Southern California Shearlines

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Summary

The shearlines in Southern California, specifically the so-called "Elsinore shearline", are described. Investigations by light powered aircraft and sailplanes show that the shearline forms in the afternoon and resembles a sea breeze front developing between the cool, "smoggy", and humid maritime air over the Los Angeles Basin and warm, clear and dry air over the inland valleys and the desert farther east. Typical discontinuities across the shearline from east to west are 70% humidity increase, 1 to 5 °F temperature drop and 45 to 180° wind shift. The Elsinore shearline visible by cumulus clouds or a haze front is usually 3,000 to 8,000 feet high and 50 miles long. It may be stationary or move slowly. Occasionally shearlines extent several 100 miles across the desert. Consistent lift on the warm side of the shearline is being used for cross country glider flights. Soaring experience and techniques along shearlines are described in detail.

The Elsinore California soaring site, Skylark Field, owes a great deal of its popularity to the consistency of soaring conditions, brought about, in part, by the meteorological phenomona known as a shearline. A shearline is defined as a line between two different air masses. This line may, or may not, be pronounced depending upon the difference between the air masses. Often, there is a wind shift present between the masses of different air. The wind shift, or shear, is what gives the condition its name.

Most of the glider pilots at Elsinore have noticed that the hazy air north of the valley in summer frequently will move over the field late in the afternoon and that up-drafts can be found along the edges of this hazy air.

The extent of the shearline in this area was not realized until I began using a motorcycle to ride between Riverside and Elsinore. The winds encountered are much more apparent out in the open on a motorcycle. I noticed that coming south from Riverside, on Highway 395, the wind consistently shifted some 180 degrees between March Air Force Base and a point somewhere south of Perris, California. The wind shift line seemed to have cooler air on the west side and the hot, dry air on the southeast side. I thought of exploring the area in a light plane. At that time, I did not realize that the line extended for some 50 miles beginning near the Elsinore Gliderport.

A description of the area

Elsinore gliderport, called Skylark Field, is located 56 airline miles southeast from the center of the Los Angeles Basin. It is only 22 miles from the Pacific Ocean to the southwest but the Santa Ana Mountain region, 2,000 to 6,000 feet above sea level, separates the area from the domain of sea air. The gliderport is 1,260 feet above sea level A.S.L. and is classed as an "intermediate valley", since it is between the coastal basin and the deserts.

The Los Angeles Coastal Plain or so called Basin is an area of almost 900 square miles. The Basin contains well over 4,000,000 people and their accompanying factories, automobiles and power plants. An immense amount of waste gases accumulate in the Basin due to several unique factors.

In illustration 1, we see the typical summer pressure and wind patterns near the west coast of the U.S.A. The northwest wind running down the California coast is squeezed into a strong jet just north of the Los Angeles Basin by the effect of the mountains at Point Arguello, which extend to the edge of the ocean, and the warm air overlying the heavy sea air. Just past this point the shoreline turns east causing the air to fan out in a large eddy. The Los Angeles Basin, therefore, has a sea breeze directly onshore from the west. The breeze is a fairly weak eddy current. This combination of a light sea breeze toward a low basin surrounded by mountains with warmer air aloft effectively bottles up the movement of the waste gases from the area. Under these conditions the action of sunshine on the waste gases forms "smog", which is a dense yellowish ingredient of the atmosphere over Los Angeles.

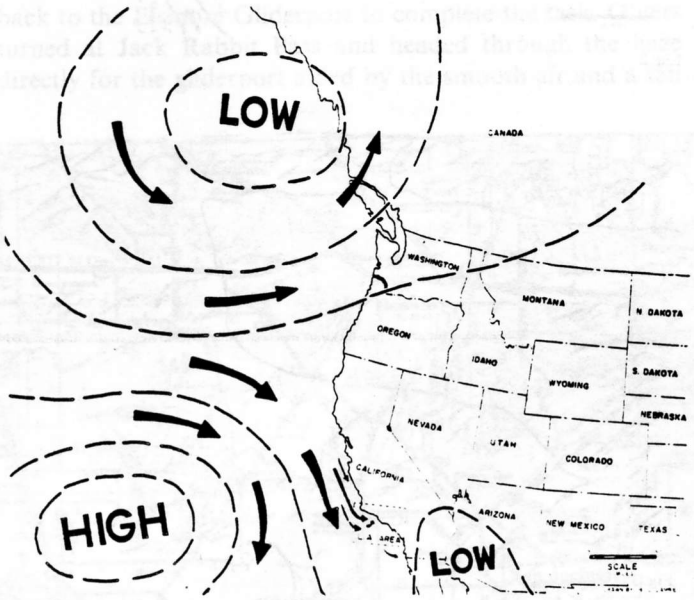

Fig. 1

By afternoon, however, the heating of the air over the inland valleys and deserts creates a low pressure area east of the Basin. This is called the "Heat Low" because of its relation to thermal heating. Since air flows from high pressure to low pressure a wind develops which creeps through the passes that puncture the mountains surrounding the Los Angeles Basin. With the increased sea breeze comes a pronounced clearing of the air over the Basin.

The shearline

From the Elsinore soaring site the dense smoggy front can be seen moving up by 1:00 p.m. in the afternoon. This shearline immediately northwest of Lake Elsinore, is at the edge of the air moving into Elsinore inland valley through the Santa Ana Pass. Joining this air from the Santa Ana Pass is air moving up out of the Pomona and Riverside areas. This then forms a solid line from Elsinore to the San Gorgonio Pass (see illustration 2). Other shearlines are created by the basin air flowing from the Cajon, Newhall and Mint Canyon Passes to

the north of the Los Angeles Basin (see illustration 5). A small shearline may often form where the Temecula Pass lets in the sea breeze some 20 miles south of Elsinore.

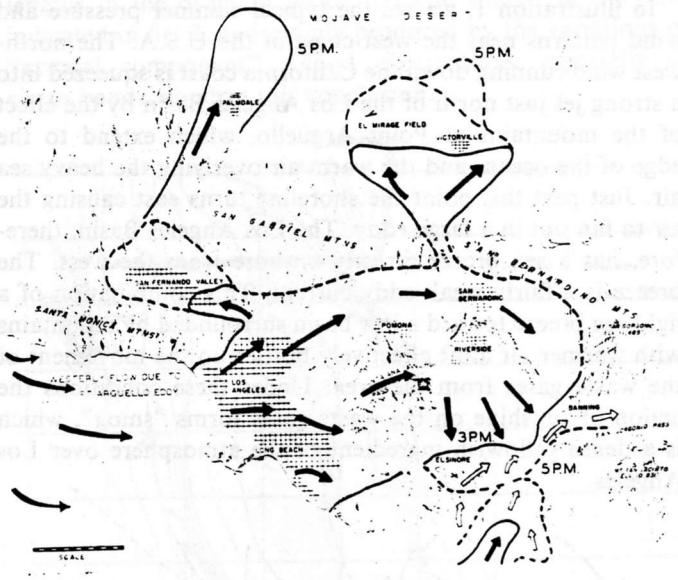

Fig. 2

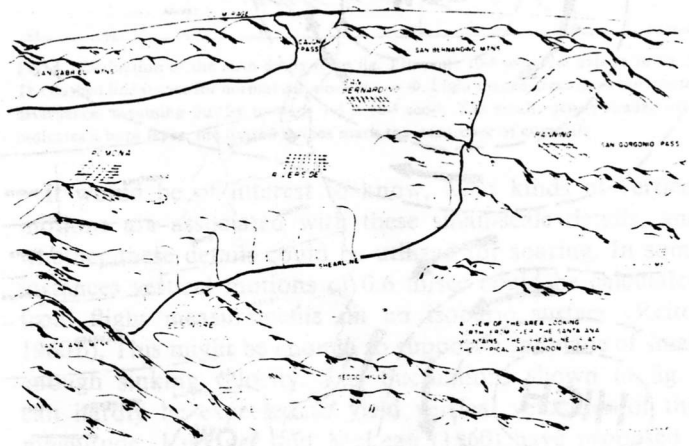

Fig. 3

The 1958 weather records of March Air Field Base, located 18 miles north of Elsinore, and the Riverside Agricultural Experiment Station 25 miles north, were checked for any indication of trends and frequency of the shearline. It was found that the shearline is in occurrence when there is a high pressure area over the Pacific, and an inversion in the Los Angeles Basin causing sea air to move inland toward the thermal low pressure area. This condition existed most often in September which showed shearlines a total of twenty days. October was second with fourteen days. This coincides with the months of the most frequent heavy smog conditions in Los Angeles. August was next, with twelve days. March, April, November and May had evidence of six shearline passages each. July had only five shearlines, December through January and February each two. In June no recorded evidence could be found. This tabulation of occurrences must be considered very conservative because of the difficulty in finding positive notation of the wind shifts and drop in visibility from the weather records. Records indicated that the humidity does make a sudden jump after the shearline passage with an increase in wind speed and change of wind direction.

Flight records

Penetrations of the smog front were made with a slow flying 40 horsepower Cub. An aerometeorgraph which records pressure, temperature and humidity was tied to the struts with rubber shockcord to damp vibration. The altitude was held at a steady 600 feet above the ground (1,860 feet A.S.L.) for the first ten minutes of penetration of the smog. Progressive climbs were then made to 1,000 feet above ground, then to 2,000, 3,000 etc. until the haze was topped (see figure 4). These records showed that the increase in humidity is the surest indication of entering the sea air side of the shearline. The humidity change averaged 20% on the sea air side. The pressure registered no change and the temperature was 1 to 5 °F less on the sea air side. As the top of the haze is gained, the humidity immediately dropped. An interesting condition is that the edge of the shearline rises higher than the following portion and the sea air side (see figure 4). During the early afternoon hours of noon to 3:00 or 4:00 p.m. the line advances and retreats, but overall, a very slow advance or static condition exists. Apparently the sea breeze air piles up at the meeting point during the static phase. After the shearline moves past, later in the afternoon, the wind picks up (early speed of 5–8 m.p.h. increasing to 18–20 m.p.h.) and the haze depth thins.

On October 18, 1959 for example, the gliders were soaring to 7,000 feet above the ground on the shearline, but when this same shearline was penetrated later in the afternoon the cold layer was only 3,000 feet deep both visually and according to the aerometeorgraph record (see figure 4).

Clouds are seen marking the edge of the shearline most often in the spring, possibly because the inversion over the Los Angeles Basin is higher in spring than in the fall and the inland valley thermals entrain more moisture from the spring rains.

The area of lowest visibility occurs just back of the shearline edge on the sea air side. The length of time for clearing and increase of visibility after passage of the shearline varies from 30 minutes to 2 hours depending on the strength of the wind. An interesting point is that clear air and good visibility in the Los Angeles Basin begins about 4:00 p.m. on smoggy days. In contrast the poorest visibility at March Air Force Base also begins near 4:00 p.m.

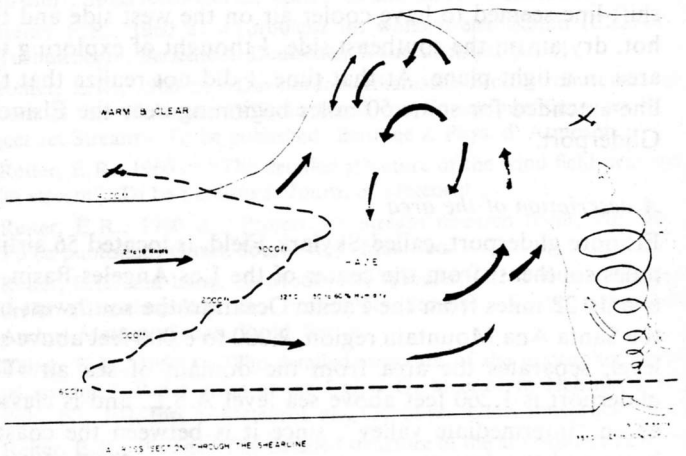

Fig. 4

Soaring the shearline

Typically on weekends a group of sailplanes will be working the edge of the shearline. The line of lift is not ordinarily a straight line and the gliders will be soon at varying distances

from the line. It is common to see gliders circling 30 or 40 yards apart, almost intermeshing circles, each probably convinced his section of the shearline is better. The pilot often finds lift turbulent but is well able to keep the glider up. The pilot will see from smoke or dust that the wind is shifted from 45 to 180 degrees between the different sides of the shearline.

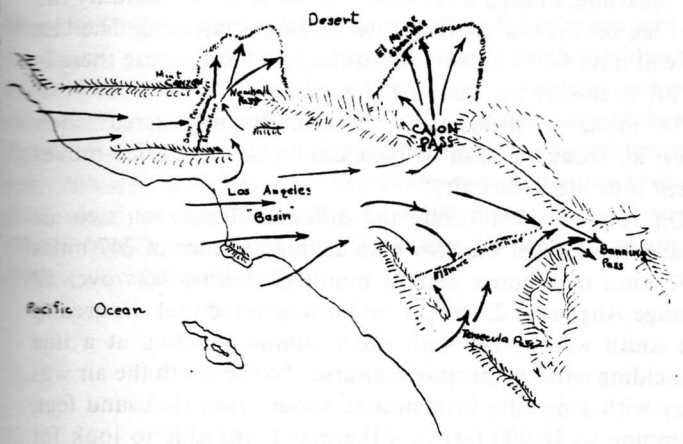

Fig. 5

A very fine shearline was present during the first half of the Elsinore Fall Soaring contest on the weekend of November 17 and 18, 1959. An 80 mile triangle was completed by flying on *two* separate shearlines. My flight was made in a Fauvel AV-36 tailless glider. Release was made at 1:10 p.m. over the Elsinore Gliderport. The glider was flown along the shearline northeastwards to San Jacinto (see figure 6, straight line). This lift was topping at 8,000 feet above the ground. Leaving San Jacinto turn point and gliding south past Hemet another hazy mass of air was seen pertruding from the Temecula Pass. Contact was made with this shearline edge and the flight was continued to the next turning point, Aguanga, near the Palomar Mountain 200″ reflector telescope. The haze was then penetrated and a straight glide to Elsinore was made in calm air. At Elsinore a large area of lift was found ahead of the shearline still hanging north of the field.

The next day the pilots were to fly from Elsinore to Ryan Field, Hemet, then to Jack Rabbit Pass and back to Elsinore (60 miles or 100 kilometers). A very well defined shearline was present (see figure 6, crossed lines). All eighteen competing pilots flew the line to gain altitude on the way to Hemet, made the turn northward, then were forced to penetrate into the haze for the second turn point at Jack Rabbit Pass. After the turn at the Pass many of the gliders turned back to the clear air and flew along the edge of the shearline back to the Elsinore Gliderport to complete the task. Others turned at Jack Rabbit Pass and headed through the haze directly for the gliderport aided by the smooth air and a tail

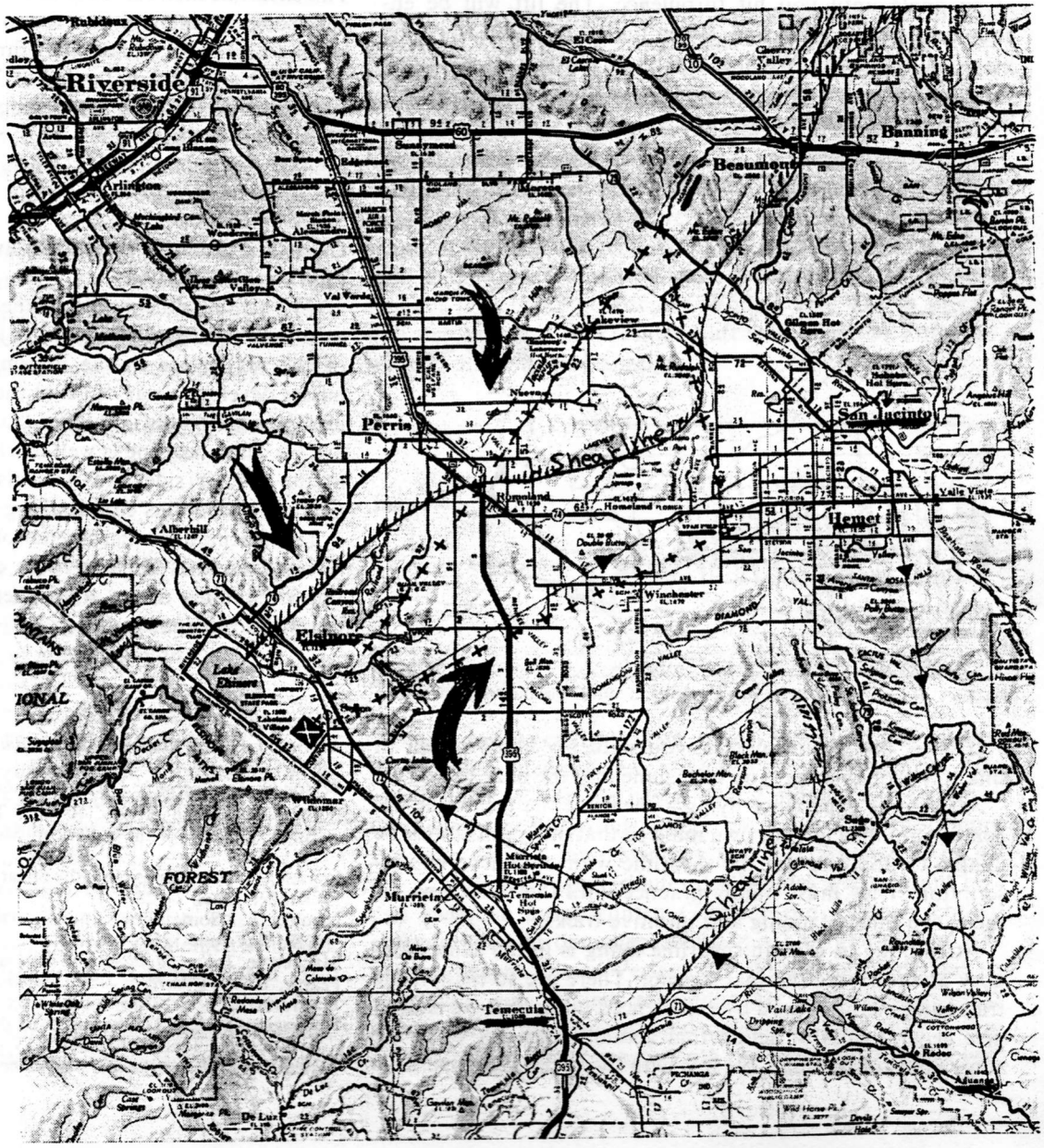

Fig. 6

- 100 Kilometer Course
- 135 Kilometer Course
- Wind Direction
- Elsinore Gliderport

wind from the northwest. Upon coming out of the haze they worked one more thermal on the edge and then zoomed back to the field. Paul Bikle flying a Schweizer 1-23-E was able to complete the task at 60 miles per hour (100 km.p.h.). The Fauvel was third at 41 m.p.h. (70 km.p.h.). In contrast, Dave McKay, in a Schweizer 1-26 was 8 m.p.h. slower than Bikle because he followed the line both ways. After arrival back at the field the aerometeorgraph was tied to the struts of the 40 HP Piper Cub and another flight into the shearline was made with the typical findings reported earlier. By this time the shearline had advanced over the area. Although the haze extended to 7,000 feet above the ground while we were completing the task earlier, it was only 3,000 feet high later when investigated with the airplane.

How to fly the shearline

There are many places where converging winds or air masses create a shearline. What should you do when you think you recognize a shearline and how do you look for them? Expect to find some kind of shear near passes that might separate different air masses. Watch for a different texture or visibility pattern near the ocean or large lakes. A row of clouds often will mark the differing air masses. Try to see some pattern in the winds of the area in which you are flying. If you do see a shearline and wish to soar along its edge turn toward the line at an angle until you hit turbulence. The lift will be encountered on the clear side. When the lift is found work the best area by circling. When at maximum altitude set out along the shearline. You may find that you can keep your altitude without circling for many miles.

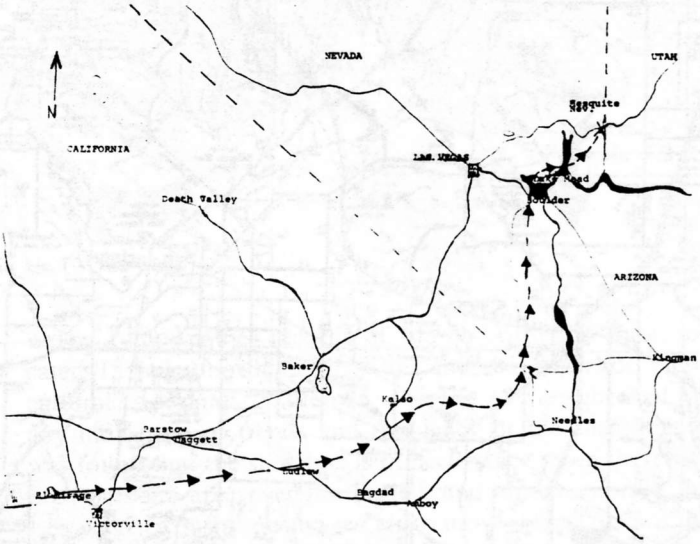

Fig. 7 ➤ ➤ ➤ ➤ Flight path 288 Miles El Mirage Field to Mesquite Nevada

If, after finding turbulence, you suddenly find yourself in sink it is probable that you have gone into the haze too far.

After some experience flying a shearline the technique becomes simplified in your own mind so that other pilots may be unable to find and use the shearline with only a verbal description. They must simply practice until they also develop their own understanding and intuitive tricks.

Attempting to explain shearline flying is in the same category as describing thermal soaring. There are so many little tricks and methods used by experienced pilots that we tend to give general rules of action that actually may not work for some kinds of thermals. So it is with flying the shearline.

This particular shearline at Elsinore is not conducive to spectacular flights but is an extremely interesting condition and one which could conceivably be used to break the 100 km triangular course record. The pilot would wait until the afternoon when a strong and well defined shearline had developed. Then he could race along the outgoing leg of the triangle on the shearline, finding a tailwind. At the turn he would fly the next leg on the sea air side, also finding a tailwind. The last leg will have to be a short run onto the field because there is no lift in the sea air side of the course.

An immense shearline is sometimes encountered when moist air from the Gulf of Baja California in Mexico moves north into the desert air.

On July 15, 1961, using the differential between two air masses the Fauvel was flown an airline distance of 247 miles (391 km.) in 5 hours and 15 minutes. Release was over El Mirage Airport at 2:05 p.m. and it was noted that the area to the south was dotted with small cumulus ending at a line coinciding with my proposed course. To the north the air was hazy with a definite inversion at about seven thousand feet. Climbing to 16,000 feet in a thermal I was able to look far ahead to the east at what appeared to be an excellent example of a shearline. I followed this line to Needles California, on the Colorado River, and then north to Boulder City where one thermal went to 17,500 feet at 6:15 p.m. (see figure 7). This shearline then curved south of the Grand Canyon which is very rough country to fly over so late in the day. I therefore headed north and immediately ran out of the shearline into a headwind and shortly landed at 7:15 p.m. at Mesquite Nevada. Actual distance along the shearline was 288 miles at 57 m.p.h. average!

Conclusions

Characteristics of the shearline and trends that appear common to the condition:

(1) This shearline develops when we have the high pressure area over the Pacific Ocean and little wind. (2) The pressure of the sea breeze in the intermediate valleys through the passes develops areas of lift at the convergence zone. (3) The leading edge builds up higher than the following layer of sea air. (4) This shearline is well marked by the reduced visibility at the sea air side and it is also occasionally marked by patches of cumulus clouds along the edge.

The fascinating micrometeorology of the Southern California shearlines appears to be complex but, with the continued handling of the atmosphere by sailplanes many holes in our knowledge are filled.

Bibliography

Aldrick, J. H. and Meadows, N., *Southland Weather Handbook*, I (1956), 6–8.

Berson, F. A., *Quarterly J. R. Meteorological Society*, LXXXIV (1958), 1.

Edinger, J. R. and Helvey, R. A., "The San Fernando Convergence Zone", Bulletin of the American Meteorological Society, September 1961, 626.

Lambie, J., "Plans to Explore the Shearline", *Soaring*, XXII (September-October 1958), 24–25.

Lambie, J., "Some Observations on the Elsinore Shearline", *Soaring*, XX (May-June 1956), 4–5.

Mackenzie, J. K., *Sailplane and Gliding*, VII (1956), 294.

Pearce, R. P., *Quarterly J. R. Meteorological Society*, LXXXI (1955), 351.

Wallington, C. E., "The Structure of the Sea Breeze Front As Revealed By Gliding Flights", *Weather*, XIV (September 1959), 351.

Watts, A. J., *Meteorological Magazine*, LXXXIV (1955), 42.

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