must necessarily be a series of successively closer approximations to the desired path.

ANOTHER MEMBER: I was interested in the visual perspective provided by the touch-down system with crossbars of different and increasing lengths and also in the number of crossbars necessary to provide the required guide slope and distance. It would be interesting to know if there is any correlation between distortion perspective angle and the real perspective angle by means of crossbar alteration; also to know the number of crossbars necessary to provide distance information from the aiming point. What guide slope information was provided by the taper?

MR. CALVERT: The original reason for using tapering bars was to indicate whether or not the aircraft was overshooting or undershooting the aiming point. I think they do this to a small extent, but the indication is poor, and I doubt if it is possible to provide a good natural indication with any pattern. However, if the pilot has already set his rate of descent by means of the radio aid, then all the approach lights have to do is to help him to carry on until he sees the threshold of the runway. In the limiting conditions, if he picks up the lights at 200 feet, he will see the threshold at 120 feet, so he has had poor aiming point guidance for only about 8 seconds. He is able to carry on through this period because the apparent motion of the bars tells him whether or not he is overshooting the furthermost bar that he can see, and whether or not he is at a safe height. Operational experience indicates that the pilot must see a minimum of two bars in order to do this without undue strain.

However, even if the tapering bars do not give a good indication of the touch-down point, they do insure that the bank indication shall always be adequate. If bars of equal length are used, the angular subtense decreases with height, and so does the sensitivity of the bank indication. The bank indication is therefore worst at the transition height where it is most needed.

MR. O. W. NEUMARK (private pilot): Could Mr. Calvert say whether any tests have been made varying the approach speed by using different aircraft; for example, a Meteor coming in at 150 miles an hour and a Miles Gemini at 35 miles an hour in the same critical visibility conditions?

MR. CALVERT: My view is that approach speeds cannot be safely increased beyond a certain value which depends on the skill of the pilot and the manœuvrability of the aircraft, because the higher the speed the more accurately the heading error has to be judged. In any given visibility there is a limit to the accuracy with which this judgment can be made. It would therefore seem that if approach speeds go up and manœuvrability goes down, the alternatives may be to install automatic landing or confine operations to good visibility conditions.

A Fix by Total Solar Eclipse

from D. H. Sadler

A TOTAL eclipse of the Sun provides an opportunity, rare though it may be, of obtaining an instantaneous fix from the Sun alone. Eclipses vary greatly in character, in position on the Earth, in the width of the path of totality, in the duration, and also in the direction of the path. However, the shadow of the Moon cast by the Sun is always a right circular cone which, in the case of a total

https://doi.org/10.1017/S0373463300028113 Published online by Cambridge University Press

eclipse, intersects the Earth's surface at some point before its vertex. Owing to the motion of the Moon in its orbit round the Earth the shadow moves at a speed of about 2000 m.p.h. from west to east (it varies considerably according to the distance of the Moon from the Earth). The intersection of this cone with the Earth's surface is an ellipse, which moves over the surface at speeds which are very high when the cone is nearly tangential (i.e. when the Sun's altitude is low) and at speeds as low as about 1000 m.p.h., when the eclipse is central over the equator at noon and the Earth's rotation has its maximum effect. The speed of the shadow is generally low enough to give a position line of considerable accuracy from the observed time of either second or third contacts, that is the beginning or ending of the total phase. An error of 1^s corresponds, in the most favourable case, to about one-third of a mile. The position line is, of course, the portion of the elliptic shadow corresponding to the observed phase and time; these can be precomputed.

Limitations of accuracy occur because of the uncertainty of the position of the Moon (actually this is due largely to the unknown variation in the rate of rotation of the Earth itself), the serrated edge of the lunar disk (due to the mountains on the Moon), and the difficulty in timing the contacts. None of the above should give rise to errors of more than, say, 2 seconds.

A second position line must be obtained by the conventional method of observing the Sun's altitude shortly before totality; unless very close to the sunrise and sunset limits, this should give a reasonable cut. The duration of totality, even when corrected for the motion of the observer, is insufficiently sensitive except very close to the edges of the path of totality.

An opportunity to use this technique, of such limited application, occurred on 30 June 1954. A Hastings aircraft from the R.A.F. Flying College at Manby, in the course of a navigational exercise, conveyed a party of astronomers to a point about 100 miles south-west of Reykjavik in Iceland where the track of totality crossed the zone of maximum auroral activity. The flight plan called for the aircraft to be at a particular point at a particular time. Navigation was by purely conventional methods; a visual fix over Keflavik was run on and checked by radio bearings, Consol and Sun sights—the estimate of uncertainty of one mile was by no means an over-estimate. Preparations were made to time the beginning of totality which, however, had no great scientific importance, but there was so much to see and do that no one succeeded in obtaining a reliable time for the second contact. Several observations were made by stopwatch of the duration of totality (nearly 170^s, this being 20^s longer than that for a stationary observer owing to the ground speed—208 knots—of the aircraft); and one, not very reliable, observation was made of the time of third contact. This was in accord with the navigator's position, within the limits of the uncertainty given above. No special sight was taken of the Sun's altitude since this would merely have duplicated the navigator's sights; as the eclipse track was practically due west–east the two position lines gave an excellent cut.

As will be seen there is some excuse for my failure to use this unique navigational opportunity to the full. It was my first eclipse, seen under the most perfect conditions. The shadow rapidly overtaking the aircraft was a thrilling sight, and so was the sudden change from the intense light of the last, rapidly diminishing crescent of the Sun itself, through the momentary glimpse of the photosphere, to the delicate colours of the corona. A most impressive spectacle was the advancing 'sunset' glow on the western horizon, with an orange band at the edge of the

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shadow. The corona was generally as expected for sunspot minimum, with long extensions in the Sun's equator; the inner corona was, however, extremely bright —almost as bright as the full Moon. No stars were seen, mainly because of the bright corona, but Venus was easily visible. By an incredible coincidence Jupiter was actually 'occulted' by the Sun during the eclipse, and was so invisible. It might be thought that the visibility of stars during a total eclipse would provide alternative means of obtaining a fix; but no one could possibly look elsewhere than at the Sun, unless they were engaged in essential scientific observations.

The flight was admirably planned and executed; great credit is due to all concerned, particularly to the crew from the Royal Air Force Flying College at Manby. They have the satisfaction of knowing that, although the main scientific observations resulted in negative information about the aurora, the large number of measures of the colour of the sky during the partial and total phases have already led to valuable theories of light scattering in the upper atmosphere.

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