A crack growing in the forward wing trunnion of a CF100 aircraft was monitored for over 60 flying hours. Acoustic emission data was detected which indicated that during climb, following take-off, the 3mm crack made unstable advances on a few occasions. The detected crack advances produced about 1mm² of new fracture surface.

The programme involves monitoring a crack in the 7075-T6 Al forward wing trunnion of a CF100 aircraft. From NDT measurements the crack is known to be growing at an average rate of 5µm/flying hour and was about 3mm long at the beginning of the program which was undertaken in an attempt to evaluate the feasibility of using acoustic emission to detect crack growth in flight. The main effort has been directed toward highly stressed components which are reasonably well acoustically isolated from the rest of the airframe, viz. wing trunnions and wing attachment fittings.

The equipment was located in the CF100 aircraft as shown in Fig. 1. The stress wave picked up by the sensor was amplified, captured in a transient recorder and recorded on audio tape. Both the preamplifier and audio tape recorder were operated by the navigator. These tapes were then sent by base maintenance to the data analysis centre at the Royal Military College where both amplitude distribution and spectrum analysis of the recorded data was carried out signal by signal.

In a preliminary in-flight fleet survey it was found that the structural noise detected by the sensor could vary considerably between components of the same type (Fig. 2). Further, the number of recorded signals above the threshold trigger level varied considerably from flight to flight on a single component (Fig. 3). The amplitude distribution of the environmental noise signals picked up by the sensor was found to be similar from flight to flight with a well defined cutoff amplitude as seen in Fig. 4. Among several thousand recorded noise signals a few acoustic emission signals were detected and have been positively identified. The amplitude of the largest of these is indicated in Figure 4 where it is seen that this crack advance signal is well above the structural noise.

Measurements of the amplitude of the signals was not sufficient to separate out acoustic emission due to crack extension from structural noises. Rather, this was done by acquiring experience of noise spectra measured in flight and of acoustic emission spectra measured in the laboratory. As is seen in Fig. 5 a typical noise spectrum decreased...
monotonically with increasing frequency while the acoustic emission spectra have pronounced maxima in the vicinity of 200 and 500 kHz. Of course these maxima include the acou\textit{stical response of the wing trunnion and the response characteristics of the Dunegan/Endevco 59201 transducer used. Figure 6 shows the response of the trunnion-sensor system to the helium gas jet calibration source(1),(2) and the corresponding laboratory system calibration. This result shows that the amplitude of the frequency point of view, the responses of the laboratory and field systems are spectrally similar but with the latter less sensitive by about 6dB. Hence the direct comparison of the laboratory and field spectra made in Figure 5 is meaningful and no correction has been made in this data for the difference between the systems. From the data of Figure 5 and our extensive laboratory testing of 7075-T6 Al we are able to state that the in-flight acoustic emission signal is due to a sudden crack advance which produced about 1mm$^2$ of new fracture surface in the forward wing trunnion. Further, correlation of the in-flight log with the data tapes showed clearly that the identified crack growth signals had all taken place during the climb following take-off.

Fig. 3 The number of recorded signals above threshold obtained for each hour of flight.

Fig. 4 A typical amplitude distribution of in-flight noise data (500 kHz, 24dB/octave bandpass filter). Also shown is the amplitude of the largest suspected A.E. signal observed in flight.

Fig. 5 Comparison of an in-flight recorded transient (A.E.) with representative A.E. spectra due to stable crack growth (= 0.1mm/cycle) and to an unstable crack advance (area = 5mm$^2$) in 7075-T6 Al. Also shown is a typical in-flight noise signal which does not have a similar spectrum.

Fig. 6 The helium gas jet spectra of the laboratory and field systems.

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