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REPORT No. T 3/54

OPERATION TOTEM

Canberra Flight Report, October, 1953

(Operation Hot Box)

Group Captain D. A. Wilson

(Royal Air Force Medical Services)

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April, 1954.
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Department of Atomic Energy

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

TRIALS DIVISION

OPERATION TOTEM - GROUP REPORT

GROUP 20 CANBERRA FLIGHT

REPORT NO. T3/54

Canberra Flight Report, October 1953 (Operation Hot Box)

Group Captain D. A. Wilson
(Royal Air Force Medical Services)

Summary

This report describes the flight of a Canberra aircraft through the cloud of Totem 1 explosion. The aircraft passed through the fringe of the cloud at H + 6 minutes and through the middle at H + 9 minutes. Further runs to obtain the height of the cloud were made subsequently before the aircraft returned to base.

Approved for Publication on 10th February, 1954.

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1. Report of Proceedings

1.1 This operation was designed to obtain the information required for Air Staff Target 924, and entailed the provision by Headquarters, Bomber Command of a new B2 Canberra aircraft complete with Marconi radio compass, a 650 gallon bomb bay tank and special clear high speed finish. This aircraft was delivered to Farnborough at the end of July, where it was fitted with special equipment designed by the Electronics Division of AERE. It was also fitted for carrying certain special filters at the request of the Radio Chemistry Division of AWRE. These filters comprised

(a) 9 in. cube cellulose acetate 'Porton' type filters, installed on the inside of a pair of wing tip tanks by Armament Division, RAE.

(b) Standard Venturi type filters of the normal AERE design mounted aft of the camera hatch.

(c) Moving strip type filters installed beside (b) in a similar type of container.

These were sent out by air freight to Australia for installation as and when required.

1.2 The aircraft left Marham in Norfolk on Sunday morning, 13th September, and proceeded by easy stages to LRWE at Woomera, where it arrived on the 19th. The crew of the aircraft were Wing Commander G. H. Dhenin, G.M. - Pilot (RAFMS - HQ, Bomber Command); Wing Commander E. W. Anderson, O.B.E., D.F.C., A.F.C. - Navigator (HQ, Bomber Command); Group Captain D. A. Wilson - Radiological Observer (RAFMS - Central Medical Establishment). A visit was paid to the X 200 site and the adjacent aerodrome was inspected with a view to its suitability for jet operation. It was agreed that the strip, although suitable for emergency use, was quite unsuitable for routine operation. Arrangements were therefore made for the aircraft to participate in the rehearsals of the trials direct from Woomera. Two rehearsal flights were made to check that timing arrangements were adequate.

1.3 On D.1., the aircraft which had previously been fitted with its filters and had had its pressurisation piping removed, took off from Woomera at 05.50 local time. Arrangements were made for the provision of a radio link aircraft - a Lincoln from 82 Wing, RAAF - to orbit a point some 60 miles away from the explosion, and act as a link in case of radio unserviceability following the experiment. This aircraft kept in radio touch with us throughout the experiment. It also carried stores and rescue equipment in case of a forced landing of the Canberra on the return journey.

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1.4 On arrival over Emu field, contact was made with the control tower, and we proceeded to orbit north of the field at 35,000 ft. until the start of the count down, when we started our descent. At one minute before zero we turned away, still descending so that we were in a rate 1 turn, at an angle of approximately 30° to the burst. At this moment we were 10 miles away at 20,000 ft. The flash lit up the cockpit and we were immediately able to watch the remainder of the explosion. At H + 6 minutes the cloud was approached and entered tangentially at 14,000 ft. The ionisation rates were noted, as were the dosages, and an immediate full passage through the cloud was made at H + 9. This occupied a period of 9.2 seconds, the cloud being then almost exactly 2,000 yd. wide. The dose rate meters on the aircraft started to register some 500 yd. away from the cloud and whilst in the cloud, showed a peak of approximately 2,000r per hour, which appeared to be fairly homogeneous. The cloud was very thick, and gave the appearance of a dense London fog. It was necessary to have the aircraft lights on whilst inside.

1.5 Turbulence was considerable, but abrupt and short in character. On emerging from the cloud, further runs were made 100 ft. above the top of the cloud, which was then at 16,000 ft., and 100 ft. below, which was then at 10,000 ft., the main run through being carried out at 12,000 ft., which was the thickest portion. Dosage rates of 300r per hour were noted above the cloud and 400r below some two minutes later.

1.6 On finishing the runs, the dose rate in the cockpit was noted as being 5.8r per hour. This dropped during the 50 minutes of the return journey to 0.8r per hour, going no lower largely due to the presence of the wing tip filter.

1.7 On arrival at Woomera, we were picked up by another Canberra which was airborne in case our own air speed indicator had become unserviceable through being blocked by dust. We landed on the run-way and taxied up to a special point where we detonated the starboard wing tip tank containing the filter. When this had dropped off, the dose rate in the cockpit was reduced to 0.3r per hour. The aircraft was then taxied on to the end of the run-way and the crew evacuated the aircraft, proceeding to the showers which were nearby and were given clean clothing. After being monitored, they went to breakfast. There was no contamination in the cockpit as far as could be ascertained, our clothing becoming contaminated on the way out of the aircraft.

1.8 One hour later, the aircraft was surveyed and the contaminated areas charted. It was then washed down by being (a) sprayed with a special decontaminating solution from buckets with a stirrup pump, which was then mopped down; (b) then washed down with brushes through which a steady stream of water was flowing; (c) the brushes were then removed and the aircraft was finished off with a high pressure jet of water. At the conclusion of this, the rate in the cockpit was just below tolerance level. This operation took an hour. It was thus possible to show that the aircraft could have been refuelled, rearmed and flown again with another crew within four hours. The aircraft was then towed from the end of the run-way, and placed for the next 48 hours inside the protected area and left over the weekend.

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1.9 At the end of this period, it was taken out again and resurveyed. It was at this time still fairly heavily contaminated on the leading edges of the wings, on the nose and in the engines, and it took 48 hours' heavy work to reduce this surface contamination down to levels that would satisfy non-operational requirements. The entire surface of the aircraft having to be rubbed down by the ground crew and ourselves.

1.10 After these operations were completed, the aircraft was returned to the hangar prior to the second explosion for the fitting of fresh filters.

1.11 Quartz fibre dosimeters reading from 0-5 and 0-50r were carried by the crew of the aircraft as well as special film badges and three dosimeters reading from 0-5. At the end of the first run, it was noted that the quartz fibre dosimeters read 4r. whilst the $\beta\gamma$ were off scale. Before the journey home, the quartz fibre readings were about 18r, and nearly another 1r was added during the journey home.

1.12 On development the film badges were found to read almost exactly half the readings found on the quartz fibre dosimeters. The reason for this is not understood at the moment, but may be due either to the extremely high $\beta\gamma$ ratio at this time, or to the aluminium casing coming into the picture in the case of the quartz fibre instruments. This matter is under discussion with AERE.

1.13 These film badge dosages brought us within 0.5r of the maximum permissible dosages allowed for the operation by the Ministry of Supply, who stated that since all the RAF requirements had been fulfilled on the first sortie, that they did not feel justified in asking us to collect samples solely for them in the second explosion. Whilst we were unwilling to forego completion of the planned exercise, it was impossible, however, to deny the commonsense of the Ministry of Supply decision, which was therefore accepted, and the explosion was witnessed from the hill at B site, which was the nearest at which observers were permitted, some four miles from T2. It was interesting to note that through an alteration in the surface wind the sampling rockets did not connect with the cloud - thus emphasizing the value of the aircraft sampling and in this case showing how useful it might have been had we been airborne, standing-by, at the time.

1.14 I then returned to Woomera and proceeded to Melbourne and interviewed the DGMS (RAAF) there, whilst the aircraft's engines were being inspected by the Rolls Royce representative. We left Woomera on Tuesday, 3rd November, arriving back at Wyton on the 6th, after a rapid and uneventful journey.

1.15 Complete medical examinations including blood, decompression and audiometry examinations, were carried out prior to the start of this exercise. A repeat of these with the exception of the decompression on return to England, showed no deterioration in the audiometry or alteration in the blood counts. Examination of larger blood samples and specimens of urine failed to show the presence of any ingested fission products.

1.16 This report has been kept as non-technical as possible, and it is intended that the more technical portions should be included as separate appendices.

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2. Conclusions

2.1 The Canberra represents an almost ideal aircraft for air sampling requirements. It is roomy, very fast with adequate range and above all has the ability to remain stable at extreme altitudes when carrying external filters etc. Many other similar type aircraft have such a small margin between stalling speed and buffeting at extreme altitude that manoeuvring becomes difficult when any other drag is attached.

2.2 Air sampling and tests of performance of aircraft in the immediate vicinity of an atomic explosion have been proved possible under controlled conditions without undue hazard to personnel.

3. Group Composition

The personnel of Group 20, Canberra Flight, were :-

Group Leader: Group Captain D. A. Wilson, RAFMS. (Central Medical Establishment). Scientific Observer.

Pilot of the aircraft: Wing Commander G. H. Dhenin, G.M., RAFMS.

Navigator: Wing Commander E. W. Anderson, O.B.E., D.F.C., A.F.C.

These latter two members of the Group are both on the staff of Headquarters, Bomber Command, Wing Commander Dhenin being the Deputy Principal Medical Officer (Flying) and Wing Commander Anderson the Command Navigation Officer.

The individual responsibilities were those relating to their positions in the aircraft. The pilot has command of the aircraft, was responsible for flying safety and for all decisions taken in the air, but was influenced in decisions relating to radiation hazards by the advice of the scientific observer (the Group Leader). The navigator was responsible solely for producing the aircraft at the right place at the right time. He was only included in the aircraft for the trials following the decision to operate from Woomera rather than from Emu. The Group Leader was responsible for the instrumentation, records and for radiation safety of the aircraft and crew in the air and subsequently on the ground.

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Appendix A

Instrumentation on WH 738

PART I

Recording

The object of this instrumentation was to provide visual recording from 0-10 0-100 0-1,000 0-10,000 r.p.h. with a spark gap recorder dealing with the two latter ranges. This it was felt would cover the dose ratio under any conditions likely to be encountered in the Exercise.

2. Two standard 1155 instruments fitted with sealed ionisation chambers were mounted in the aircraft under the navigators table and tilted so that the scales were easily readable. That on the right reading 0-10, that on the left 0-100 r.p.h. These were fitted in slots so that though fixed, they were readily removable.

3. The higher ranges were dealt with by a modification of the AERE high rate gamma flux meter and consisted of two sealed ionisation chambers A and B reading 0-10,000 and 0-1,000 r.p.h. respectively. The visual meters for these were placed just beside the table and navigators seat. The amplifier was placed underneath them and the recorder under the table beside the 1155. They were worked from a special invertor. The Radiological Observer used the navigator's seat.

4. With these it was considered possible to measure the gamma flux throughout its range with the possibility of making both 1155s read the same scale for accurate recording.

5. The Recorder itself was switched on from the main panel and had a Slow test switch incorporated in the amplifier. This ran the rolls of paper at 2 in. per minute, the normal running rate being 60 in. per minute. On both the high range visual dials and the recorders the pointers were at rest on the centre line moving to zero on warming up.

6. On the D.1. runs the instrumentation was checked before take off and then switched off until H-9 minutes when it was switched on with the exception of the recorders. No evidence of any radiation was noticed from the gamma flash which was just over 10 miles away. On the run in towards the cloud the recorders were switched on at about one minute from H+6 the arranged time of entry. After about 50 seconds the 0-10 and 0-100 instruments went off scale and the 0-1,000 swung nearly off. We turned away and made a re-entry 3 minutes later for a complete penetration, and on this occasion the three rate meters swung violently off scale and the 0-10,000 was oscillating in the region of 1,500 - 2,500 r.p.h. Subsequent runs showed 300 r.p.h. 100 ft. above the cloud, and 2 minutes later 400 r.p.h. 100 ft. below

7. The recording instruments worked perfectly in spite of considerable turbulence, settling after the 4th run at 5.8 r.p.h. The second 1155 was switched over to the 0-10 scale to check the figures for the decay rate in the cockpit on the journey back which took 45 minutes. On landing the rate in the cockpit was 0.8 r.p.h. and after jettisoning the big filter on the starboard wing tip, this fell to 0.3 r.p.h.

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PART II

Personal Dosimetry

Each individual (three) was supplied with two packs of film, one the standard red pack of film, and the other a special white pack containing $\beta\gamma$ film. In addition each had one 0-50r γ quartz fibre dosimeter and one 0-5r γ quartz fibre, and one 0-5r $\beta\gamma$ instrument.

2. These were checked against leakage and charged on the morning of D.1. and rechecked at H-9 (in the case of those belonging to myself. This is of interest in view of the results).

3. After the first run the 0-5 γ instruments showed 4r, the $\beta\gamma$ instruments being off scale. The 0-50 γ instrument showed 4r also.

4. These readings were increased during the passage through the cloud by a further 10r, increasing during the height runs to a total of 17.8r in my case. On the journey back another 1.2r was collected, making a total of 19r on the exercise recorded on my personal Q.F. gamma dosimeters. It was unfortunate that we did not have the use of some of the existing 0-50 $\beta\gamma$ instruments.

5. The pilot had 21r on his dosimeter and the navigator 18r. This distribution is probably consistent with the geometry of the aircraft.

6. On the film badge packs when developed, the total dosage was almost exactly half (in my case 9.5r). No explanation of this large discrepancy can be given until the actual instruments have been checked after return to AERE. However, as the film pack doses were more in keeping with MOS requirements (and our calculations) they were used pending clearance of the discrepancy.

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Appendix B

Decontamination of WH 738

On arrival back at Woomera the aircraft was surveyed on the ground after we had had our showers. It was not necessary to have showers in the straight sense since it was only the overalls and gloves which were contaminated and these only from contact with the outside of the aircraft on leaving.

2. There was a high rate of radiation chiefly beta on the surface of the aircraft, especially the perspex nose, leading edges of the wings and the engine lacelles. A drill had been worked out for decontamination which consisted of marking off the end of the run-way as a dirty area. A standard battery operated 1295 was stationed there in the back of a utility. Three ground crew were dressed in full protective clothing with the exception of gas masks and hoods, and started off the decontamination by spraying the aircraft with a special solution of detergent supplied by the R.H. Group from buckets with stirrup pumps. This later was worked well into the aircraft with mops. A 500 gallon tanker which had a low pressure pump was then brought to the nose of the aircraft with two 60 ft. leads of hose with special brushes permitting a flow of water through the brush. These brushes were then used to wash off the detergent and fission products. The long handles of the brushes were used to keep the operators out of contact. The ground was therefore contaminated with fission products washed off the aircraft, but everyone in the area wore canvas covers to their boots which proved sufficient. After a thorough scrub down with these brushes another tanker was brought with high pressure hoses, and the aircraft was hosed down thoroughly. It was not possible to put the aircraft tail to wind as we should have liked for this exercise since cold wind impinging on the hot turbines was liable to distort them. The aircraft was therefore, placed cross wind and hosed down with a high pressure hose; was then re-surveyed when although the dosages on the surface were high, i.e. more than 3,000 c.p.s., the cockpit tolerance was below 12.5 m.r. per hour, thus showing it would be possible to refuel and fly the aircraft immediately without great hazard to the servicing and arming crews. The aircraft was then taxied from the end of the run-way into the security compound where it was locked and left for 48 hours.

3. At the end of this period (a weekend) the dosage rates of the aircraft had decayed as expected, but it was not found easy to decontaminate the aircraft further and smears still gave a reading of over 2,000 c.p.s. For security reasons it was not considered advisable to let this state of affairs continue, and the aircraft was then taken out again on to the run-way and manually scrubbed down - a proceeding which employed the six of us for 48 working hours. Although arduous this proceeding was effective, reducing the counts down to below a 100 with exception of certain areas of the engines. The aircraft was then considered fit to work on and the engines' blanks were therefore removed, the engines run up and air samples were taken. These proved negative, and the pressurization piping was therefore reconnected. The aircraft was flown home later.

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4. On arrival at Wyton on 6th November, instructions were given for the removal of the engines from the aircraft, and they were sent at the end of the month, after consultation with D.Air Eng., Air Ministry, to RAF Station, St.Athan. There the port engine was taken from its case and checked, when the levels of radiation were found satisfactory for stripping purposes.

5. Three fitters started this stripping under the guidance of the Rolls Royce representative from the engine point of view and myself from the health physics point of view. It soon became apparent that the area around the bleed valve, particularly the blanks on the underneath side of the engine and the flame chambers, were the most highly contaminated. To strip an Avon it is put on a stand vertically with the impellor at the base, thus the flame chambers were removed early. One which gave a reading of 500 c.p.s. was put into a cresol bath and left for the maximum period, when although no smear samples could be taken from it, it was still reading over 200 c.p.s. It was then put in a caustic bath when the aluminising was removed. This rendered the chamber completely clean. At this point it was decided that as the engines had only run 100 hours, that it would be sufficient to put the remaining flame chambers through the cresol bath only and let the engine be reassembled and be put back into service for its remaining 400 hours, since the radiation levels would by that time be negligible. It must be remembered that the engines had had approximately half a ton of contaminated air through them, followed during the test flying afterwards and the journey home by another 6,000 tons each. Therefore it was surprising to find the bleed valve blanks on the inside of the engine still visibly contaminated with radio active dust which must from its activity have come from the inside of the cloud.

6. At this point I handed over supervision of the engine to Wing Commander Dhenin who states that much the same degree of decontamination exists in the impellor and stator sections of the compressor, and agrees with me that the No.2 (starboard) engine should be returned to service forthwith, as I understand that No.1 (port) engine is to be returned to Messrs.Rolls Royce for rebuild. The No.2 engine has had a thoroughly external wash with paraffin and removal and cleaning of the bleed valve plates. It represents no hazard to re-install or service.

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