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Department of Atomic Energy

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

TRIALS DIVISION

OPERATION TOTEM - TEAM REPORT

GROUP 4 TEAM R.C.1

REPORT NO. T 5/54

Fission Product Sampling

Part I - D. T. Lewis

Part II - Lt. Col. L. J. Howard, (Royal Artillery, Australian Army)

Summary

Part I of this report describes the various methods which were set out to try and obtain satisfactory fission products of the explosions, and the results which were obtained.

Part II describes in considerable detail the use of three inch rockets for obtaining samples.

- and Alice heard the Rabbit say, "A barrowful will do, to begin with".

Lewis Carroll

Approved for publication on 5th March, 1954.

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PART I

PART II

1. Introduction [redacted]

From the analysis of the radioactive particles which constitute the atomic cloud produced by the explosion of an atomic weapon, or by the radiochemical analyses of bomb debris, it is possible to determine the amount of unconsumed plutonium, the quantity of Np^{239} produced by irradiation of the uranium tamper, and the fission product ratios of a large number of beta emitting substances produced by fission. From these data one may quantitatively determine the efficiency of the weapon and the energy released. It is, therefore, of considerable importance to devise means whereby good active samples may be obtained, both from the cloud at the time of its formation and during its subsequent path, and also of fused or contaminated earth debris in the vicinity of the explosion.

The Radiochemical Team RC1 was stationed at Emu camp in the Woomera desert and was responsible for obtaining samples of the atomic cloud and of earth debris from the explosions which could be immediately forwarded to the radiochemical team RC2 who were stationed at a laboratory centre kindly provided by L.R.W.E., Salisbury, near Adelaide. The RC1 Team consisted of two U.K. staff, who were assisted by three Australian officers, and a total of twelve other Army personnel as detailed in Part II of this report.

2. Methods of Sampling

The sampling methods employed for fission products during the Totem operation will be detailed individually in Part I of this report and may b generally classified as follows:-

	Method Employed	Type of Sample Obtained
(a)	Firing 3 in. rockets with special filter heads through cloud.	Particulate dust from atomic cloud above ground zero.
(b)	Sampling by wing-tip filters attached to Canberra aircraft flying through cloud.	Particulate dust from atomic cloud above ground zero.
(c)	Firing of static rockets 100 yd. from ground zero.	Particulate dust from atomic cloud and neighbouring grou
(d)	Steel trays containing fused borax at 100 yd. from ground zero.	Particulate dust and earth debris.
(e)	Filters attached to Lincoln aircraft for cloud sampling at long ranges.	Particulate dust at long r
(f)	Special movable filter strip in camera-type apparatus beneath	Particulate dust above gr zero.

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(e)	Filters attached to Lincoln aircraft for cloud sampling at long ranges.	Particulate dust at long ranges.
(f)	Special movable filter strip in camera-type apparatus beneath Canberra bomber.	Particulate dust above ground zero.
(g)	Manual recovery by personnel of fused debris at ground zero.	Fused earth and sand.
(h)	Manual collection by personnel of fall-out particles approximately 800 yd. from ground zero.	Fused spherical fall-out drople[ts] from the atomic cloud.

Method Employed	Type of Sample Obtained
(i) Quartz wool filters attached to the air intake of the Centurion tank.	Particulate dust at 350 yd. from ground zero.

2.1 Method 2 (a)

Rocket Sampling The results obtained by firing 3 in. sampling rockets through the cloud at the Hurricane trial of 1952 well warranted a continuation of this method at Totem, and in Part II of this report, Colonel Howard of the L.R.W.E. Staff gives a complete and detailed account of the siting of the Rocket projectors and the ballistic functioning of this type of rocket.

As an addendum to this Australian report, it may be stated that the filter heads which were screwed into the noses of the projectiles were not filled with glass wool as at Hurricane. In the case of Totem, half the filter body was filled with quartz wool at the nose end, and the remaining half was stemmed finger tight with glass wool. The major fission products thus collected on the quartz wool were readily segregated for chemical analysis, because this pure silica type fibre dissolves very readily indeed in hydrofluoric acid and contains none of the alkali and alkaline earth impurities which are associated with normal glass wool. This considerably simplifies the radiochemical manipulation of the samples collected. It may also be reported that the soft ground at Emu gave these filter heads far more protection than was given by the rocky surfaces on which they were fired during the Hurricane operation, and it was found at the Totem trials that the heads were very readily removed and were in a sensibly undamaged condition. The "digging out" of the buried rockets in the heat of the desert sun was, however, a major operation for personnel encumbered by protective clothing and gas mask type respirators. The work was carried out speedily and effectively, and as leader of the RC1 Team, I would like to express in this document my great appreciation of the manner in which Colonel Howard and his Australian assistants carried out this very essential work.

Some of the rocket heads carried photographic film inserted by the R.H. Group for the determination of gamma emission in the cloud, and a number of these gamma film units were salvaged during Totem 1 and Totem 2 trials.

Only one projector, No. 8 Mark I Land Service was used in each trial, and during Totem 2 the meteorological conditions were particularly adverse, the cloud rising rapidly to nearly 25,000 ft. and drifting swiftly away in the higher air currents. For this reason the rockets fired during the Totem 2 trial missed their target, and negligible gamma activities were recorded on the collected samples. It is obvious that at future trials of this type, some arrangement must be considered whereby a battery of rocket projectors can cover a fairly wide range on each side of ground zero in order that there should exist a good chance of hitting the cloud, regardless of weather conditions. It may be of interest to record that during rocket sampling operations, personnel were free to move in the target area without respirators, which were donned only after the digging out of the rockets. The average activity of the rocket heads in Totem 1 was of the order of 1 roentgen per hr. at the surface, approximately one hr. after the explosion. (See Figure 1).

2.2 Method 2 (b)

Wing-Tip Filters. The Air Ministry had arranged that a U.K. Canberra aircraft should fly through the cloud at a period between 5 and 15 minutes after zero hour. By arrangement with Group Captain Denis Wilson, D.M.R.E., it was agreed that the Canberra would carry two wing-tip tanks fitted with special filters, the modification of this sampling equipment being carried out by Dr. A. H. Wilson of the RAF Establishment, Farnborough. The filters were specially made by Dr. Thomas of CDEE Porton, and contained cellulose acetate and polystyrene filtering media which would be readily soluble in organic solvents and yield the fission products as residue. The Canberra flight was originally scheduled from Emu airfield, but because of the poor nature of the strip it was ultimately decided to use Woomera as a base. The flight through the cloud took place as scheduled, and the wing-tip filters were collected by the RC2 Team at Woomera and found to have a surface activity of approximately 8 roentgens per hr. at one hr. after the explosion.

There can be little doubt that this method of sampling is extremely effective, but it was impossible to apply it to Totem 2 because of the relatively large radiation dose received by Group Captain Wilson and his crew during the Totem 1 operation.

The attachment and design of the Canberra wing-tip filters is shown in Photographs 2, 3 and 4.

2.3 Method 2 (c)

Static Rocket Firings. The general principle underlying this method of sampling entails the use of the high velocity jet from the burning cordite of an aircraft take-off rocket inserted nose first into a steel tube buried in the ground, to produce a pressure differential through a filter attached to its tail. Photograph 7 illustrates the loading of one of these 5 in. No.5, Mark N.2, K. Type 12 A.S. - 1,000 D rocket motors into its ground tube, the cylindrical filter at the tail containing quartz wool. Unfortunately the great energy release both from Totem 1 and Totem 2 violently blasted the areas in which these rockets were sited, i.e. at 100 yd. from the towers, and they were not found after the explosion. It is doubtful whether further experiments along these lines are worth proceeding with because of the difficulty of estimating a safe zone for siting the rocket.

2.4 Method 2 (d)

Borax Tray Sampling. Steel trays filled to a depth of in. with fused sodium bi-borate were securely stapled into the sandy earth at 100 yd. from the towers. The trays were approximately 1 yd. square, and the details of their siting are shown in Photograph 6. Unfortunately these sites again fell within the area of major destruction caused by both weapons, and could not be found after the firings. The general idea behind this method was that the fused borax would absorb particulate dust when in the molten condition and retain it for analysis. The trays were undoubtedly lost beyond recovery under many feet of fused sand and debris, and this method again compares unfavourably with the methods 2 (g) and 2 (h) which will shortly be described.

2.5 Method 2 (e)

Aircraft Filter Systems. A number of Lincoln aircraft took cloud samples at hundreds of miles from ground zero using special paper filters which contained assemblies of the type illustrated in Photograph 5. This method has been employed in the U.K. for a considerable time for dust sampling of the upper atmospheres and the results obtained will be discussed in the reports of the RC2 and RC3 Teams.

2.6 Method 2 (f)

Moving Filter Strip. The special purpose of this particular apparatus was to record the beta-gamma distribution of fission products from samples taken horizontally at various intervals through the cloud. The apparatus was designed by Dr. F. Morgan of the RC2 Team and consisted of a camera type instrument with a 35 mm. filter strip attachment which moved behind a slit in an assembly of the 2 (e) type, which was fitted to the outside of the Canberra aircraft as shown in Photograph 4. The motor producing movement of the filter strip was actuated by 12 volt aircraft batteries and should have been switched on immediately the Canberra entered the fringe of the cloud. Unfortunately, owing to the great speed of the aircraft it was difficult for the RAF operator to judge this time exactly, and radioactive analysis of sections taken along the strip suggests that the movement was actuated too early in the operation. Some useful information was, however, obtained and there can be no doubt that this method of sampling, either with guided aircraft or used in conjunction with rockets, will prove invaluable in future trials for providing an estimation of the distribution of fission products in planes of varying altitude out through the cloud structure.

2.7 Method 2 (g)

Manual Recovery of Fused Debris. In conjunction with the R.H. Group, sorties were made into the crater area at intervals of approximately 3-10 days after the explosions, the intensity of radiation during the later periods being of the order of 8-10 roentgens per hr. at the centre. The red desert sand had been fused over an area of approximately 100 yd. radius, and a large number of samples of brittle, black glassy fused material of high activity were collected in polythene bags, placed in lead lined boxes and transported to the U.K. for future radio-chemical analysis. Samples of this type were necessary in order to obtain fairly large quantities, e.g. 100 micrograms of residual plutonium which could be assayed either by mass spectroscopic or kick-sorting methods for its Pu^{238}, Pu^{239} and Pu^{240} concentration.

2.8 Method 2 (h)

Collection of Fall-Out Particles. Because of the failure of the rocket sampling during Totem 2, the author decided to make a sortie 1 hr. after the explosion into an area where fall-out particles might be obtained in quantity, and on the advice of Colonel Stewart of the R.H.Group a Land Rover was driven towards the photographic tower 'C' and at a distance of approximately 1 mile from ground zero. In this area the activity was of the order of 50-60 roentgens per hr. and the desert sand was covered at approximately $\frac{1}{2}$ cm. intervals with fused, brittle black droplets, varying in size from fine powdery particles to particles of over 1 mm. in diameter. Using a long handled shovel it was possible to skim the earth surface and to collect hundreds of these particles mixed with adulterating sand, and place them in a polyvinyl-chloride bag placed on the ground at a convenient position. During this operation the Land Rover and its driver left the collection area, and awaited a signal from the operator at about 200 yd. distance. When about 3 lb. of earth surface had been collected in this way the gamma activity at the plastic bag surface was of the order of 60 röentgens. This sample was taken back to base and some of it was flown immediately by aircraft from Emu to Salisbury, where the RC2 Team succeeded in segregating manually large numbers of the fused black spheres. They were found to be extremely active and to contain very large quantities of plutonium. There can be little doubt that this method of sampling provides the easiest and surest means of obtaining the necessary quantities of plutonium for the determination of isotopic ratios.

2.9 Method 2 (i)

Centurion Tank Sampling. A Centurion tank was sited at 350 yd. from the Totem 1 tower and it was considered that if modified air intake filters were installed in this tank, there was a good probability that a reasonable sample of fission product dust would be collected on the filters. Special filters for this purpose, containing quartz wool filter media were prepared by Mr. A. Grange of AWRE. Mr. E. R. Drake-Seager of the War Office was in charge of the tank operation, and I would like to express appreciation for the help given by him and Colonel Messenger in installing and recovering these filters. The tank engines were started about half an hour before the blast and they appeared to have continued running quite effectively after approximately a similar period after the explosion. Unfortunately the force of the blast was sufficient to distort badly the contained quartz filters and their wire mesh support, and the samples obtained had not the activity which we anticipated. After eight days they had an activity in the neighbourhood of the filter of the order of 200 milli-röentgens per hr., and have been returned to the U.K. for critical examina-tion. The condition of the air intake filter after the explosion is shown very clearly in Photograph 8.

3. Other Methods Considered

In the early stages of the trial a suggestion was made by L.R.W.E. that a remotely controlled Jindivik aircraft, carrying suitable filters, might prove a good means of obtaining highly radioactive samples of cloud fission products. This matter received very serious consideration but a[t] the time, June 1953, it was considered that it was too late for the Totem experiment in view of the major operational work necessary to ensure satisfactory functioning of the Jindivik.

There can be no doubt, however, that the use of pilotless aircraft of this type will play a very important part in the cloud sampling of fu[ture] atomic weapon trials, and serious consideration should be given to the u[se] of aircraft of this type - (a) Firefly Mark 8; (b) Meteor 4; (c) Lanca[ster] (day and night). A summary of the characteristics of these latter airc[raft] is given in RAE Technical Memo G.W.198.

4. Conclusion

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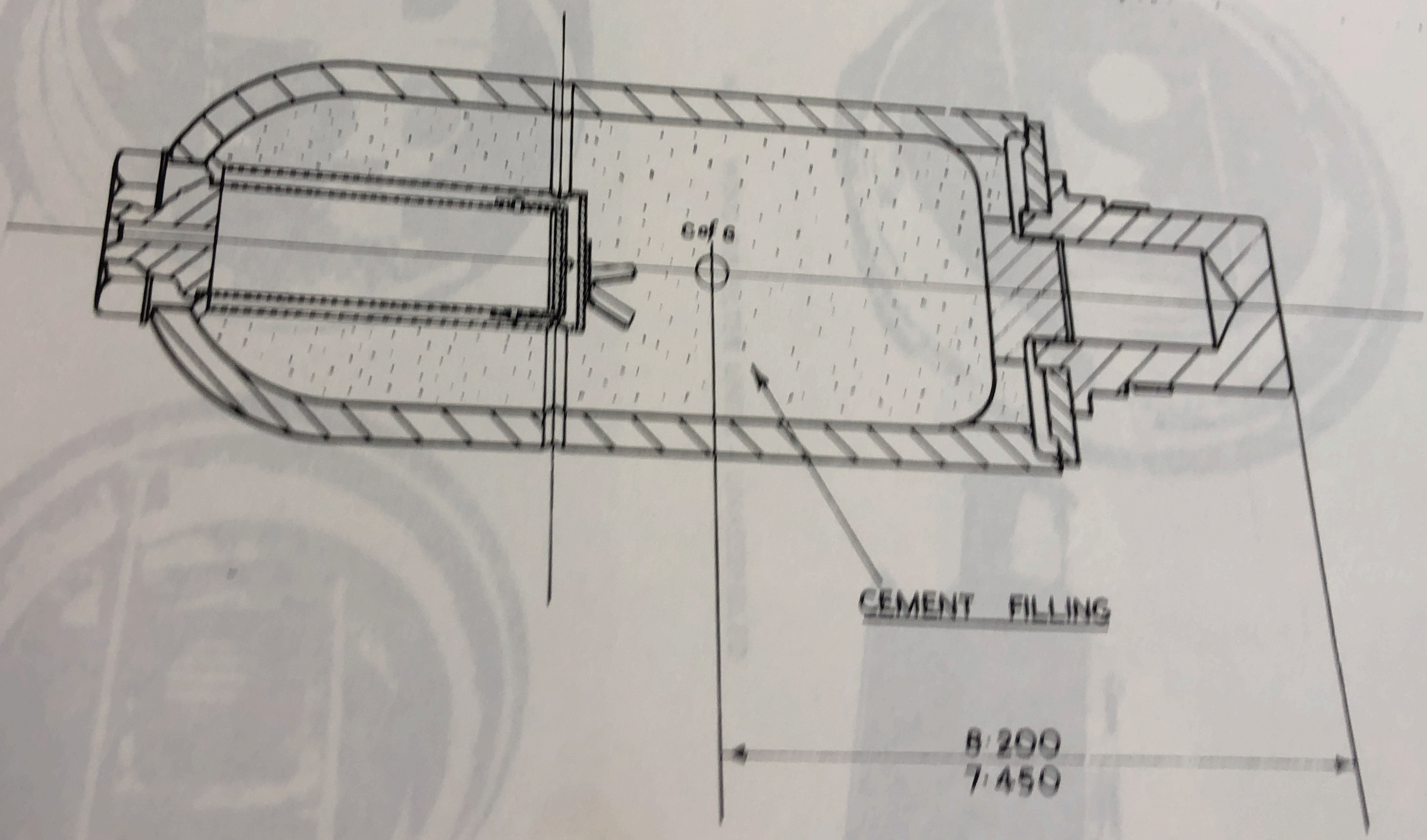
It is considered that the experiments carried out on fission product sampling at the trials Totem 1 and Totem 2 have given very valuable information regarding the methods which are most likely to give suitable radio-chemical samples. Firing rockets through the cloud is undoubtedly one of the most effective means of securing low order fission product samples, but by the use of filters attached to aircraft a much larger volume of sample, and hence augmented activity, can be collected. One unique method adopted during the Totem trials was the immediate collection of fall-out particles which were found to possess high activity. This method involves a certain amount of risk to the operator, but it does give samples which are extremely rich in plutonium and which, on chemical treatment, may be made to yield ideal specimens for determination of plutonium isotopic ratios.

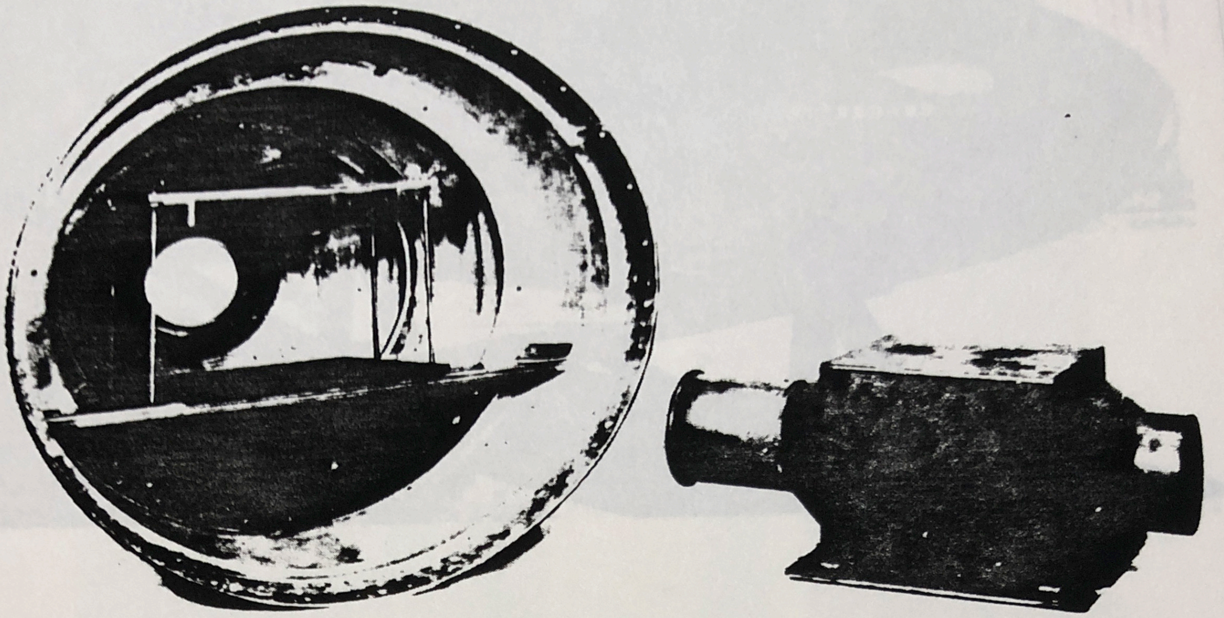
Recommendations of interest relating to the use of rockets are detailed in the conclusions of Part II of this report of the RC1 Team.

~~SECRET~~

ROCKET HEAD

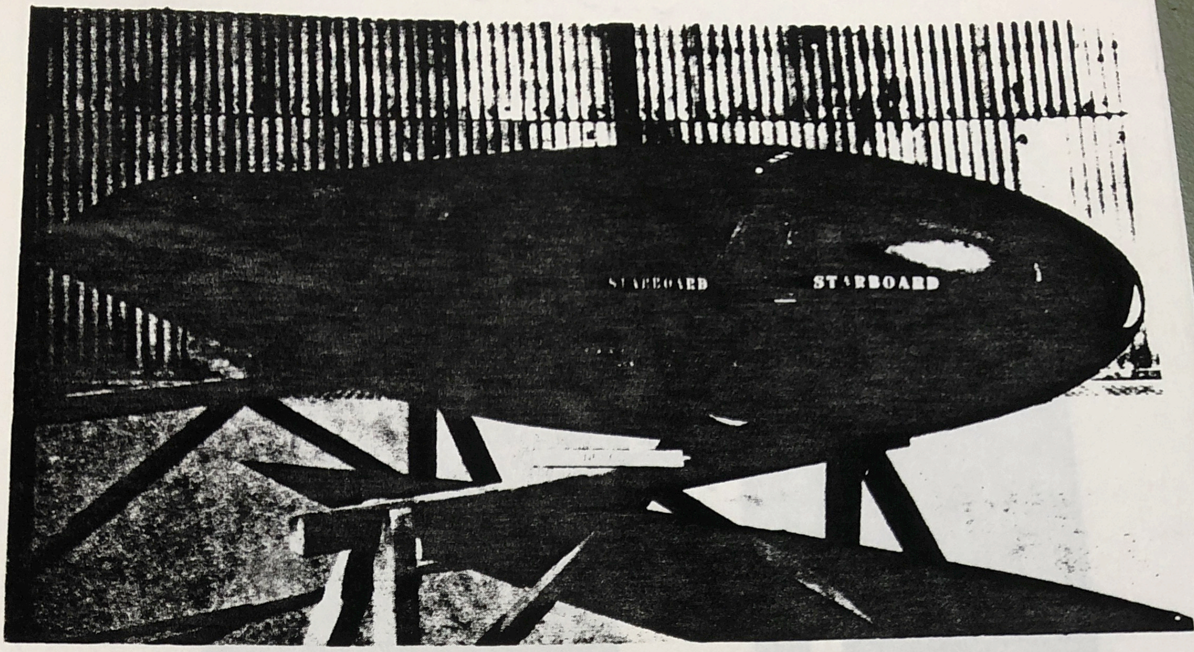
FIG.I.



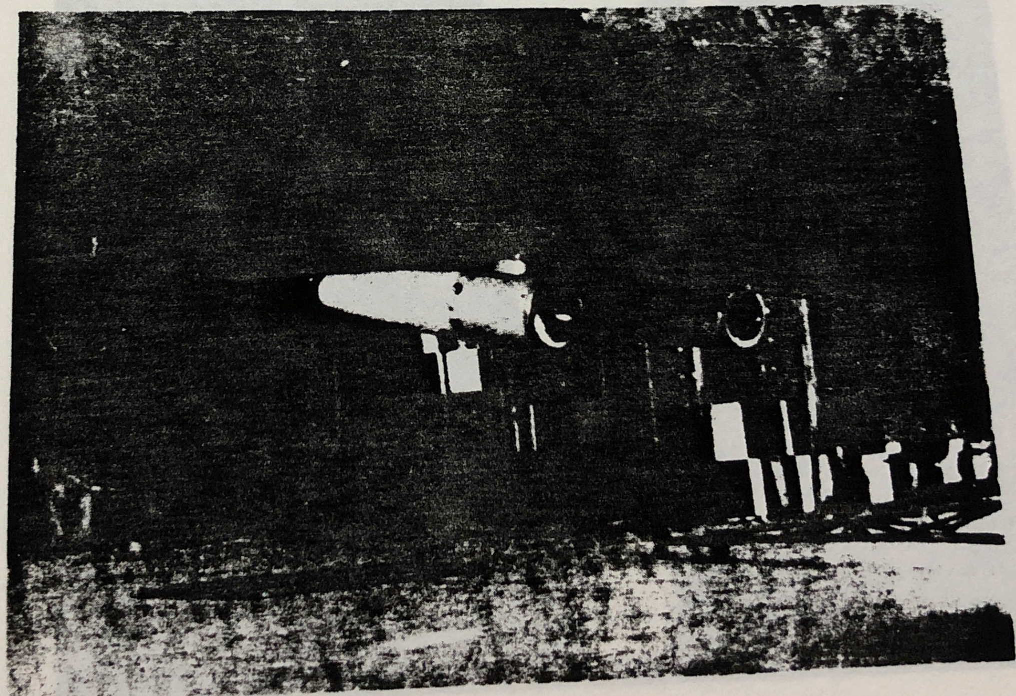


No. 1. WING TIP FILTER UNITS - UNASSEMBLED

No. 2. WING TIP FILTER UNITS - ASSEMBLED

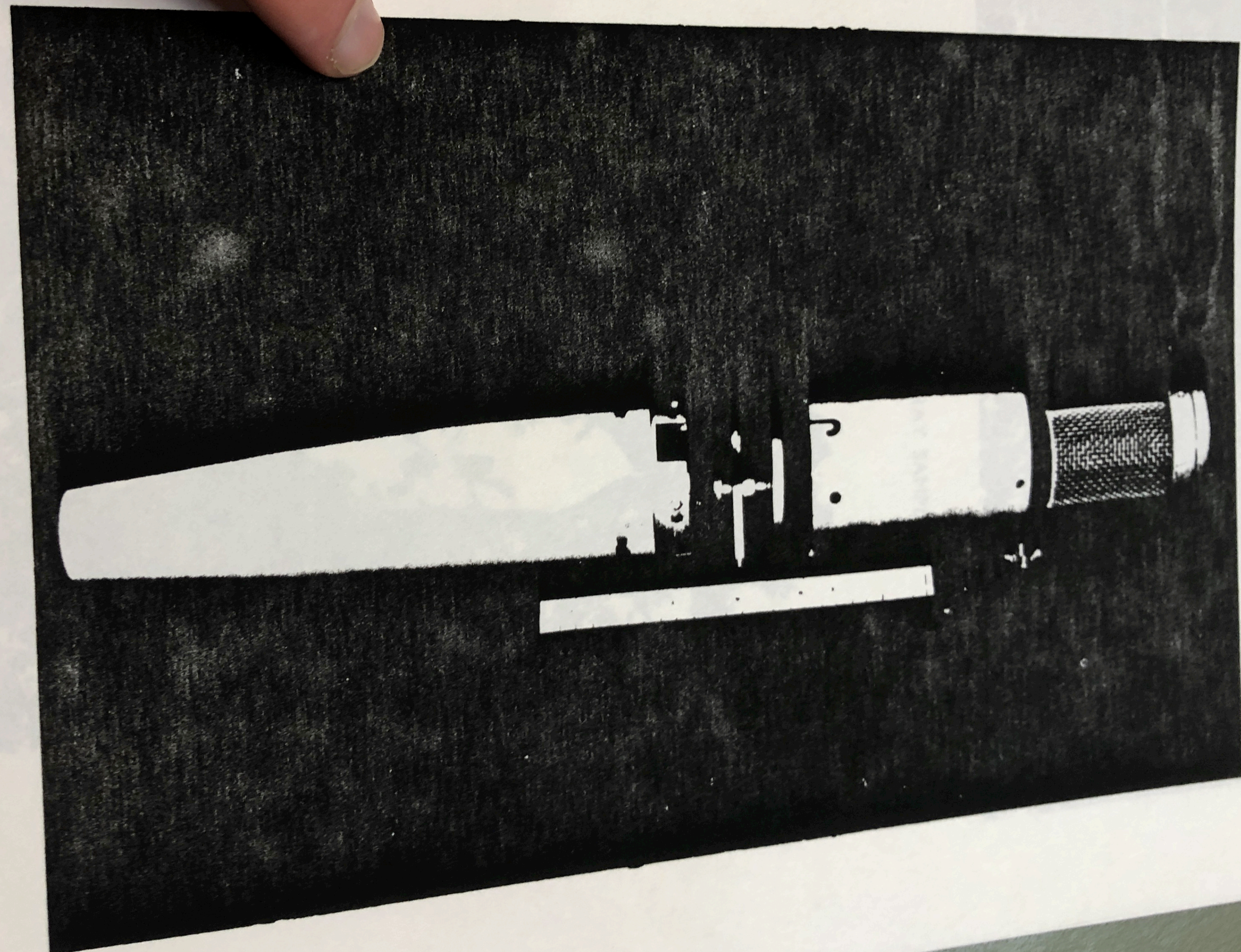


No. 3. COMPLETE WING TIP UNIT



No. 4. ATTACHMENT OF FILTER UNITS TO CANBERRA

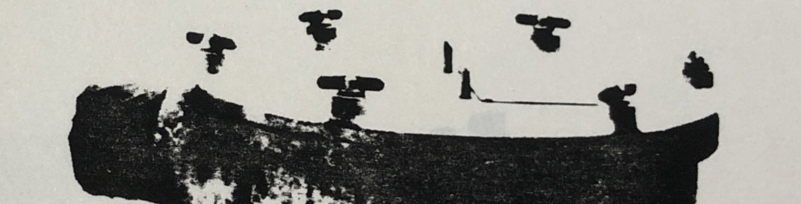
... FILTER UNIT DISMANTLED



No. 6. BORAX TRAY SAMPLING

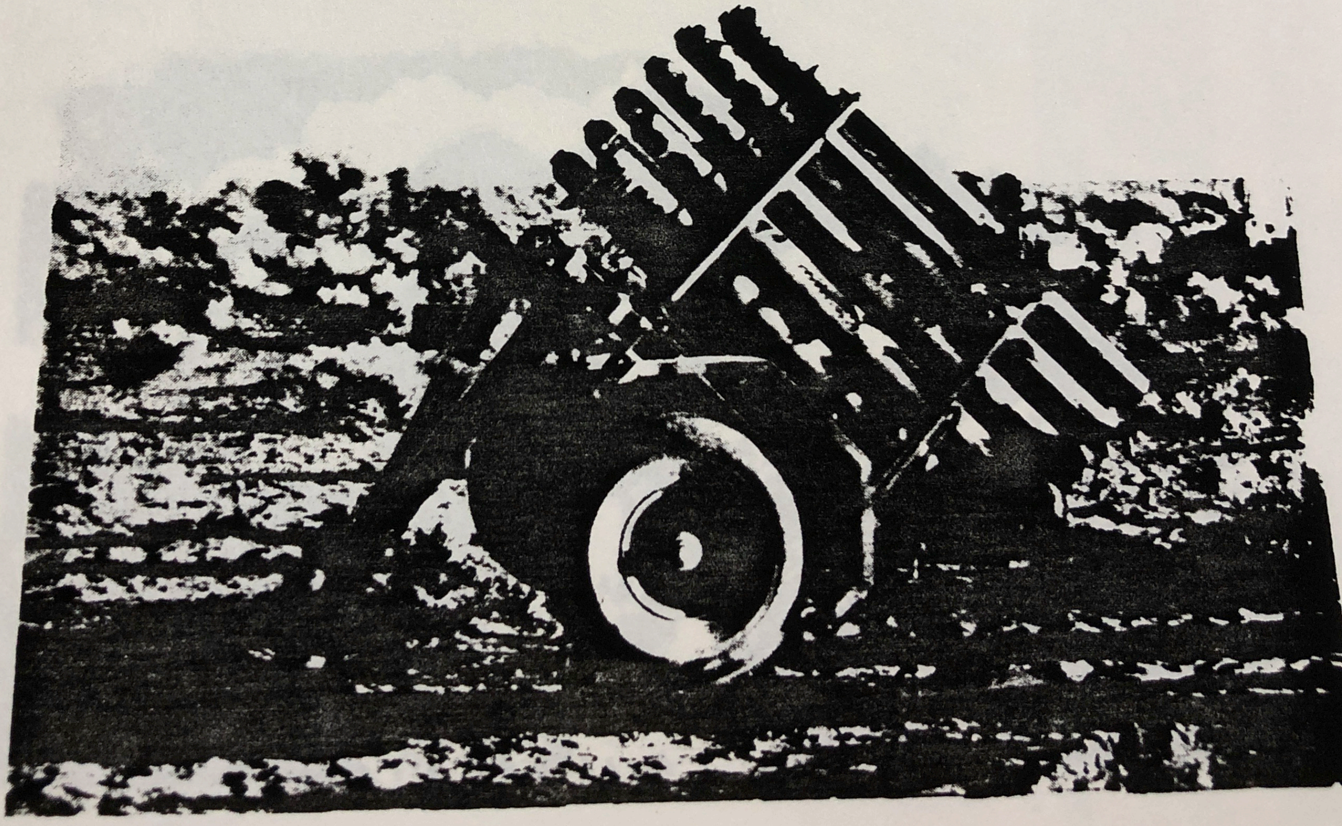
No. 7. STATIC ROCKET FILTER UNIT

No. 8. AIR INTAKE FILTER AFTER EXPLOSION (CENTURION TANK)

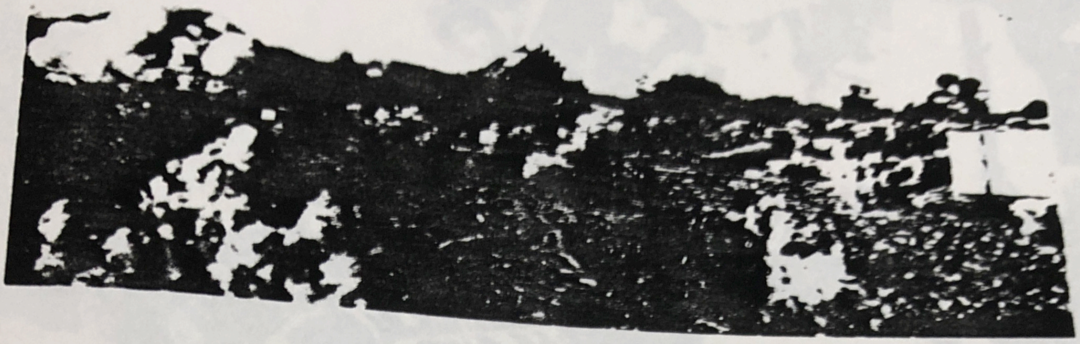


No. 9. COMPLETE CENTURION TANK FILTER UNIT

No. 10. LOADING ROCKET PROJECTOR



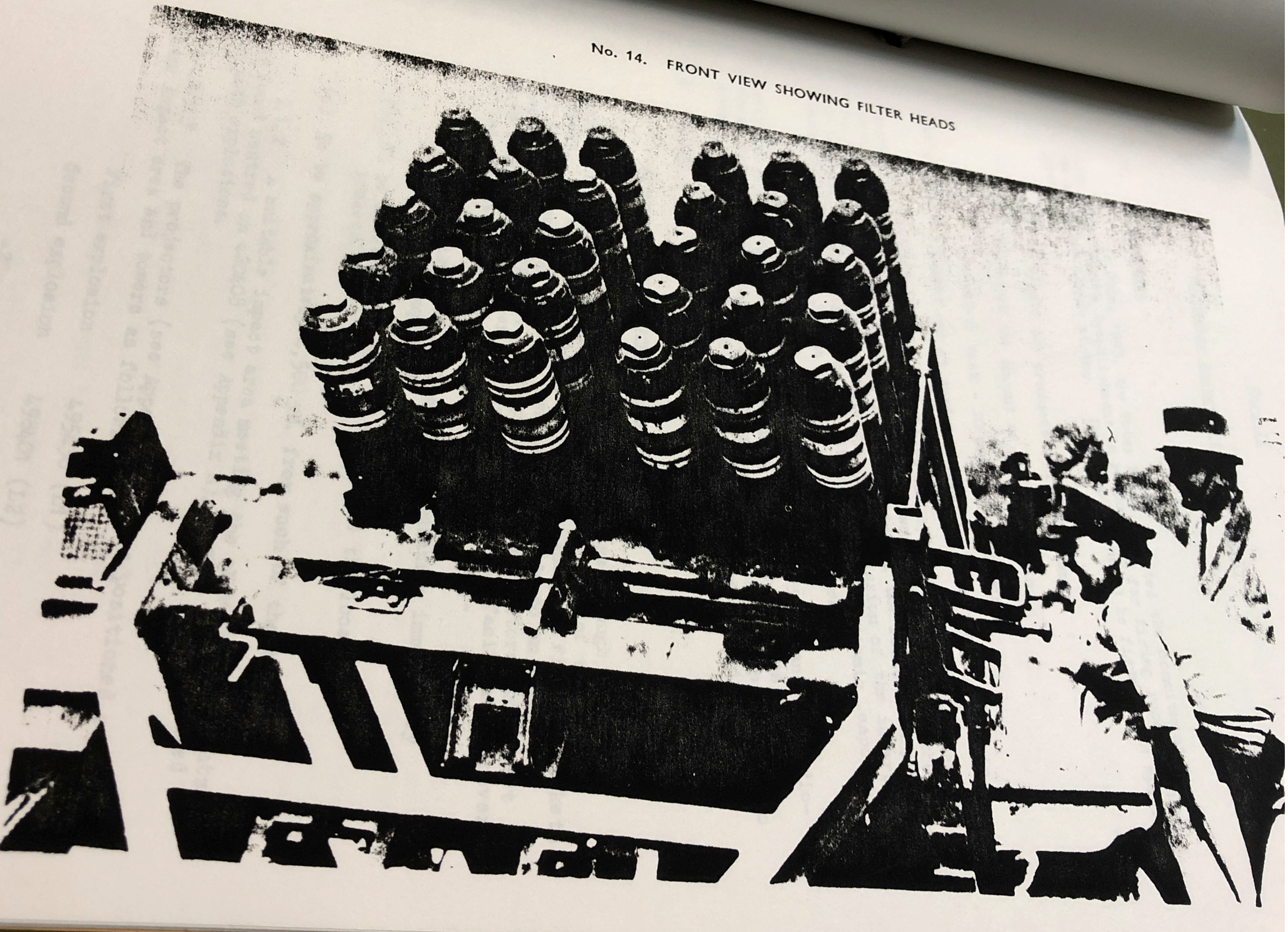
No. 11 PROJECTOR READY FOR FIRING



No. 12. PROJECTOR FIRING FIRST ROUND

No. 13. PROJECTOR AREA AT COMPLETION OF FIRING

No. 14. FRONT VIEW SHOWING FILTER HEADS



(Projector Rocket 3 in. No.8. Mk.I)

1. Introduction

1.1 In June, 1953, the Totem Panel accepted the commitment that Long Range Weapons Establishment be responsible for firing rockets through the explosion clouds at Emu. These rockets would be fitted with special inserts :-

(a) to sample the products of fission, and

(b) to record the amount of gamma radiation

(secondary task - 20 per cent of inserts)

at a specified height and at predetermined times after each explosion.

1.2 Multiple barrelled launchers and special rocket heads were provided by the United Kingdom but L.R.W.E. were responsible for the provision of rocket motors and fins, for siting of the rocket launchers and impact areas, and for the recovery and transmission of the inserts to the special laboratory which was established by the Atomic Weapons Research Establishment in the L.R.W.E., Salisbury Area.

1.3 This report includes the results of the firing and the recovery of the recovered rounds and inserts. Some comments are made concerning recovery techniques and future trials. No attempt is made to comment on the radio-chemical or radiation aspects of the trials.

2. Method

2.1 Siting of Projectors and Impact Area

2.1.1 The rockets were required to pass through the explosion clouds approximately 6,500 ft. above each of the two towers. To achieve this height, it was necessary to fire the rockets at the maximum range 7,800 yd., which corresponds to an angle of projection of 45 degrees, and to position the projectors and impact area relative to the tower used in each test. To facilitate recovery of the inserts the impact area was required to be :-

(a) An area likely to be free of contamination immediately after each explosion.

(b) To be relatively open - to facilitate the location of rockets.

(c) To be approximately 4,500 yd. from each of the towers.

2.1.2 A suitable impact area meeting the above requirements was found centred on 420408 (see Appendix A). This area was used for both explosions.

2.1.3 The projectors (see Appendix A) were positioned relativ to the impact area and towers as follows :-

First explosion	495430 (L1)
Second explosion	498401 (L2)

2.2 Firing Procedure

2.2.1 The thirty barrelled projectors (Projector Rocket 3 in. No. 8 Mk. I) had been modified in the United Kingdom to fire the thirty rockets at one sec. intervals.

2.2.2 The first explosion cloud was calculated to reach a height of 6,500 ft. in one minute.

2.2.3 The rate of ascent of the second explosion could not be predicted. It was decided that the time sequence should be the same as used in the first explosion.

2.2.4 To meet this height and time limit, the firing of the first rocket was delayed until approximately 40 sec. after the explosion. As the time of flight was 40 sec. the first rocket would reach the cloud approximately one minute after the explosion. A delay mechanism, incorporated in the rocket projector, received the firing signal from a central sequence unit (Control) at H. hr. - .8 sec. Rockets would pass approximately 6,500 ft. above the tower from H. hr. + 60 sec. until H. hr + 90 sec.

2.3 Recovery

2.3.1 The 50 per cent zone for the Projector Rockets 3 in. No. 8 Mk. I is 315 yd. in breadth and 175 yd. in length. The actual 100 per cent zone is taken as four time the 50 per cent zone so that rockets could be expected to fall in an area approximately 1,200 yd. in breadth and 700 yd. in length.

2.3.2 The effect of the turbulence of the explosion clouds on the ballistics of the rockets was not known but it was considered that if there was any effect it would be to increase the lateral dispersion and also cause the rockets to range short.

2.3.3 There was a requirement for the four best inserts, that is those with the highest gamma radiation, to be forwarded to the laboratory at Salisbury by air to arrive not later than H. hr + 10 hr. The flight time from Emu to Parafield (3 miles from Salisbury) via Woomera, of a York aircraft is approximately four hr. This meant that to meet the time requirement and based on the main explosion occurring at 0700 hr., the rounds would have to be located and the filters removed and sent to reach Emu airfield not later than 1300 hr. H. hr. + 10 hr, however, was a maximum limit and every effort was to be made to reduce it.

2.3.4 The possible spread of rounds and the stringent time factor made it essential that the location of rounds and recovery of the inserts be carried out systematically and quickly. The recovery technique was as follows :-

(a) The impact area was marked out into an area 1,000 yd. in breadth (500 yd. each side of the line of fire) and 1,300 yd. in length (1,000 yd. for Totem 2). The area was further broken up into lanes (100 - 300 yd. wide) and at right angles to the line of fire. Each lane and the line of fire was marked by a line of coloured poles.

(See diagrams of impact areas for Totem 1 and Totem 2 at Appendix B).

(b) The method of search was as follows :-

Twelve men (dressed in protective clothing, carrying hoods, respirators and flags) marched in extended line across the lane to be searched. Rockets were flagged as they were located. Other personnel travelling by vehicle slightly in rear of the search party tested the radiation of the visible portion (if any) of the rocket or the hole, and if it was of the required level left digging implements at the spot.

(c) In this way the impact area was searched until sufficient (three or four) good samples had been located.

(d) When the search was discontinued the party was divided into digging teams - two men to each rocket. A careful check was kept of the gamma radiation emanating from rounds during recovery. Respirators and hoods were worn when rounds being recovered were radio-active.

(e) When the round was removed from the hole the nose filter was unscrewed and the filter exposed. The unmasked radiation was recorded - the filter was placed first into a polythene bag and then into a lead box. Long-handled tongs, spanners and chain wrenches were provided for protection of personnel during the removal of inserts.

(f) When four samples had been obtained the lead boxes were taken to the decontamination centre A (RH) and placed in clean wooden boxes for transport to Emu Airfield and Salisbury.

2.3.5 The tails of the six motors carrying heads fitted with film inserts to record the maximum radiation of the explosion cloud were specially marked. A time limit for recovery did not apply to these inserts.

2.4 Operational Procedure

2.4.1 The projectors were emplaced at least a week before the commencement of the standby period preceding each explosion.

Note: Prior to the first dress rehearsal the cable connecting the firing circuit at the tower to the projector some 3,500 yd. distant was laid above the ground. During the afternoon and night preceding the rehearsal unscheduled vehicle movement caused seven breaks or shorts in the cable between the tower and projector. The situation was remedied, and underground 8 pair cable was laid to each projector. This also had the effect of providing a graded track direct from each tower to the associated projector.

2.4.2 Ammunition was stored in a special magazine erected in the Camp Area. Sufficient ammunition for each test was brought to the projector site at the beginning of the standby period preceding each test. (See photograph of ammunition storage at Appendix E).

2.4.3 Fitting of fins and heads and loading of the projector (firing leads were not connected until approximately H. hr - 3 hr.) took place during the afternoon of the first D-1 day occurring during the standby period.

2.4.4 The projector was not unloaded if D-1 was cancelled (as was the case in each test). Polythene cups were placed over the rear ends of the projector tubes and a tent erected over projector to protect the ammunition from the sun.

2.4.5 On the afternoon of D-1 the line and angle of projection of the projector was checked and the functioning of delay box and projector, when initiated by the firing sequence, tested.

(See photographs at Appendix E)

2.4.6 The final connections were made at approximately 0400 - 0430 hr. on D days, when the firing leads were connected and the projector set "ready to fire".

2.4.7 The projector position was then evacuated and the party returned to A (RH) - to be dressed in protective clothing in readiness for the search.

2.4.8 To obtain some idea of the fall of shot in the impact area two members of the party observed the explosions from B Site.

2.4.9 The party and the recovery team left A (RH) for the impact area at H. hr + 15 minutes. A radiation survey of the area was carried out before the search for rockets began.

2.5 Personnel

2.5.1 An Officer in Scientific Charge (Lt. Col. R.A.A.) was appointed by L.R.W.E. The team chosen in addition to the Officer in Scientific Charge were -

A Captain REME - Electrical Engineer

An Experimental Officer - Mechanical Engineer

2.5.2 A party of twelve personnel (1 W O and 11 O R's) was obtained from X. 200 Force for search and recovery of rounds.

2.5.3 The Officer in Scientific Charge was responsible to the Head of the Radio Chemistry Team, AWRE, who was a member of the U.K. Scientific Staff at Emu.

3. Trial Results

3.1 Totem 1 - 15th October, 1953

3.1.1 All the rockets were fired from the projector and fell in the impact area (see Fall of Shot at Appendix C). There were no misfires. Normal meterological conditions affecting the ballistics of the rockets at time of firing (H. hr.) were -

Barometer (station height)	29.06 in.
Temperature	48°F.
Surface wind 0 - 1,000 ft.	3 knots from 267°
Upper wind 7,000 ft.	26 knots from 217°

The effect of these conditions on rocket flight is to place the MPI 250 yd. short. No line error was predicted or obtained.

3.1.2 Deducting the normal meteor and comparing actual fall of rockets with range table performance leaves a range discrepancy of 100 yd. This discrepancy is negligible and is probably caused by the slight variation of the nose filter from the contours of the fuse fitted to the normal rocket head. The same discrepancy was also observed during two practice series, each of six rounds, which were fired at L.R.W.E. Range, Woomera, and the rehearsal firing of twelve rounds at Emu prior to the first explosion.

3.1.3 The rocket recovery party left A (RH) at H.+ 30 minutes. (0730). The survey of the impact area for contamination took approximately 15 minutes. No contamination was recorded.

3.1.4 The search for rockets began at approximately 0745 hr.

3.1.5 Twenty-three (23) of the thirty (30) rockets were located by 0845 hr. As sufficient rockets had been located the search was discontinued.

Note: Six (6) of the remaining seven (7) rounds were found at a later date in the next search zone. If the search had been continued on D + 1 day 29 out of 30 rockets would have been located in approximately 90 minutes.

3.1.6 Each rocket was tested for gamma radiation as it was located. Initial radiation measurements of the selected rounds are shown at Appendix C, Table 1. Note that some of these measurements were made on the visible tail of buried rockets. The remaining rockets (less those mentioned in Paragraph 3.1.11) were either buried or produced little or no radiation.

3.1.7 Four good samples were selected and the digging out of these rockets and removal of the inserts commenced at 0900 hr.

3.1.8 Radiation measurements of the four recovered filters are also shown in Appendix C, Table 1.

3.1.9 The samples were despatched from the impact area to A (RH) at approximately 1000 hr. for on movement to Emu Airfield.

3.1.10 The special York aircraft departed from Emu Airfield at 1042 hr. The samples were received in the laboratory at Salisbury at 1415 hr, i.e. nearly 3 hr. within the time limit.

3.1.11 Four of the six rounds containing film inserts were recovered on 22nd October, 1953.

3.2 Totem 2 - 27th October, 1953

3.2.1 29 out of the 30 rockets were fired from the projector and fell in the impact area, (see Fall of Shot at Appendix D). There was one misfire.

3.2.1 The meteorological conditions at the time of firing were -

Barometer (station height)	29.05 in.
Temperature	65°F.
Surface wind 0 - 1,000 ft.	NW gusting to 20 knots (approximately)
Upper wind	24 knots from NW (approximately)

The effect of these conditions and the fuse factor (see Paragraph 3.1.2) on rocket flight is to place the MPI 50 yd. short and to the right of the predicted line of fire.

3.2.3 The rocket recovery party left A (RH) at H. + 15 minutes. The survey of the impact area for contamination was completed in approximately 15 minutes. No area contamination was recorded.

3.2.4 Twenty-six of the twenty-nine rockets fired were located by 0930 hr.

3.1.5 Only one rocket-tail produced any radiation and that of only 1 milli-roentgen.

3.2.6 Six rockets were recovered and inserts removed, but all inserts failed to provide a reading on the radiation meter. These inserts were not despatched to Salisbury.

3.2.7 A post-mortem with the meteorological team confirmed the fact that the explosion cloud rose faster than did the first explosion. The strong cross wind (cross wind to the rocket line of fire) had also carried the narrow stalk of the explosion cloud away from the line of fire by the time the first rocket reached the sampling area at H.hr + 1 minute (approximately).

3.2.8 The cause of the one misfire is unknown. The motors had been reconditioned in March, 1953. In addition, the continuity and the resistance of all the igniters was checked with a Safety Ohmmeter after the rounds had been loaded into the Projector. This was the only misfire experienced in the firing of a total of 90 rounds.

4. Conclusions

4.1 Range table performance was achieved and normal grouping around the predicted mean point of impact obtained.

4.2 Good samples of the explosion cloud of Totem 1 were obtained due to the reliability of the forecast rate of ascent of the explosion cloud.

4.3 The lack of samples in Totem 2 were due to -

4.3.1 Inability to forecast the rate of ascent of the explosion cloud.

4.3.2 The prevailing meteorological conditions at the time of firing.

4.4 The method of search and recovery of inserts after both explosions was quick and effective.

4.5 Protective clothing, without respirators, was comfortable for marches of 3 - 4 miles.

4.6 Heavy manual labour was carried out by personnel clad in protective clothing and using respirators without undue discomfort. (The heavy manual labour consisted of digging the equivalent of slit trenches 6 ft. × 2 ft. 6 in. × 5 ft. deep, using crowbars, picks and shovels. The only complaint received concerned the heavy rubber gloves and the normal discomfort felt when carrying out manual labour in respirators).

4.7 The size of the L.R.W.E. team was found to be adequate for the task, although personnel were of greater seniority than the task warranted.

4.8 The size of the search and recovery party was found to be adequate for the task.

5. Future Trials

5.1 The Use of Rockets

5.1.1 The use of multi-barrelled projectors at the Monte Bello and Woomera trials has shown that this form of cloud sampling is effective if the rate of rise of the cloud is known, and the meteorological conditions are favourable. However, the system is rigid and allows no flexibility once the experiment has been formulated, the projector sited and firing sequence arranged.

5.1.2 If this type of projector and rocket head are used again, it is suggested that :-

(a) More than one projector be used and the explosion be sampled over a period after initiation and at more than one height. (Other projectors could be sited to cover lower heights above a tower and still fire rockets into a clean area).

(b) A facility be incorporated in the control system to allow rockets to be fired by a remote manual control if the rate of rise of the explosion cloud differs from that predicted.

5.1.3 Consideration be given to the use of a larger rocket containing more complex equipment to sample, say temperature, alpha beta and gamma radiation, etc. It should be possible to blow the nose off such a projectile in flight and so decrease the stability and velocity of the projectile and allow a parachute to be ejected. (This technique has been used with success by L.R.W.E.). The projectile could sample the cloud over a relatively longer period and still have sufficient forward velocity to fall in a clean area.

5.2 The Use of Radio Controlled Pilotless Aircraft

5.2.1 Radio controlled pilotless aircraft like Jindivik have many advantages over the use of rockets for such a task in that -

(a) Aircraft when airborne are flexible and can be directed at will.

(b) There is no recovery problem. A landing on a runway or claypan "dump strip" can be made with ground or air control.

(c) Filters and other recording gear could be carried in wing tip pods or within the fuselage.

(d) Telemetry equipment can be carried and/or the means by remote control for unmasking filters to differentiate between samples made on different runs.

6. Miscellaneous Suggestions

6.1 Protective Dress

6.1.1 Some means of identification be provided for personnel clad in protective dress and wearing hoods and respirators. Control over personnel under these conditions is very difficult. It is suggested that some external name tag be provided and in addition Officers, NCO's and men be distinguished by a change in colour or form of some garment.

6.1.2 External pockets for pencils and maps be provided. The pockets for dosimeters are inadequate for any other gear.

6.1.3 Some means of improving rubber gloves be investigated, such as the provision of sweat absorbent under-gloves of wool or si

[redacted]

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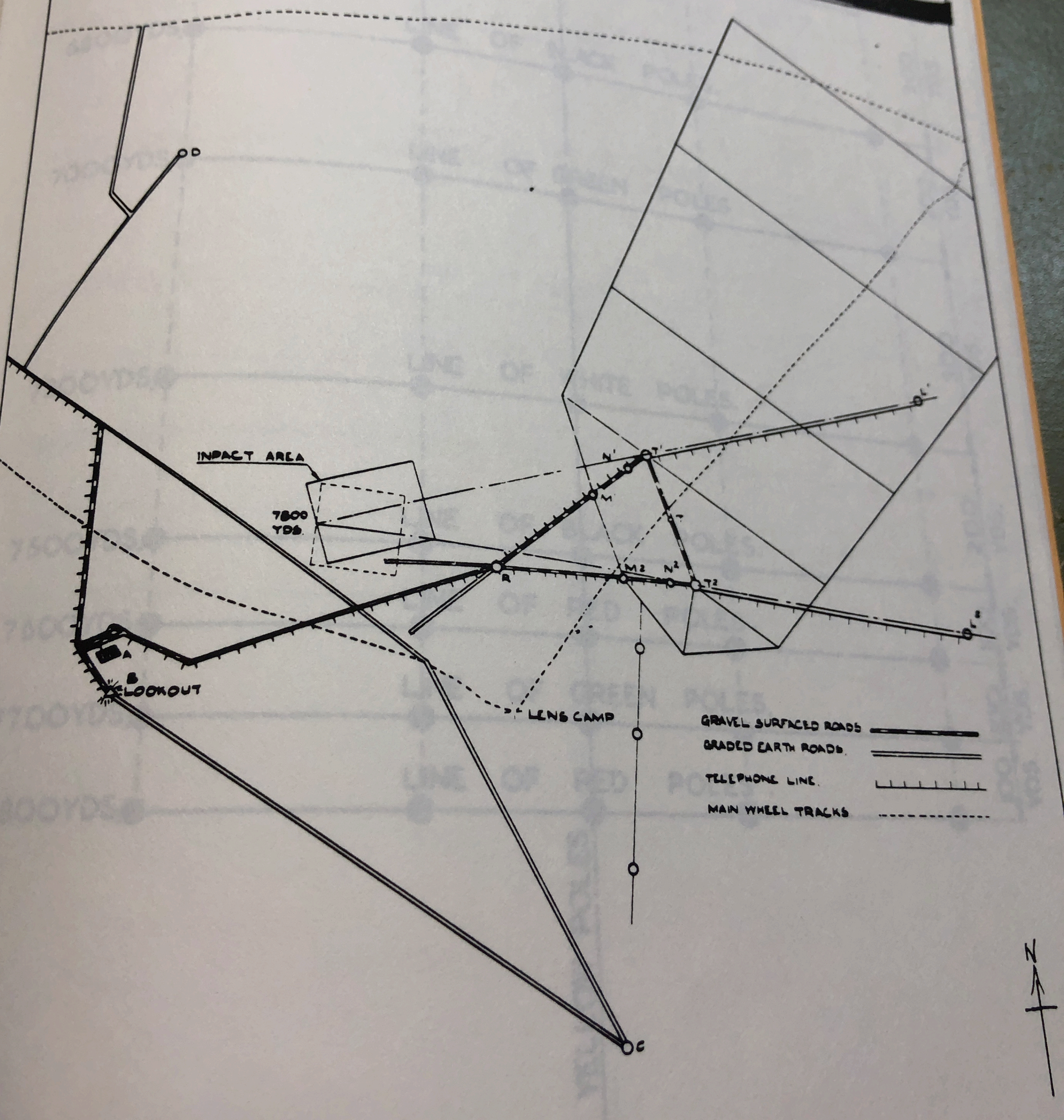
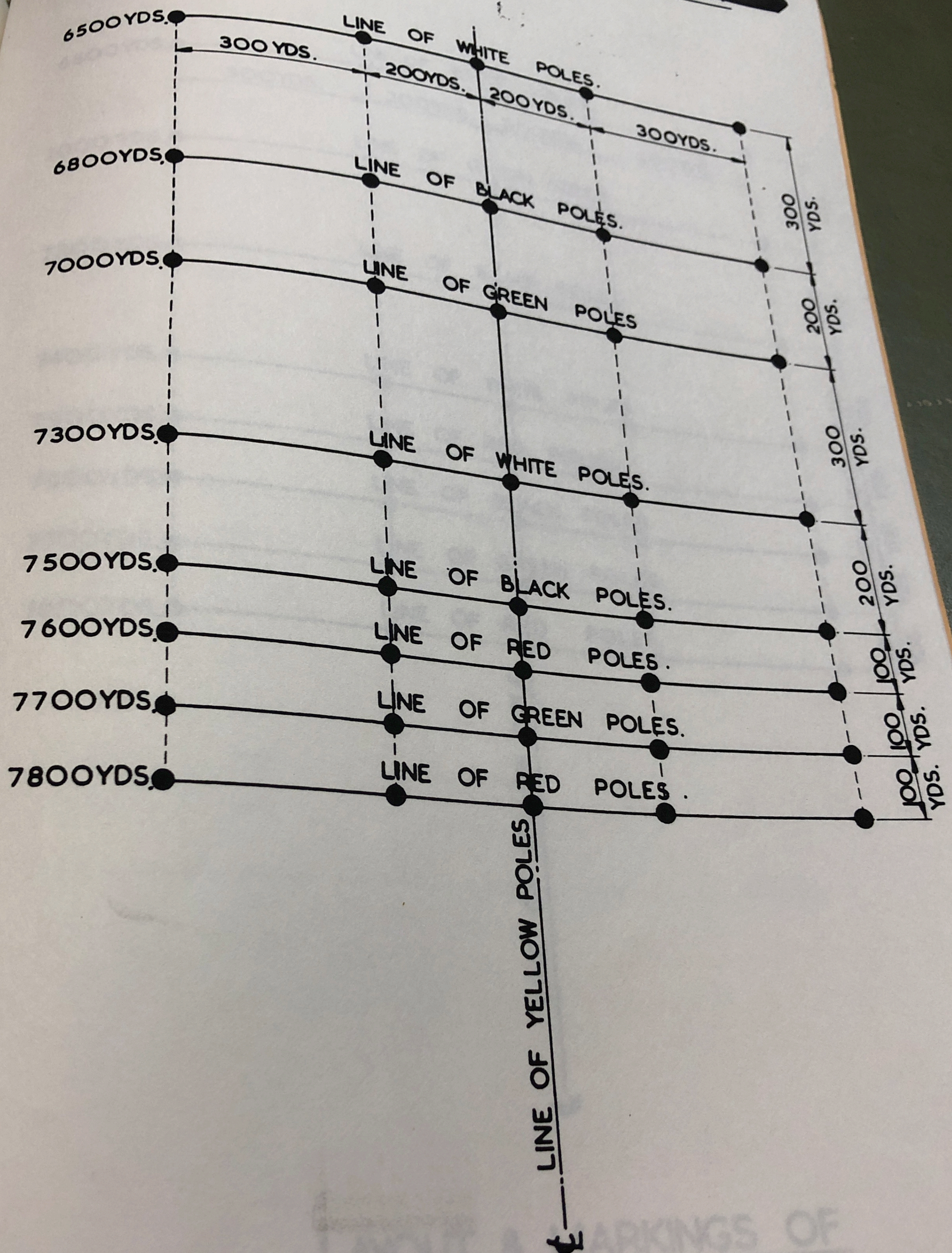
APPENDIX A

[redacted]

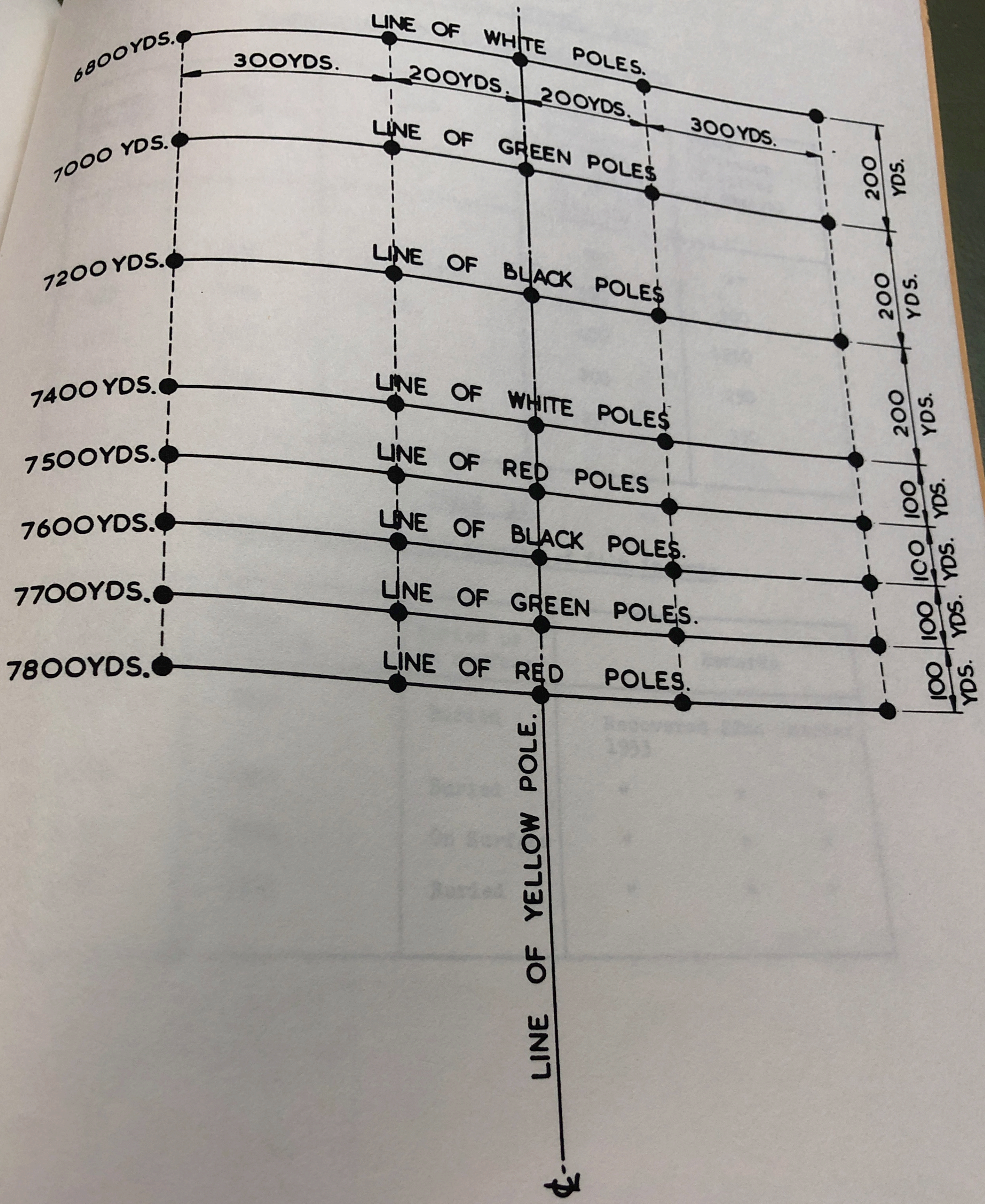


X. B1.

[redacted]



LAYOUT & MARKINGS OF IMPACT AREA FOR TOTEM ONE



LAYOUT & MARKINGS OF IMPACT AREA FOR TOTEM TWO.

TABLE I

TOTEM ONE - 15th OCTOBER, 1953

Rounds recovered for removal of inserts

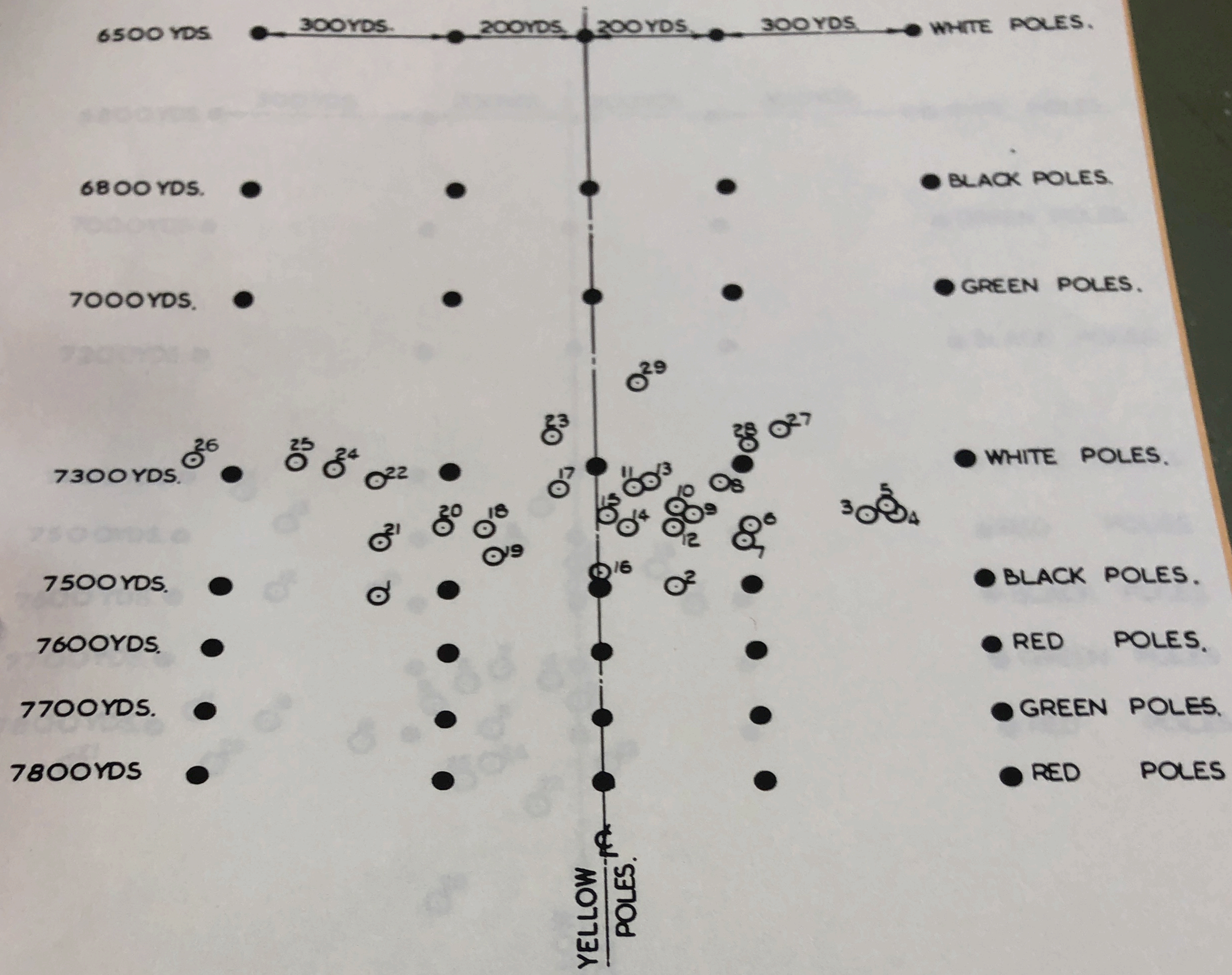
Round Number	Range in yards	Found	Gamma Radiation of Round on Surface or of visible tail	Gamma Radiation of Filter on removal
			mr	mr
1/1	7403	On Surface	300	900
1/3	7505	Buried	400	1250
1/10	7318	"	200	290
1/14	7415	"	290	350

TABLE II

Rounds recovered for removal of film inserts

Round Number	Range in yards	Buried or on Surface	Remarks
1/6	7240	Buried	Recovered 22nd October, 1953
1/12	7385	Buried	" " "
1/24	7390	On Surface	" " "
1/30	7295	Buried	" " "

APPENDIX C. [redacted]



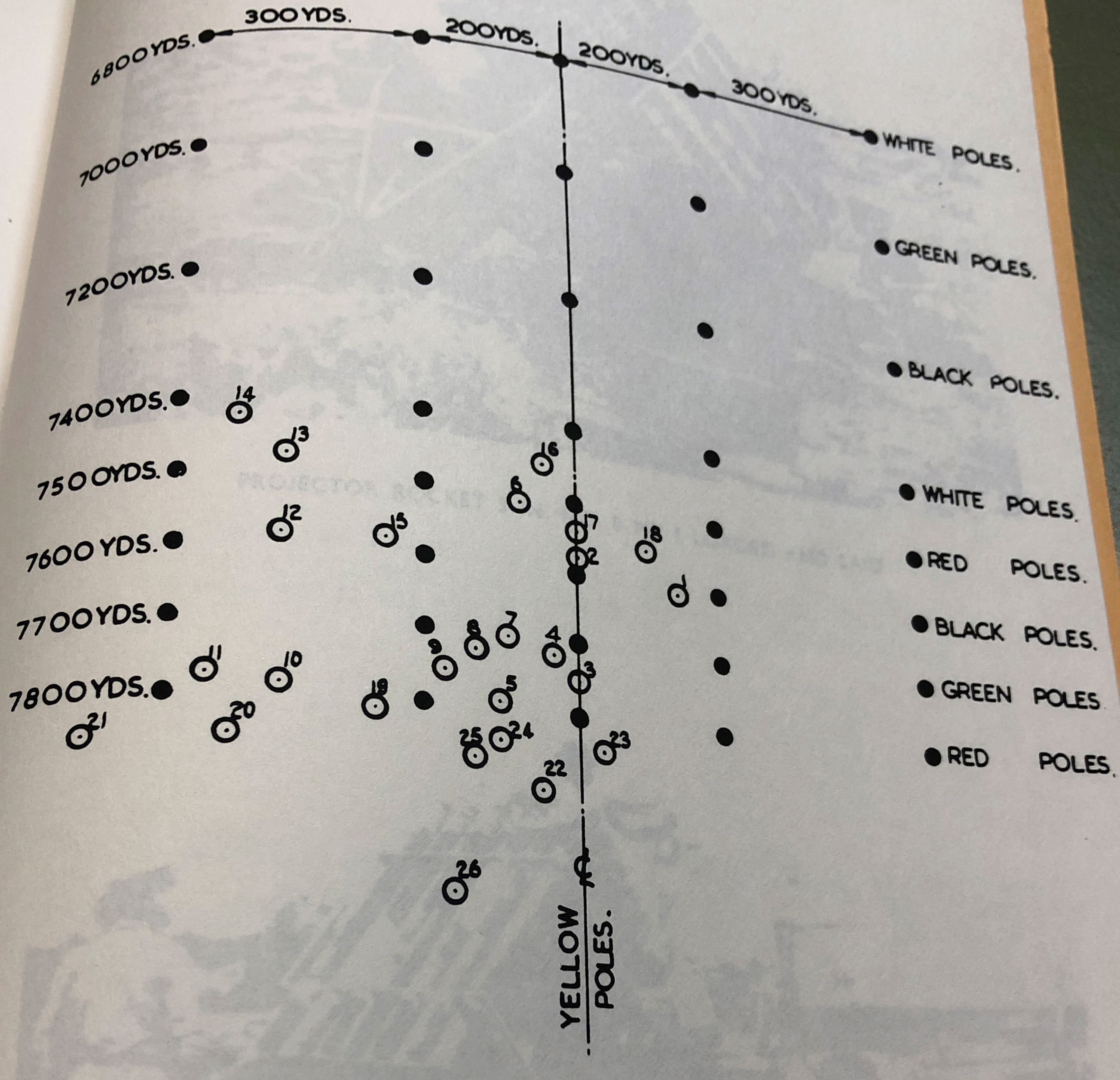
NOTE:- NOS. ABOVE REFER TO SEQUENCE OF RECOVERY.

ROUNDS DESPATCHED.	
AS RECOVERED	ROUND Nº
1	1/3.
6	1/1.
21	1/14.
22	1/10.
PHOTO SAMPLES.	
3	1/24.
15	1/12.
24	1/30.
27	1/6.

IMPACT AREA CHART & GROUPING FOR TOTEM ONE.

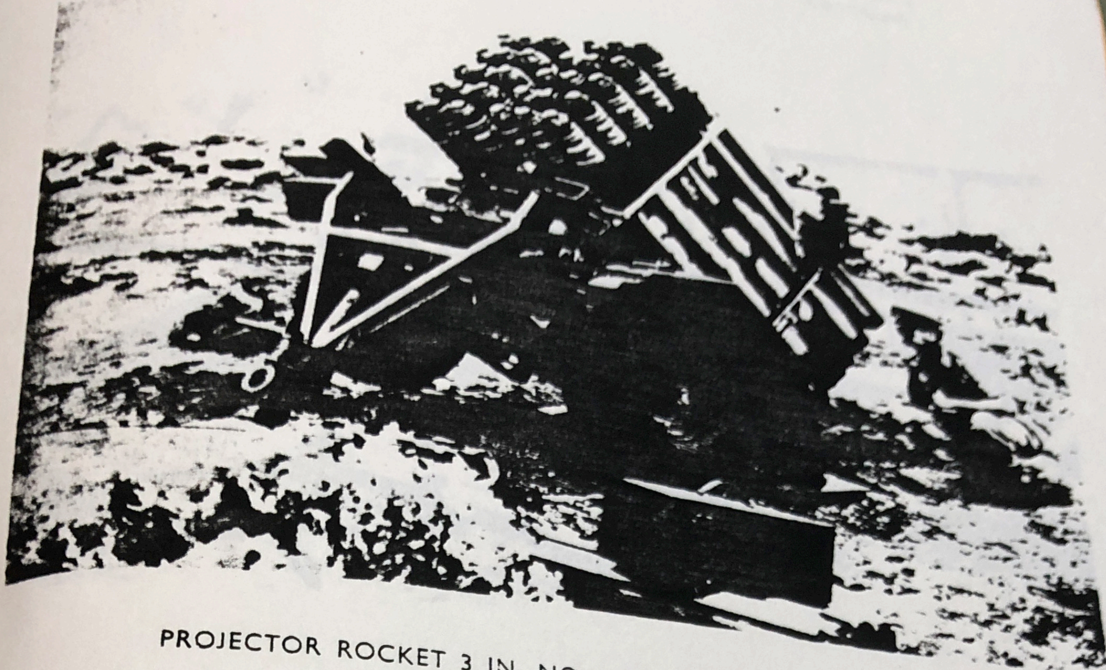
APPENDIX D.

[redacted]

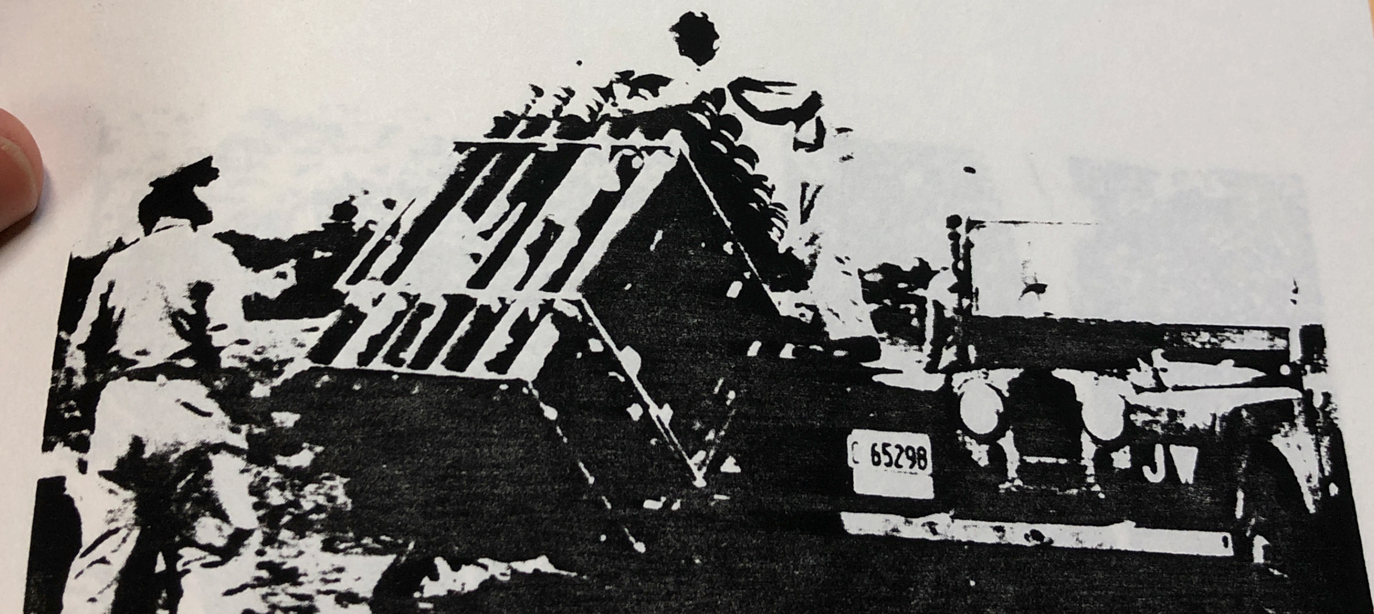


NOTE:- NOS. ABOVE REFER TO SEQUENCE OF RECOVERY.

IMPACT AREA CHART & GROUPING FOR TOTEM TWO.

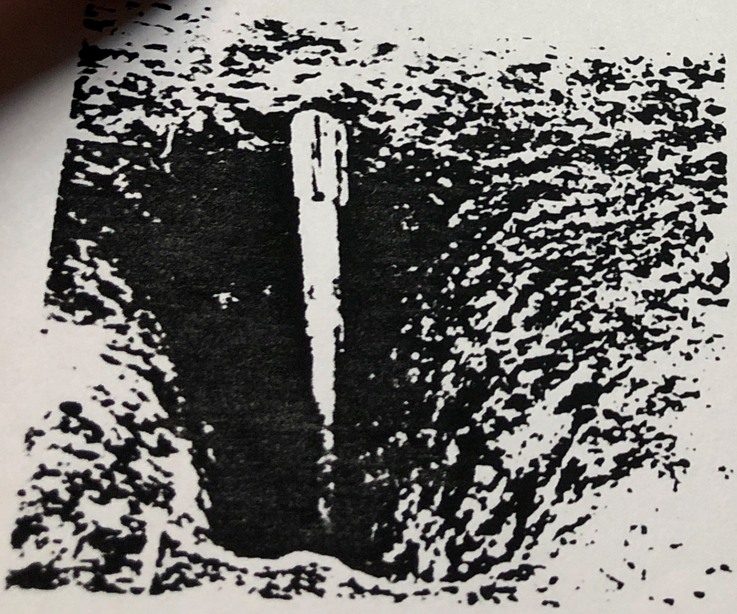


PROJECTOR ROCKET 3 IN. NO. 8 MK I LOADED AND LAID

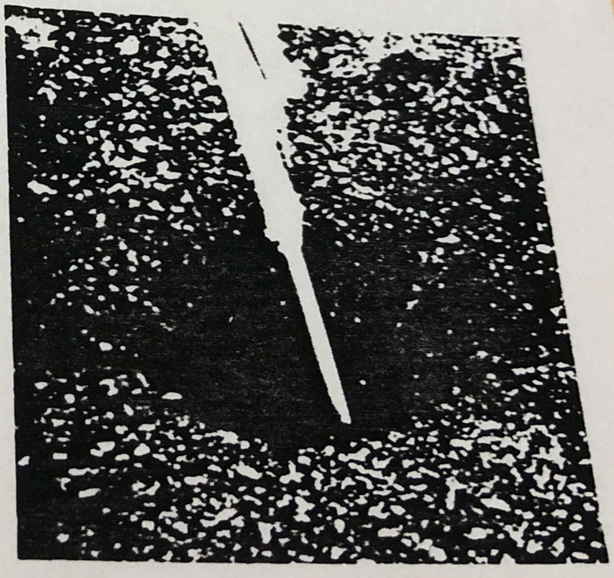


CHECKING THE ANGLE OF PROJECTION OF ROCKET LAUNCHER

TEMPORARY AMMUNITION STORAGE AT A PROJECTOR SITE. (NOTE THE ROCKET MOTORS IN CASES IN THE TENT.) HEADS AND FINS WERE FITTED ON D - 1 DAY.



ROCKET UNEARTHED BEFORE REMOVAL.



HOLE MADE BY ROCKET. APPROXIMATE SIZE OF TOP OF HOLE 18 INCHES IN DIAMETER.