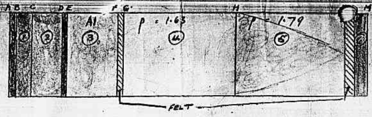
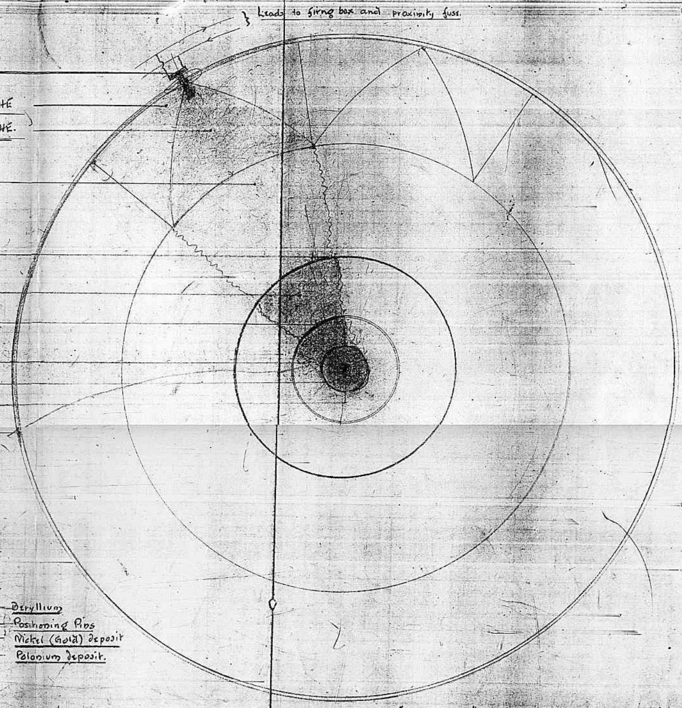


RADII

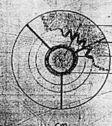
	μ = 1·45	μ = 1·50	μ = 1·513	μ = 1·55
AB	0·4"	SAME		
AC	1·8"			
AD	4·5"			
AE	4·6"			
AF	9·0"			
AG	9·25"			
AH	18·66"			
AK	27·92"	27·301"	27·165"	26·780"
AL	28·17"	27·551"	27·415"	27·030"
AM	28·67"	28·051"	27·915"	27·530"

WEIGHT (LBS)

	μ = 1·45	μ = 1·50	μ = 1·513	μ = 1·66
①	17	SAME		
②	241			
③	257			
④	1405			
⑤	4138	3740	3672	3444
⑥	493	472	467	455
TOTAL	6660	6132	6059	5819



INITIATOR



$Be^{9}(\alpha n)\ C^{12}$

$Be^{9} + He^{4} = C^{12} + n$

PLUTONIUM WEAPON - GENERAL DESCRIPTION.

INTRODUCTION.

The following general description of the plutonium weapon has been compiled with the object of anticipating difficulties in experimentation, design, and manufacture, so that the programme of development may run concurrently.

Of necessity, the description can only give an overall picture and does not profess scientific or technical detail.

COMPONENTS OF THE WEAPON.

2. The components may be divided into seven separate assemblies consisting of:-

(a) The imploder system.

(b) The plutonium core.

(c) The initiator.

(d) The casing of the explosive assembly.

(e) The detonator firing mechanism.

(f) The proximity fusing device.

(g) The ballistic outer casing.

Although the imploder system is shewn above as one assembly, it is, in fact, a multiple assembly having the following components:-

(a) The detonators.

(b) The outer composite H.E. shell.

(c) The inner homogeneous H.E. shell.

(d) The aluminium inner liner.

(e) The boron 10 shield.

(f) The uranium 238 tamper.

In addition to these components, there is also a thin felt washer between the homogeneous explosive and the aluminium liner in order to take up manufacturing inaccuracies.

3. The main object of this somewhat complicated imploder system is to ensure that the detonation waves initiated by the detonators arrive at the main plutonium core as one concentric converging shock wave, withot 'jets'.

~~xxxxxxxes~~.

4. A sectional schematic drawing approximately to scale is attached and each component is briefly described in the appendices listed below:-

Appendix 'A'.	The Detonator System.
Appendix 'B'.	The Outer Composite H.E. Shell.
Appendix 'C'.	The Inner H.E. Shell.
Appendix 'D'.	The Aluminium Liner.
Appendix 'E'.	The Boron 10 Shield.
Appendix 'F'.	The Uranium 238 Liner.
Appendix 'G'.	The Plutonium Core.
Appendix 'H'.	The Initiator.
Appendix 'I'.	The Casing and Explosive Assembly.
Appendix 'J'.	Firing Mechanism and Proximity Fusing Device.
Appendix 'K'.	The Ballistic Outer Casing.
Appendix 'L'.	The Arming Plug.
Appendix 'M'.	Tabulated Notes prepared by Dr. Tuck.

5. Although production of plutonium cores must be on a limited scale in the first instance, consideration must be given to the total number of bombs likely to be required as this may affect manufacturing processes of components, i.e. a limited number hand-made or in sufficient number to justify special presses, moulds, etc.

THE DETONATOR SYSTEM.

INITIATION OF DETONATION.

There are 32 points of initiation of detonation round the surface of the H.E. outer shell. Each detonator is in fact a twin system to ensure against failure.

DESCRIPTION.

2. Each detonator is of the "fuse-bridge" type, the wire bridge being imbedded in a small quantity of PETN (Pentolite) and having a tetryl booster.

STANDARD OF ACCURACY.

3. The whole detonator system from bridge to booster must be accurate to within 0.2 microseconds to ensure subsequent concentricity of the detonation wave.

MANUFACTURING PROBLEMS.

4. The main manufacturing problems are the consistency of the pentolite and tetryl as well as the characteristics of the bridge to ensure this high order of timing accuracy.

DISCUSSION.

5. When facilities are complete, C.S.A.R. will be able to undertake all research, experimentation, design and production.

QUESTIONS AS AT 1.7.1947.

6. Nil, pending further progress with preliminary research.

APPENDIX 'B'.

THE OUTER COMPOSITE H.E. SHELL.

OBJECT.

A detonation wave initiated in a H.E. progresses spherically outwards, but as it is essential for the implosion wave to arrive as a convergent sphere, some mechanical means is required to convert the former type into the latter, and this is the main function of the outer H.E. shell.

DESCRIPTION.

2. The shell consists of 20 hexagonal and 12 pentagonal uncased H.E. lenses, each being a truncated pyramid about 8" high, and having an external radius of about 27".

3. Each lens comprises a composite filling, the outer being 60/40 RDX/TNT having a relatively high rate of detonation, and the inner being BARON~~AL~~TOL having a slower rate of detonation. Other explosives may be used as the result of experimentation.

4. The shape and size of the inner cavity, which contains the Baronal, is governed by the relative rates of detonation as it is in this assembly that the conversion mentioned in paragraph 1 above is effected.

5. Pockets to accommodate the detonators are provided on the outer surface of the sphere, their relative positions being determined by the need for symmetrical initiation.

DESIGN AND MANUFACTURING PROBLEMS.

6. (a) Developing the technique of producing consistent RDX/TNT, and Baronal, or other similar explosives.

   (b) Accurate determination of rates of detonation of the intended explosives.

   (c) Size and shape of the cavity containing the slower explosive.

   (d) The method of pressing the fast explosive in the first instance, and then the slow explosive into the cavity to obtain consistency of detonation and avoidance of jet action.

   (e) Accurate shaping of the sections to ensure face-contact.

Associated Problems.

7. (a) Variations in temperature during storage or carriage affect the density of explosive and thus vary the rate of detonation.

   (b) Design of containers for transport so that the sections do not become chipped, flaked, cracked, or distorted.

DISCUSSION. /

DISCUSSION.

8. When facilities are complete, C.S.A.R. will be able to undertake all research, experimentation, design and production.

QUESTIONS AS AT 1.7.1947.

9. Nil, pending further research.

THE INNER H.E. SHELL.

OBJECT.

To produce the initial implosive effect on to the main core.

2. As the detonation wave is initiated over the whole outer surface of this component through the medium of the outer shell, it will travel through the inner shell as a convergent wave.

DESCRIPTION.

3. The shell is composed of segments approximately 9" thick of RDX/TNT.

DESIGN AND MANUFACTURING PROBLEMS.

4. As with the outer shell, consistency throughout this component is essential as is the flush fitting of all faces.

Note. On the inner face of this component is a felt lining approximately 0.15" thick; the object is to take up manufacturing irregularities but as it is a minor component, a separate appendix is not justified.

DISCUSSION.

5. When facilities are complete, C.S.A.R. will be able to undertake all research, experimentation, design and production.

QUESTIONS AS AT 1.7.1947.

6. Nil, pending further research.

THE ALUMINIUM LINER.

OBJECT.

The main object of this liner is to smooth out any irregularities or jet proclivities in the convergent detonation wave.

DESCRIPTION.

2. It is a hollow sphere about 4½" thick.

DESIGN AND MANUFACTURING PROBLEMS.

3. The manufacture of this component is relatively simple. It will probably be made in two hemispheres screwed together but the faces at the joints must be flush.

DISCUSSION.

4. C.S.A.R. would be able to produce this component within his resources, but, in order to relieve his workshops of unnecessary work, it may be advisable to put this component to the trade.

QUESTIONS AS AT 1.7.1947.

5. If only limited numbers are required, they could be turned out from the solid, but, if otherwise, pressings or moulds will be necessary. What should be the policy in this respect?

BORON 10 LINER.

OBJECT.

To prevent "rogue" neutrons from outside sources entering the core and initiator assemblies.

DESCRIPTION.

2. Consists of a hollow sphere having a thickness of approximately 0.125".

DESIGN AND MANUFACTURING PROBLEMS.

3. Nil.

DISCUSSION.

4. In view of the limited numbers required, it may be unnecessary to g to the expense of making dies for this pressing; therefore, hand manufacture may be preferable.

5. It may be advisable to give this work to the trade.

QUESTIONS AS AT 1.7.1947.

(2) 6. Opinion seems to be divided on the necessity for this component; therefore, is further research required to establish the need?

(2) 7. If found necessary, are any special measures required in connection with boron chemistry, extraction and manufacture?

THE URANIUM 238 LINER.

OBJECT.

The object of this liner is fourfold:-

(A) To convert the detonation shock wave into an impulse.

(B) To smooth out any remaining irregularities in the wave.

(C) To act as a reflector of neutrons during fission.

(D) To act as a "container" to the plutonium during fission and thus prevent premature disruption of the plutonium core.

DESCRIPTION.

2. A hollow sphere having a thickness of approximately $2\frac{1}{2}$".

DESIGN AND MANUFACTURING PROBLEMS.

3. In all probability this shell would be made in two hemispheres and no manufacturing difficulties are anticipated except possibly the means of fastening them together.

DISCUSSION.

4. C.S.A.R. could undertake the manufacture of this component.

QUESTIONS AS AT 1.7.1947.

5. According to the numbers required, should the liner be handmade or will pressings be necessary?

APPENDIX 'G'.

THE PLUTONIUM CORE.

OBJECT.

The main fissile material.

DESCRIPTION.

2. The core consists of a hollow sphere approximately 2" thick of a plutonium/gallium alloy. The proportion of gallium is of the order of 3 atoms per cent.

DESIGN AND MANUFACTURING PROBLEMS.

3. Very little is known concerning plutonium chemistry in this country nor the machining or processing of the element.

4. It is believed that the method of manufacture of the hollow hemispheres was ~~done~~ by hot pressing; but the method of finishing the inner faces and bolting the hemispheres together is uncertain.

5. Appropriate precautions against radioactivity will have to be taken throughout manufacture.

Associated Problems.

6. Suitable containers for storage and transport.

DISCUSSION.

7. No facilities exist for the handling or fashioning of plutonium; nor has a technique been developed in this country.

8. The question arises where a plutonium workshop should be erected. The alternatives are at Springfield, Harwell, or within C.S.A.R.'s organisation. There are advantages or disadvantages on each of these alternatives, but, whichever be selected, early consideration must be given to the design and erection of the plant and to getting the appropriate nucleus of the staff considering the problem.

9. The team engaged on manufacture of this item must have developed their processes to a high order of perfection by the time plutonium is available in adequate quantity; therefore, early consideration must be given to this problem.

QUESTIONS AS AT 1.7.1947.

10. What facilities are required for research into and final production of this component?

11. Where should they be located?

12. Have we the competent staff within our resources or will it be necessary

THE INITIATOR.

OBJECT.

To ensure the release of sufficient neutrons to initiate fission, by the admixture of Beryllium and Polonium.

DESCRIPTION.

2. The initiator consists of two main components.

3. The outer component is a hollow beryllium sphere 1 cm. diameter having the inner face serrated by four-sided 60° pyramids.

4. Inside this cone is another sphere of beryllium which is centred by means of radial pins projecting internally from the outer shell.

5. Both the inner serrated surface of the outer shell and the surface of the inner sphere are coated with nickel or gold, or possibly both. On top of the nickel deposit of the inner sphere a film of polonium is deposited. Thus, the nickel deposit acts as an "insulator" to prevent neutron reaction between the beryllium and polonium until the appropriate time.

6. The serrations on the inner surface convert the shock wave into a multitude of jet actions which thus ensure complete shattering and mixture of the two elements, thus causing neutron emission.

DESIGN AND MANUFACTURING PROBLEMS.

7. The main difficulty is our lack of knowledge of polonium chemistry and considerable research will no doubt be required on this aspect of the project.

8. As with the other assemblies, the method of the manufacture of the beryllium outer shell and bolting the two hemispheres together requires development.

DISCUSSION.

9. The design and manufacture of this component also calls for techniques new to this country. It is estimated that a nucleus staff of one engineer and a chemist will require a year deliberating on the problem before they could start to tackle it.

10. In addition, plant will be required for the fabrication and this should be ordered in good time.

11. The location of the plant is also debatable, the alternatives being

similar to that for the plutonium core.

QUESTIONS AS AT 1.7.1947.

12. What facilities are required for research into and final production of this component?

13. Where should they be located?

14. Have we the competent staff within our resources or will it be necessary to recruit from outside?

Important footnote.

The half life of the initiator is approximately six months; therefore, replacements will have to be continuously provided.

APPENDIX 'I'.

THE CASING FOR EXPLOSIVE ASSEMBLY.

OBJECT.

The object of this component is to hold the whole explosive and fissile assembly solidly together.

DESIGN AND MANUFACTURING PROBLEMS.

2. Little is known concerning the method used in previous models, but, in all probability, it consists of the aluminium shell about $\frac{3}{8}$" thick having separate polar caps and equatorial sections. The various sections would be bolted together as assembly of the bomb progresses.

3. As some mention has been made in various reports concerning the effect of temperature changes during flight, it is questionable whether internal or external lagging should be incorporated to prevent heat loss.

4. Owing to the difficulty of ensuring that the holes in this casing for the detonators coincide with the detonator sockets of the lenses, enlarged holes in the former must be provided with "floating seals", having holes of the right size, superimposed.

5. Owing to the limited number of weapons envisaged, it is questionable whether the cost of making presses for this casing would be justified and whether hand manufacture should not be undertaken in the same way that the early parabolic reflectors for radar were handmade to a high degree of accuracy. If presses or moulds have to be made, early consideration of their design will be necessary, and it might be advisable to think in terms of plastics rather than metal.

DISCUSSION.

6. As with the aluminium liner, the fabrication of the casing is a straightforward metal-working job and could probably be put to the trade.

QUESTIONS AS AT 1.7.1947.

7. According to the numbers required, should they be handmade or machine fabricated.

8. Should the job be put to the trade?

FIRING MECHANISM AND PROXIMITY FUSING DEVICE.

Whereas the firing mechanism may be relatively simple and standard components could be used, the proximity fusing device will call for considerable research and experiment.

2. C.S.A.R. visualises that such a fuse must have the following characteristics:-

(a) Selective fusing between 1500 feet and 100 feet above the target.

(b) Accuracy to within + or - 200 feet at the greater height but + or - 30 feet at the lesser.

(c) Probability of failure reduced to the minimum.

(d) Immunity from jambing or from other interferences.

DISCUSSION.

3. The fulfilment of this requirement will be a major task for the Electronics Section and will finally necessitate air trials, but these might be incorporated with the normal ballistic trials if the fuses are completed in time.

4. No doubt T.R.E. could undertake the research into and design of the proximity fuse but it is for discussion whether it would not be preferable to detach personnel from that Establishment to work under the direct supervision of C.S.A.R.

QUESTIONS AS AT 1.7.1947.

(11) 5. Who should undertake this research and where should it be located?

(12) 6. What is the earliest date on which it should start.

APPENDIX 'K'.

THE BALLISTIC OUTER CASING.

The design of this component must also wait until the general overall assembly has been decided upon, but it would also house the firing and fusing mechanisms.

DISCUSSION.

2. The design of the ballistic casing would primarily concern the bomb design section at R.A.E., but it would be preferable for personnel from that Establishment to be loaned to C.S.A.R. during the design period, which would cover the ballistic trials.

3. The manufacture of the casing should be put to the trade, and orders for 2-or-300 given. Some of these cases will have to be innered ? inert filled for ballistic trials whilst others will be required for fuse functioning tests.

QUESTIONS AS AT 1.7.1947.

4. As a large number of these outer casings will be required for ballistic trials, is it agreed that the trade should undertake manufacture?

5. Should the design team work at R.A.E. or be attached to C.S.A.R.?

6. When should work start on this component?

THE ARMING PLUG.

The weapon is assembled component by component, the last being the plutonium core into which the initiator has already been inserted. It therefore follows that a passage has to be provided through which the core can be entered, the passage being finally sealed.

2. Starting from the inside of the assembly, a hole of the proper dimensions is cut in the uranium tamper, the boron shield, and the aluminiu liner.

3. In the H.E. component, a section of the inner H.E. shell corresponding to the dimensions of a complete lens is also removed.

4. After the insertion of the plutonium core, these plugs are replaced, thus sealing the assembly. In all cases, flush fitting of the plugs in their respective sockets must be guaranteed.

QUESTIONS AS AT 1.7.1947.

5. Nil.

APPEND. 'M'.

Review of G production problem. J.L.T. May 1947.

	Urchin	Pu Kernel	B^{10} Shield	Tamper	Pusher	Lenses + HE	Elect.Det. + assoc.electronics	Prox. Fuse	External Ironmongery	Ballistics
Could we go straight ahead and make?	No.	No.	No.	Yes	Yes	No.	No.	No.	No.	No.
Do we lack special knowledge in the subject?	Yes	Yes	Yes.	No?	No.	A little	A little	No.	No.	No.
External bar to progress?	Pile	Pile	Separat--ion plant	-	-	-	-	-	-	-
Nature of Difficulties.	Knowledge and experience Po Chem.	Pu Chem. and Metallurgy	Ignorance of method	-	-	Experience in precision casting and testing	Experience in production and testing	Exper--ience	-	Experience
Scale of American Effort where known	Appreciable: Monsanto contract on Po. Chem. 1-2 Physicists 3-5 Chemists at Los Ala--mos.	Large Hanford Effort + Chicago Met.Lab.+ C.M.Division at Los Alamos. 1000-2000 on production. 25-50 Chemists and Metallurgists at L.A.	Don't know	Mostly drawing office and machine shop	As with tamper	Full scale lenses. Say 50 operat--ives + 12 on testing	Appreciable: External contact with U of Cal. for production. 50 on production at L.A. 10 research on testing.	1 A.A.F. Group for field testing 25-30 lab.tech. + research	Don't know.	Together with Prox. Fuse.
Is it easy to make when you know how and have materials and equipment i.e. quick and few people	Yes	No.		Yes	Yes	No.	Yes	Super high class electr--onics	Big mach--ine shop job.	