Moonshine

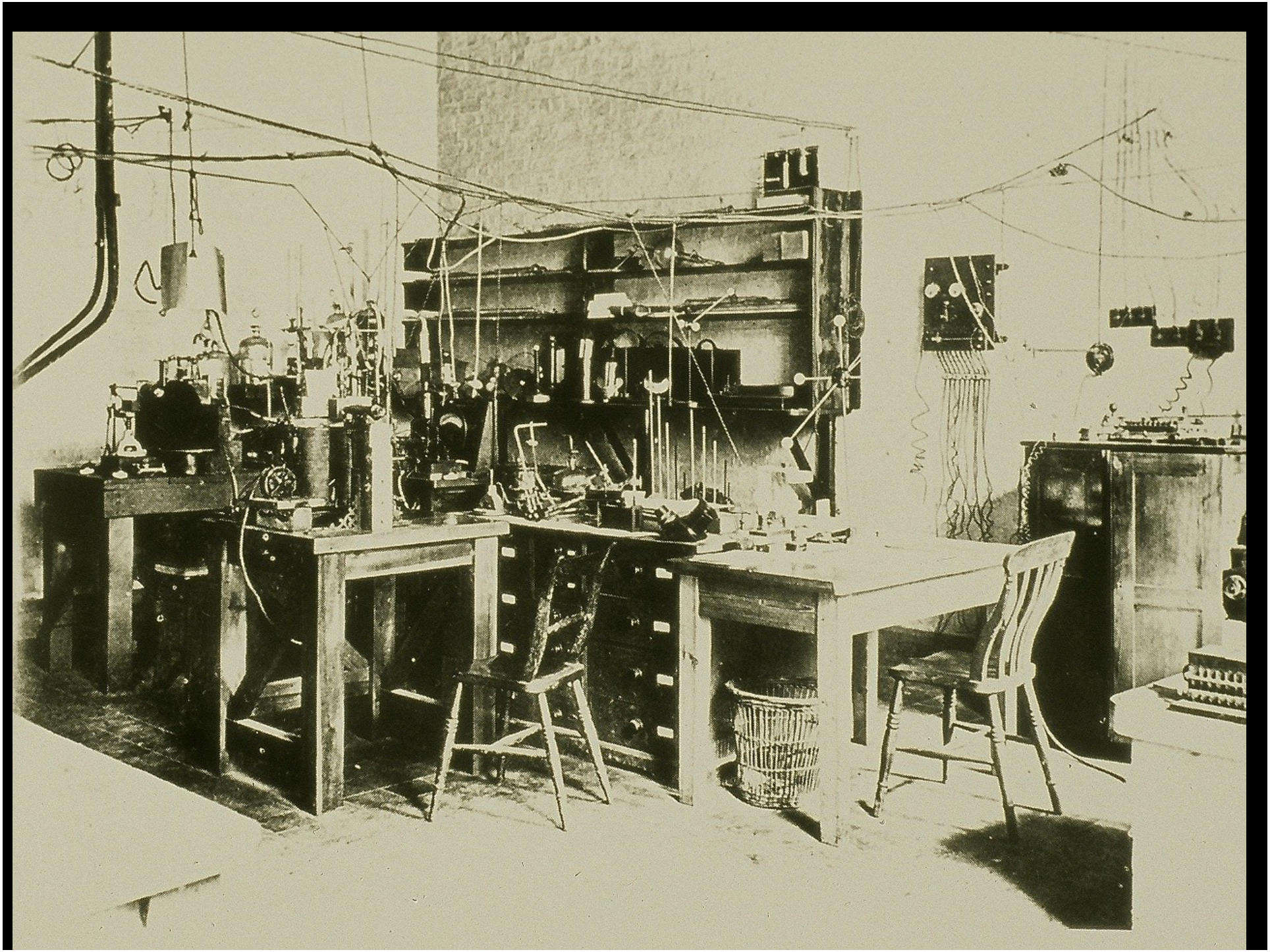
Manhattan

Maud

Monte Bello

British scientists and nuclear policy Andrew Brown

[*MTA 6/2/07*]



TALK
SOFTLY
PLEASE

Comparative Curves

	max	P mm	M	$P\sqrt{M}$	$\frac{P}{M}$	mean vel.	mean $\frac{dV}{dx}$	S	V mean velocity	V original vel.	S scale $= \frac{L}{2r}$
Hydrogen	2.8	2.9	1	[illegible]	.48, .70 } 0.60	.015 v₀	2.9×10^{9}	0.13	1.25×10^{8}	2.2×10^{8} King number	0.56
P decreases rapidly for $r_0 > 0.7$ mm	[7.4]										
Helium	1.25, 1.73 } 80 mean, C = 0.80	1.5, C = 0.7	4	3.0	1.42, 1.12 } 1.27 mm	.062 v₀	1.9×10^{9}	0.38	1.35×10^{8}	King number 4.4×10^{8}	0.26
Air	0.61, 0.61, 0.75 } 0.73 mm	0.73	14.3	2.8	.35, .39, .35 } 0.45	.031 v₀	1.6×10^{9}	0.94	0.50×10^{8}	King number 2.0×10^{8}	0.075

Value of $\sqrt{\frac{W}{2m}} = c$

In Pb $W = 13.5$ volts $\therefore W = \frac{13.5}{300} \times 4.8\times10^{-10}$

$m = 9\times10^{-28}$

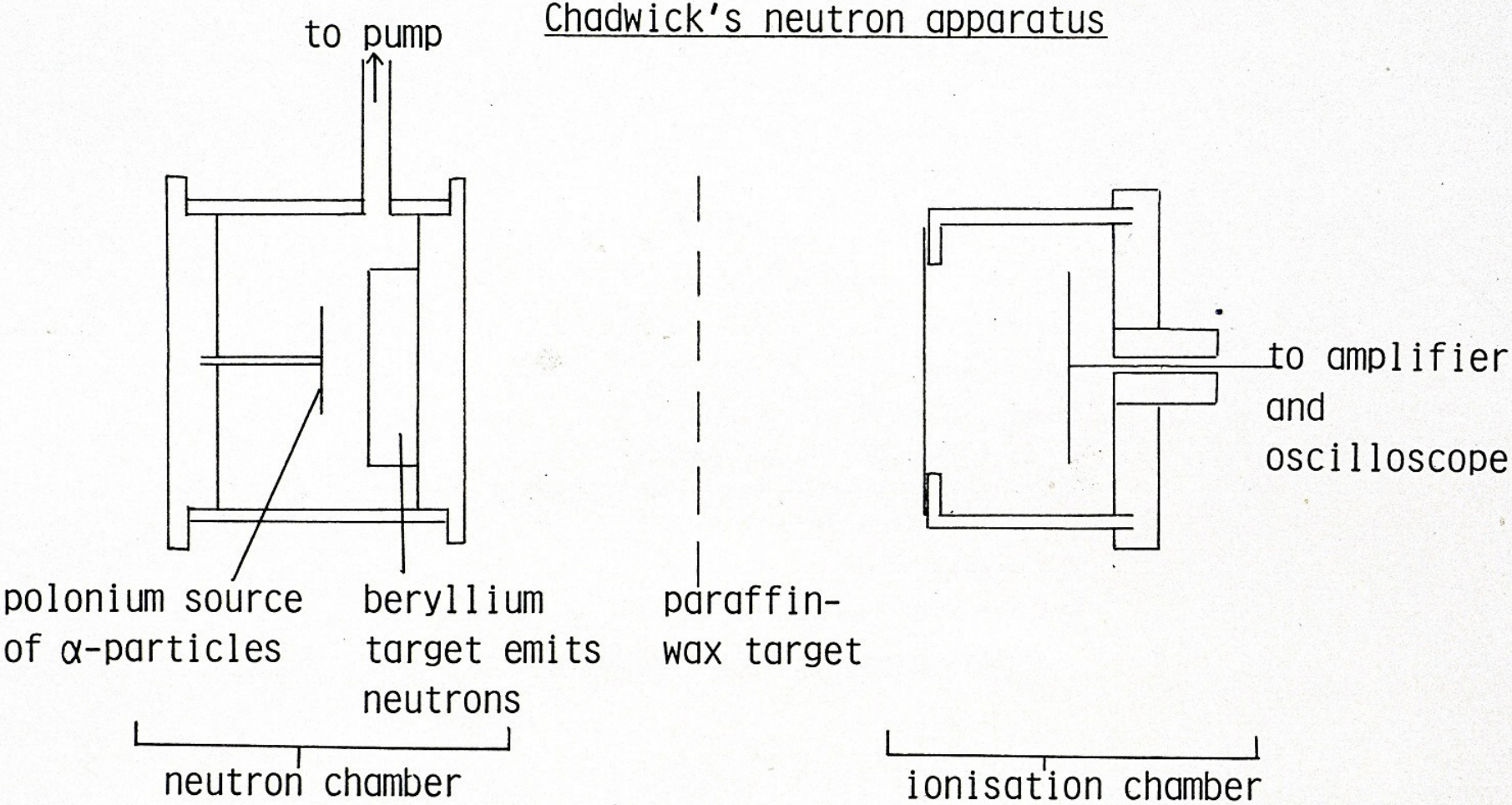
$\therefore c^2 = \frac{2.4\times10^{18}}{2}$

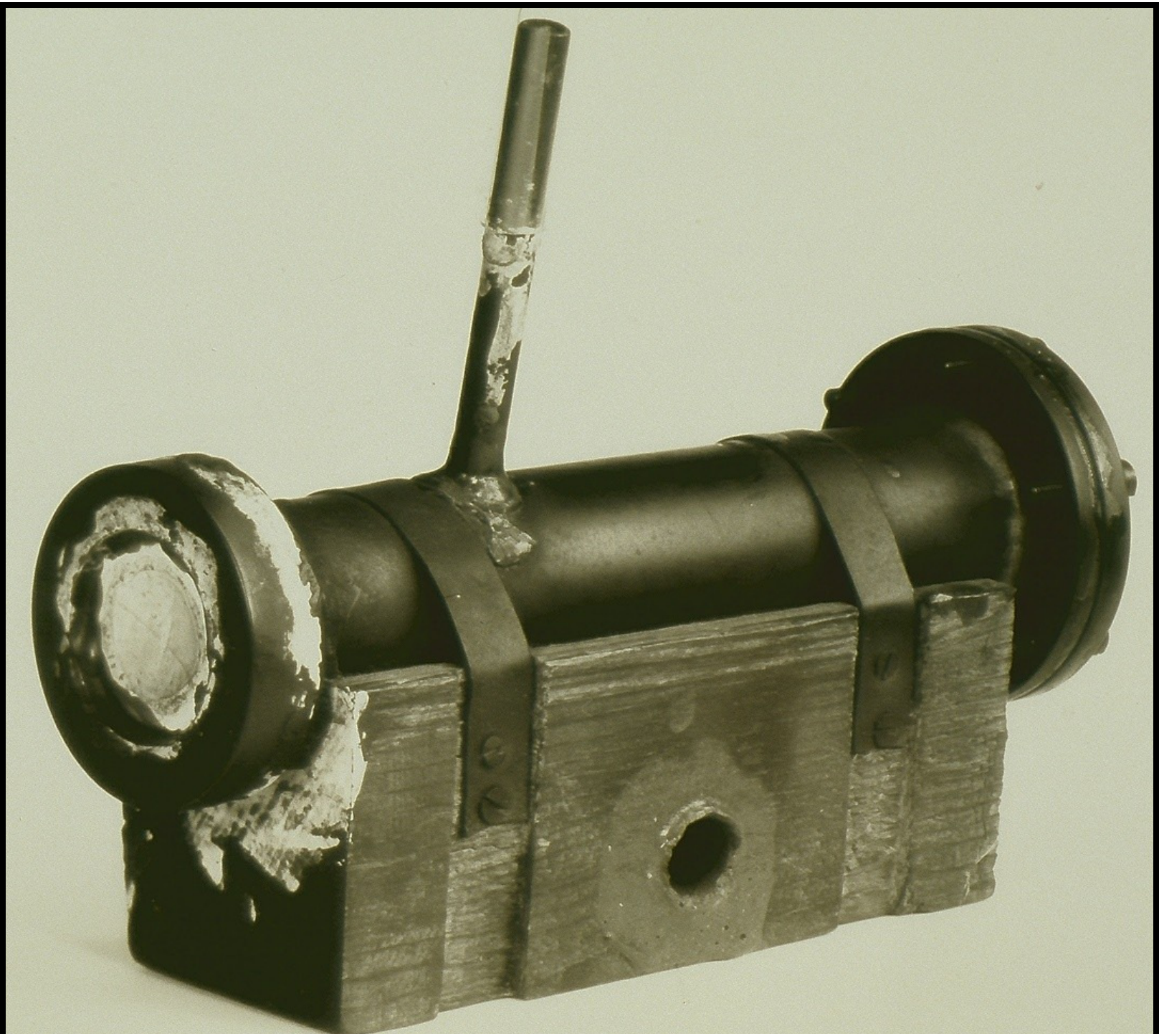
$\therefore c = 1.10\times10^{8}$

Dr Rutherford

quite all right.

Chadwick's neutron apparatus





298 Meeting 1932 19 January

Growth, volatilisation, melting & solution of crystals

W. A. Wooster

299 Meeting 1932. 26 January

Møllers relativistic collision theory (Z. f. P. 70 p 786)

P. A. M. Dirac

Experiments of Curie & Joliot, action of Be γ rays on free hydrogen

N. Feather

300 Meeting 1932 2 February.

Adsorption. Theory of Lennard-Jones

R. H. Fowler

301 Meeting 1932 16 February.

Nuclear moments

C. P. Snow

302 Meeting 1932 23 February.

Neutron?

J. Chadwick.

do.

G. Lee

do. (expansion chamber)

N. Feather

Cavendish Laboratory,
Cambridge,

24 February 1932.

Dear Bohr.

I enclose the proof of a letter I have written to "Nature" and which will appear either this week or next. I thought you might like to know about it beforehand.

The suggestion is that α particles eject from beryllium (and also from boron) particles which have no nett charge, and which probably have a mass not equal to that of the proton. As you will see, I put this forward rather cautiously, but I think the evidence is really rather strong. Whatever the radiation from Be may be, it has most remarkable properties. I have made many experiments which I do not mention in the

Letters to the Editor

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Possible Existence of a Neutron

IT has been shown by Bothe and others that beryllium when bombarded by α-particles of polonium emits a radiation of great penetrating power, which has an absorption coefficient in lead of about 0·3 (cm.)$^{-1}$. Recently Mme. Curie-Joliot and M. Joliot found, when measuring the ionisation produced by this beryllium radiation in a vessel with a thin window, that the ionisation increased when matter containing hydrogen was placed in front of the window. The effect appeared to be due to the ejection of protons with velocities up to a maximum of nearly 3×10^9 cm. per sec. They suggested that the transference of energy to the proton was by a process similar to the Compton effect, and estimated that the beryllium radiation had a quantum energy of 50×10^6 electron volts.

I have made some experiments using the valve counter to examine the properties of this radiation excited in beryllium. The valve counter consists of a small ionisation chamber connected to an amplifier, and the sudden production of ions by the entry of a particle, such as a proton or α-particle, is recorded by the deflexion of an oscillograph. These experiments have shown that the radiation ejects particles from hydrogen, helium, lithium, beryllium, carbon, air, and argon. The particles ejected from hydrogen behave, as regards range and ionising power, like protons with speeds up to about $3{\cdot}2 \times 10^9$ cm. per sec. The particles from the other elements have a large ionising power, and appear to be in each case recoil atoms of the elements.

If we ascribe the ejection of the proton to a Compton recoil from a quantum of 52×10^6 electron volts, then the nitrogen recoil atom arising by a similar process should have an energy not greater than about 400,000 volts, should produce not more than about 10,000 ions, and have a range in air at N.T.P. of about 1·3 mm. Actually, some of the recoil atoms in nitrogen produce at least 30,000 ions. In collaboration with Dr. Feather, I have observed the recoil atoms in an expansion chamber, and their range, estimated visually, was sometimes as much as 3 mm. at N.T.P.

These results, and others I have obtained in the course of the work, are very difficult to explain on the assumption that the radiation from beryllium is a quantum radiation, if energy and momentum are to be conserved in the collisions. The difficulties disappear, however, if it be assumed that the radiation consists of particles of mass 1 and charge 0, or neutrons. The capture of the α-particle by the Be^9 nucleus may be supposed to result in the formation of a C^{12} nucleus and the emission of the neutron. From the energy relations of this process the velocity of the neutron emitted in the forward direction may well be about 3×10^9 cm. per sec. The collisions of this neutron with the atoms through which it passes give rise to the recoil atoms, and the observed energies of the recoil atoms are in fair agreement with this view. Moreover, I have observed that the protons ejected from hydrogen by the radiation emitted in the opposite direction to that of the exciting α-particle appear to have a much smaller range than those ejected by the forward radiation. This again receives a simple explanation on the neutron hypothesis.

If it be supposed that the radiation consists of quanta, then the capture of the α-particle by the Be^9 nucleus will form a C^{13} nucleus. The mass defect of C^{13} is known with sufficient accuracy to show that the energy of the quantum emitted in this process cannot be greater than about 14×10^6 volts. It is difficult to make such a quantum responsible for the effects observed.

It is to be expected that many of the effects of a neutron in passing through matter should resemble those of a quantum of high energy, and it is not easy to reach the final decision between the two hypotheses. Up to the present, all the evidence is in favour of the neutron, while the quantum hypothesis can only be upheld if the conservation of energy and momentum be relinquished at some point.

J. CHADWICK.

Cavendish Laboratory,
Cambridge, Feb. 17.

The Oldoway Human Skeleton

A LETTER appeared in NATURE of Oct. 24, 1931, signed by Messrs. Leakey, Hopwood, and Reck, in which, among other conclusions, it is stated that "there is no possible doubt that the human skeleton came from Bed No. 2 and not from Bed No. 4". This must be taken to mean that the skeleton is to be considered as a natural deposit in Bed No. 2, which is overlaid by the later beds Nos. 3 and 4, and that all consideration of human interment is ruled out.

If this be true, it is a most unusual occurrence. The skeleton, which is of modern type, with filed teeth, was found completely articulated down even to the phalanges, and in a position of extraordinary contraction. Complete mammalian skeletons of any age are, as field palæontologists know, of great rarity. When they occur, their perfection can usually be explained as the result of sudden death and immediate covering by volcanic dust. Many of the more or less perfect skeletons which may be seen in museums have been rearticulated from bones found somewhat scattered as the result of death from floods, or in the neighbourhood of drying water-holes. We know of no case of a perfect articulated skeleton being found in company with such broken and scattered remains as appear to be abundant at Oldoway. Either the skeletons are all complete, as in the *Stenomylus* quarry at Sioux City, Nebraska, or are all scattered and broken in various degrees, as in ordinary bone beds. The probability, therefore, that the Oldoway skeleton represents an artificial burial is thus one that will occur to palæontologists.

The skeleton was exhumed in 1913, and published photographs show that the excavation made for its disinterment was extensive. It is, therefore, very difficult to believe that in 1931 there can be reliable evidence left at the site as to the conditions under which it was deposited. If naturally deposited in Bed No. 2, the skeleton is of the highest possible importance, because it would be of pre-Mousterian age, and would be in the company of *Pithecanthropus* and the Piltdown, Heidelberg, and Peking men, all of whose remains are fragmentary to the last degree. Of the few other human remains for which such antiquity is claimed, the Galley Hill skeleton and the Ipswich skeleton are, or apparently were, complete. The first of these was never seen *in situ* by any trained observer, and the latter has, we believe, been withdrawn by its discoverer. The other fragments, found long ago, are entirely without satisfactory evidence as to their mode of occurrence.

Oliphant, Harteck and Rutherford (1934)

Transmutation effects observed with Heavy Hydrogen

diplon + diplon = tritium + proton

diplon + diplon = helium3 + neutron

Begging, like swindling, is only respectable on a big scale.

Chadwick to Rutherford
(May 1936)

I presume that we are in the same stage as yourself with regard to getting the magnet, etc going. The parts are all waiting in the Laboratory, and we are hoping to get them erected shortly. I have long since recognised that the cyclotron is a costly toy in this country, and I hope you will manage to get through without exhausting your funds.

Rutherford to Chadwick
(October 1937)

Science policy in England

Depends on the fact that a handful of the more important scientists in the country know one another, and between them know practically everybody else…

J D Bernal 'The social function of science' (1939)

University of Birmingham 1940

- Professor of Physics, Marcus Oliphant(1901-2000)
- Professor of Applied Mathematics, Rudolf Peierls
- Lecturer in Physics, Otto Frisch
- John Randall invented magnetron, Nov 1939

Frisch-Peierls Conversation

- "What would happen if someone gave you the pure isotope, U-235?"
- Estimated critical size "about a pound"
- Fast neutrons

Frisch-Peierls Memorandum

- As a weapon, the super-bomb would be practically irresistible
- Owing to the spread of radioactive substances with the wind, the bomb could probably not be used without killing large numbers of civilians, and this may make it unsuitable as a weapon for use by this country
- We have no information that the same idea has also occurred to other scientists but…it is quite conceivable that Germany is, in fact, developing this weapon

Frisch-Peierls Memorandum

- The most effective reply would be a counter-threat with a similar bomb

- Therefore, it seems to us important to start production as soon and as rapidly as possible, even if it is not intended to use the bomb as a means of attack

G.P. Thomson's Committee

- 5 members, all Cavendish Lab
- F-P memorandum presented at first meeting, 24 April 1940
- Chadwick "embarrassed, confessing that he had reached conclusions"
- Telegram from Meitner to say Bohr was safe. "Tell Cockcroft and Maud Ray Kent"

M.A.U.D. Technical Sub-Committee 1940-1

- Chaired by Chadwick
- After protest Frisch and Peierls included
- Experimental work in Liverpool, Birmingham, Cambridge, Oxford, Bristol
- Isotope separation, neutron cross section etc

MAUD REPORT, July 1941

- Entered project with more scepticism than belief
- Convinced that the release of atomic energy on a large scale is possible
- Can be a very powerful weapon of war
- An effective uranium bomb , containing some 25lb of active material, would be equivalent to…1,800 tons of TNT and would release large quantities of radioactive substances

‘…whoever possesses such a plant should be able to dictate terms to the rest of the world. However much I trust my neighbour, and depend on him, I am very much averse to putting myself completely at his mercy and I would, therefore, not press the Americans to undertake this work.’

Lord Cherwell letter to Winston Churchill (27/8/41)

‘It appears desirable that we should soon correspond or converse concerning the subject which is under study by your M.A.U.D. Committee and by Dr Bush’s organization in this country in order that any extended efforts may be coordinated or even jointly conducted’
President Roosevelt to PM Churchill (Oct 1941)

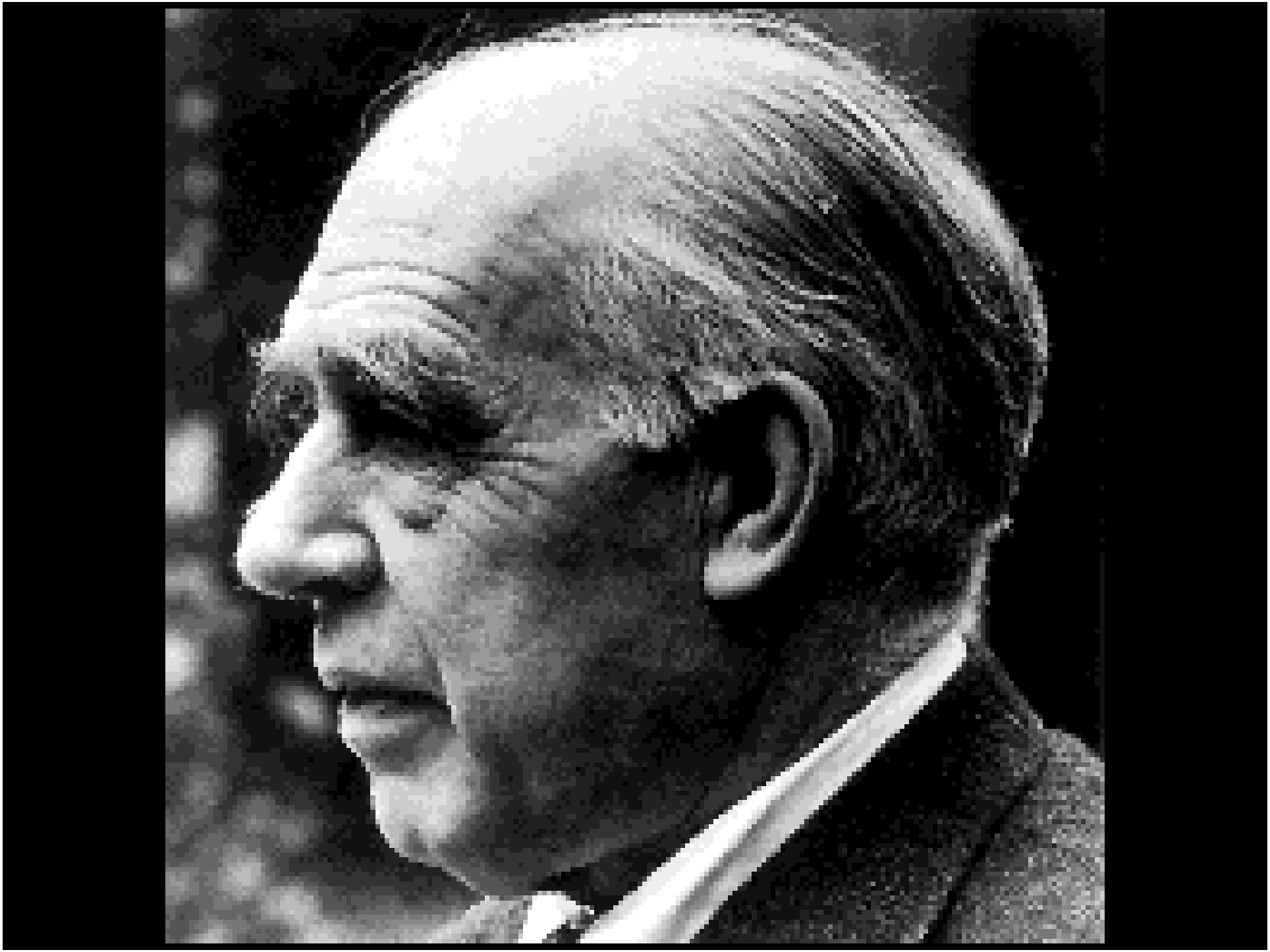
June 1942 Manhattan Project
Aug 1942 British relinquish idea of UK plant but raise question of international control

No further communication on
•Electromagnetic separation
•Production of heavy water
•Fast neutron reactions
•Production of urnanium hexafluoride
Conant memorandum (Jan 1943)

Quebec Agreement (*19 August 1943)*

Articles of agreement governing collaboration 'twixt USA & UK

1. Never use this agency against each other
2. Don't use it against third parties without each other's agreement
3. Don't communicate any information to third parties except by mutual consent
4. US President to dictate post-war commercial terms for atomic energy



Bohr Memo to Roosevelt (*3 July 1944*)

- Initiative to forestall a fateful competition about the formidable weapon
- Uproot any cause of distrust between the powers on whose harmonious collaboration the fate of coming generations will depend
- The responsible statesmen alone can have the insight in the actual possibilities

308

10, Downing Street,
Whitehall.

TOP SECRET

TUBE ALLOYS

Aide Mémoire

~~Conclusions of~~ discussion between the President and the Prime Minister at Hyde Park, September 18, 1944.

1. The suggestion that the world should be informed regarding Tube Alloys, with a view to an international agreement regarding its control and use, is not accepted. The matter should continue to be regarded as of the utmost secrecy; but when a "bomb" is finally available, it might perhaps after further consideration be used against the Japanese, who should be warned that this bombardment will be repeated until they surrender.

2. Full collaboration between the United States and the British Government in developing Tube Alloys for military and commercial purposes should continue after the defeat of Japan unless and until terminated by joint agreement.

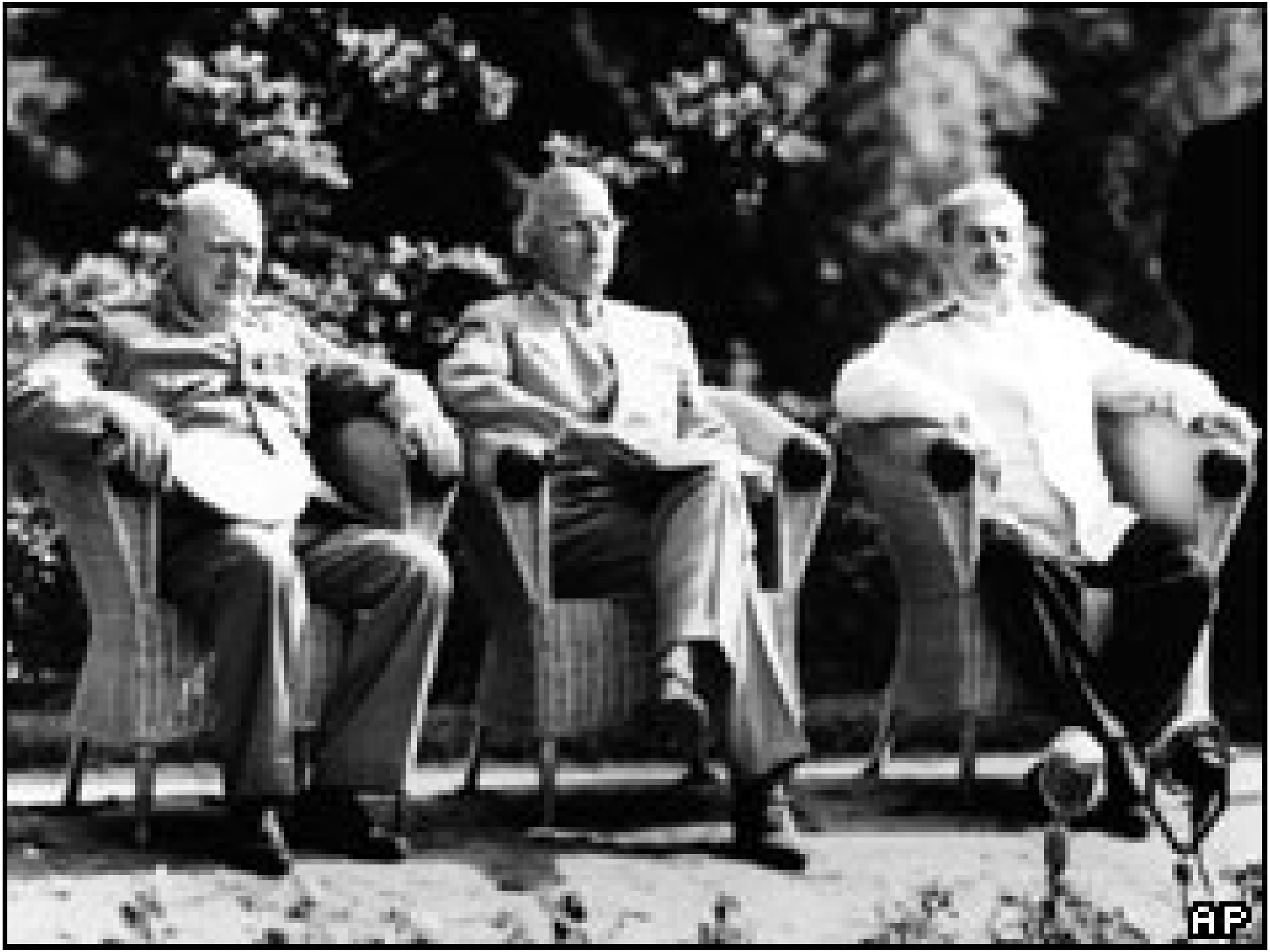
3. Enquiries should be made regarding the activities of Professor Bohr and steps taken to ensure that he is responsible for no leakage of information, particularly to the Russians.

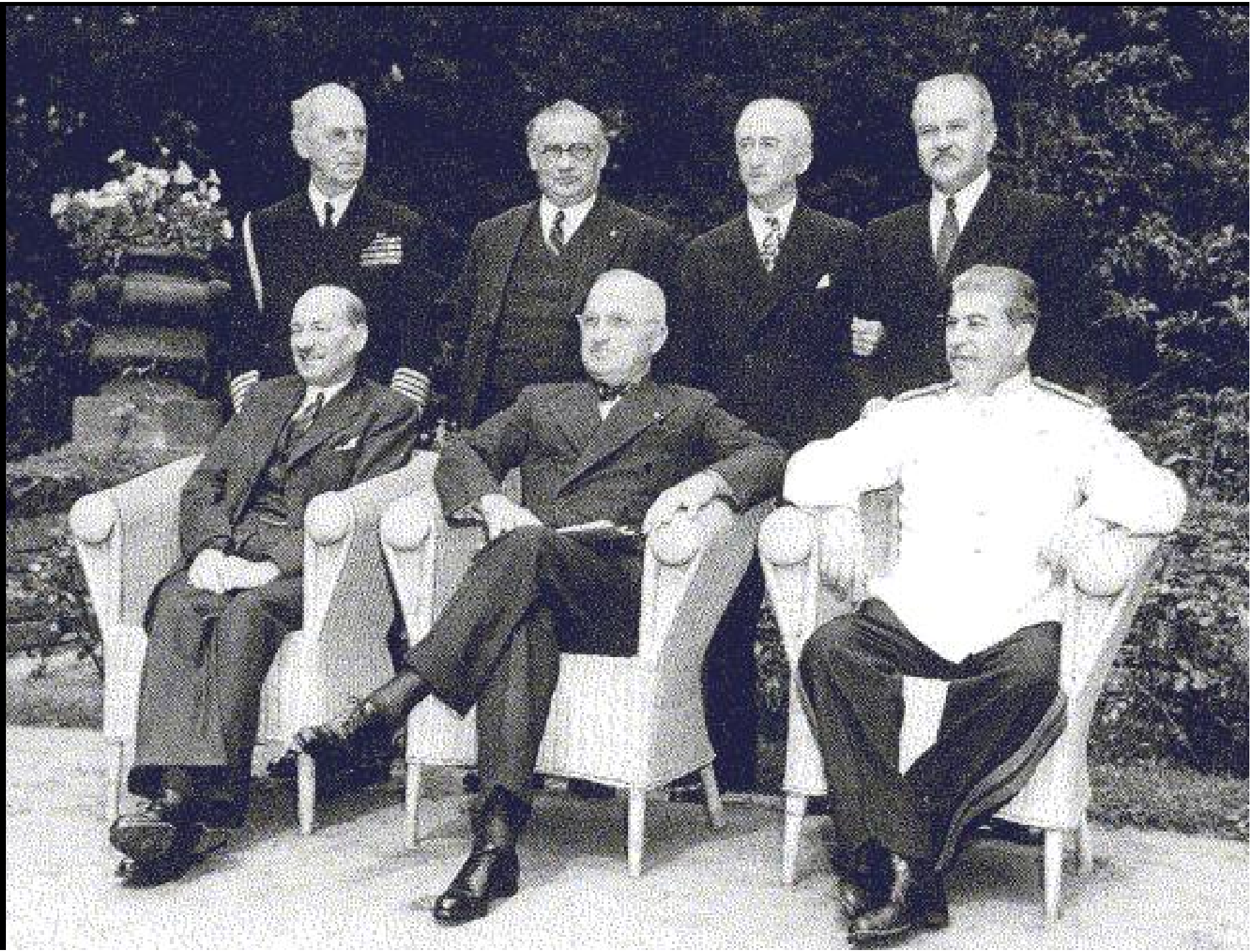
‘Sir Henry Tizard…surely has lots of things to get on with without plunging into this exceptionally secret matter. It may be that in a few years or even months that this secret can no longer be kept. One must always realise that for every one of these scientists who is informed there is a little group around him who also hears the news.’

Churchill minute to General Ismay, April 1945

Tizard report (June 1944)

The only answer that we can see to the AB is to be prepared to use it ourselves in retaliation. A knowledge that we were prepared, in the last resort, to do this might well deter an aggressive nation. Duelling was a well recognized method of settling quarrels between men of high social standing so long as the duellists stood 20 paces apart and fired at each other with pistols of primitive type. If the rule had been that they should stand a yd apart with pistols at each other's hearts, we doubt whether it would long have remained a recognized method of settling affairs of honour.

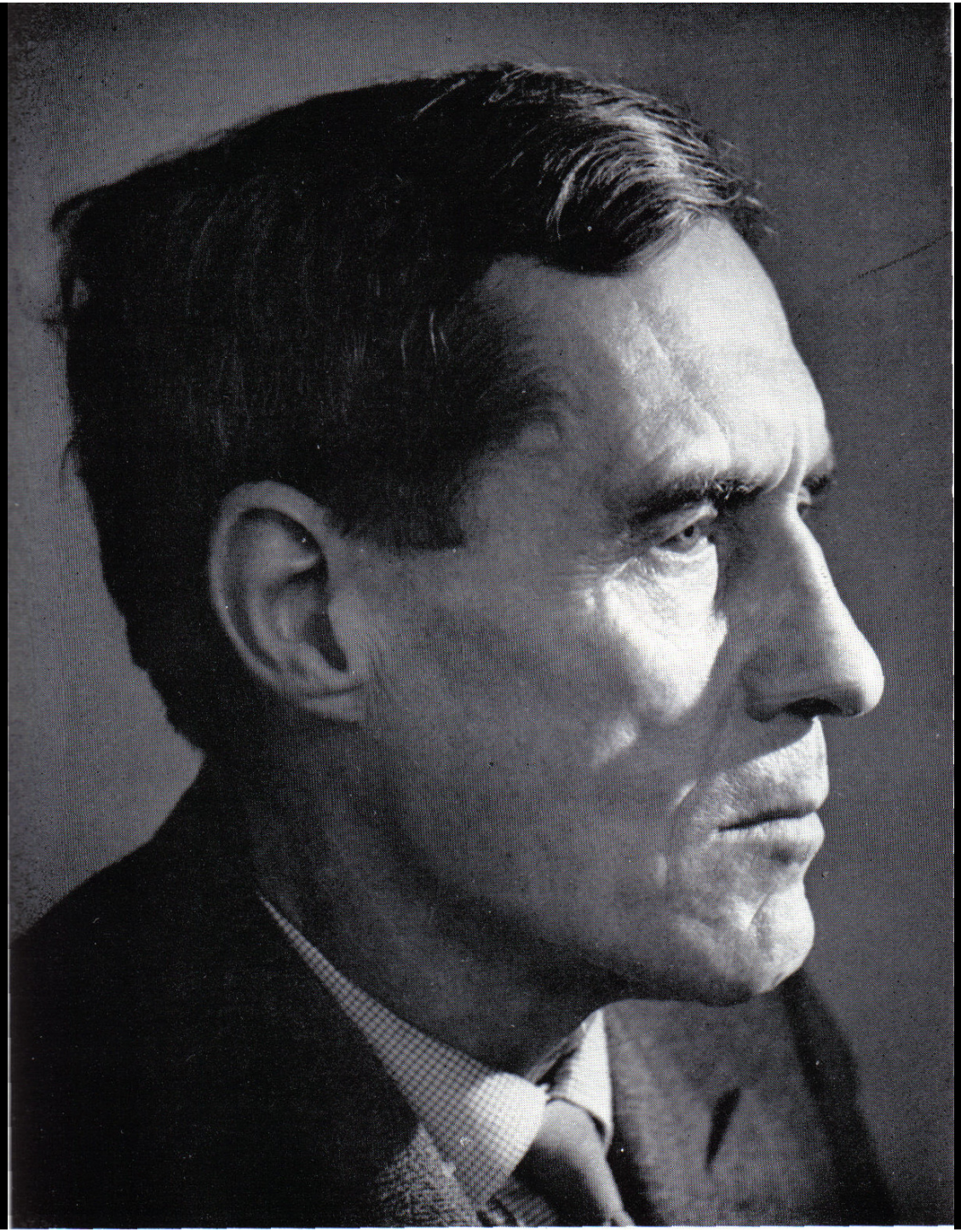

AP



•Obvious that Military applications make a production plant of our own essential for the defence of the UK and British Commonwealth

•Ignore U235 because ‘We cannot afford to shoot all over the target’

Chadwick cable to ACAE (10/9/45)



Patrick Blackett

- *Dissenter on Maud Committee (1941)*
- *'Preaching against the employment of scientists on T.A.' (1943)*
- *Doubted economic cost/military benefit ratio to UK (1945)*

- The Manhattan Project ‘seems to indicate that any other country possessing the necessary scientific and industrial resources could also produce atomic bombs within a few years’

- ‘The successful manufacture of bombs from plutonium shows that the harnessing of atomic energy as a source of power cannot be achieved without the simultaneous production of material capable of being used in a bomb.’

PM Attlee letter to President Truman (25 Sept 1945)

Anglo-American Breakdown 1945-6

- Nov 45 *Groves-Anderson memo US-UK-Canada*

- Dec 45 *Byrnes with his 'obstructive and evasive abilities' refutes memo because of UN Article 102*
- *McMahon Bill: civilian controlled AEC*

- Feb 46 *Nunn May arrested for spying*

- April 46 *'We must by hook or by crook divert some of the Congo material to England' Chadwick*

- Aug 46 *Final McMahon Bill restrictive*

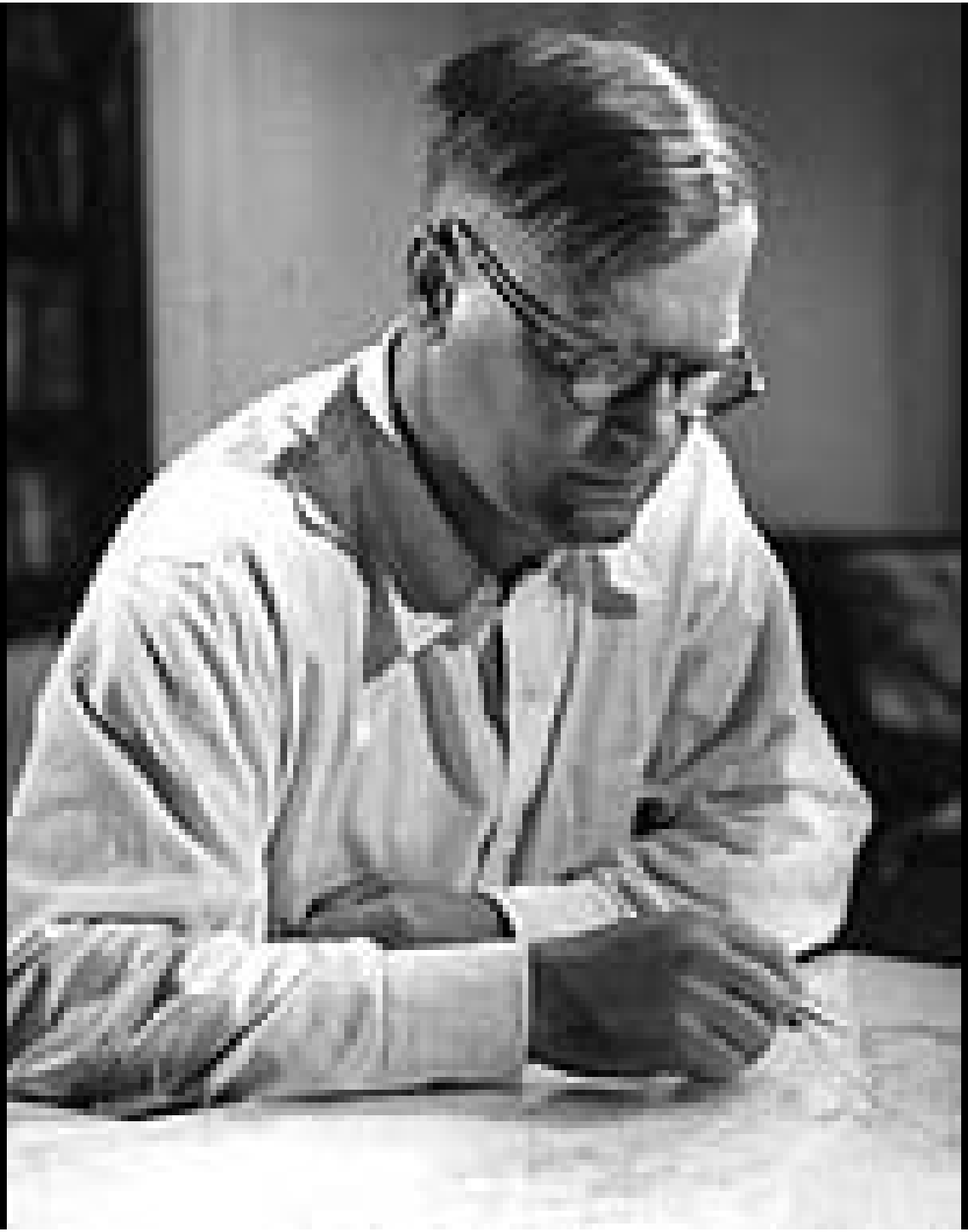
UN AEC 1946

Sir Alexander Cadogan ***'Well, if this is a discussion about the future arrangements on nuclear bombs and such matters, it's really a matter for the physicists.'***

Sir James Chadwick ***'The physicists wouldn't have any difficulty in coming to some kind of reasonable agreement between themselves, but it wouldn't mean anything whatever.'***

Hard Crust Café

Transport strike, January 1947. Soldiers deliver horses to Brixton.



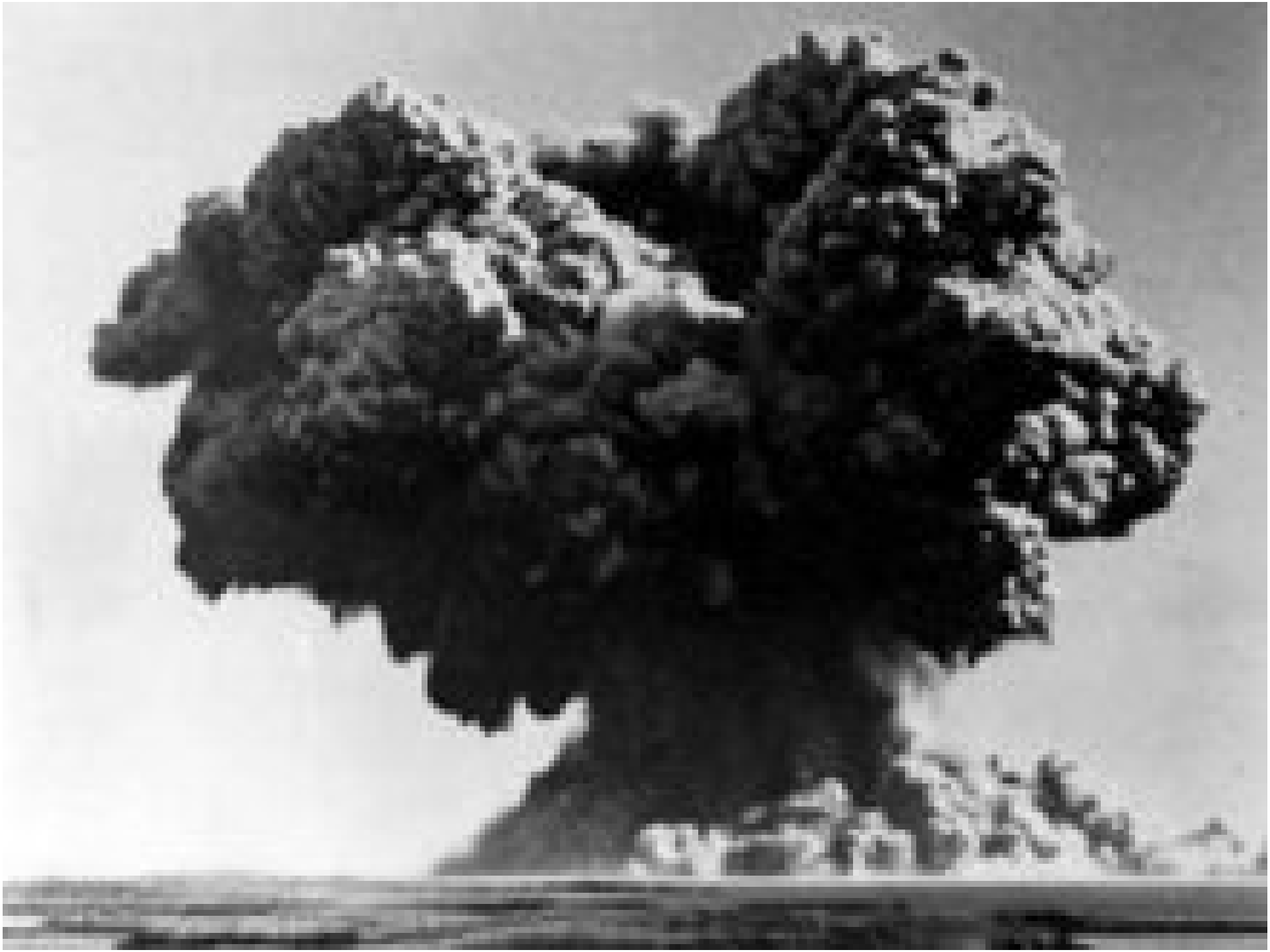
- 1947 Tizard chairs DRPC

- 1949 Informs COS that AB project starving other R&D
- May 1949 PM, Minister Defence meet Tizard & agree to review by COS. COS decides AB not the absolute priority

- Sept 1949 News of Soviet bomb test

- Feb 1950 Klaus Fuchs arrested

F271



Bohr's crusade for an open world

No kind of customary measures will suffice for this purpose and that no real safety can be achieved without a universal agreement based on mutual confidence.

Letter to Sir John Anderson (16 Feb 1944)