HENRY TIZARD FRS, J.P.V.MADSEN & DAVID RIVETT FRS: 1908-1949.

SCIENCE & THE BATTLE OF BRITAIN 1940.

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Roger W. Madsen: October, 2020.

Sir HenryTizard FRS, J P V Madsen & Sir David Rivett FRS.

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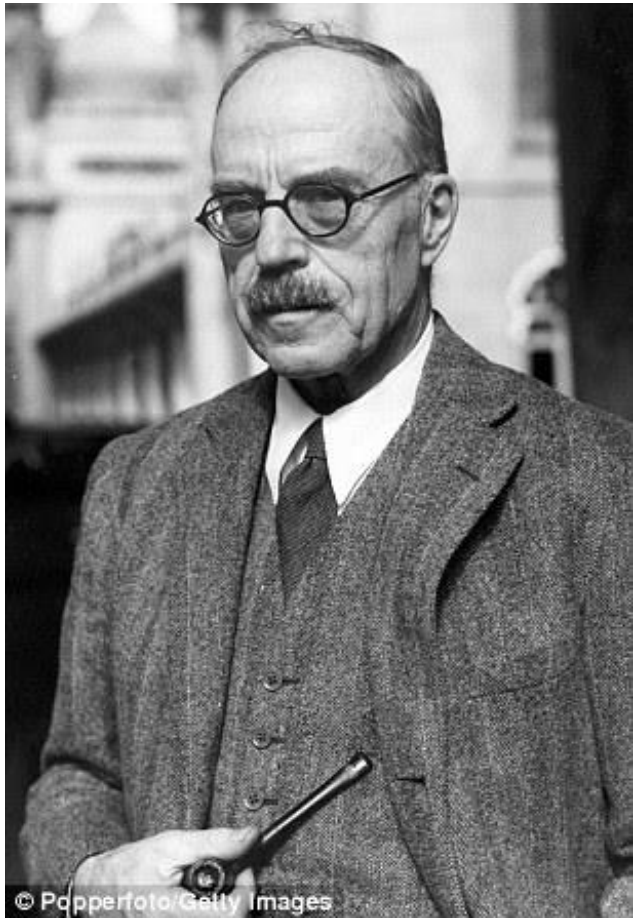
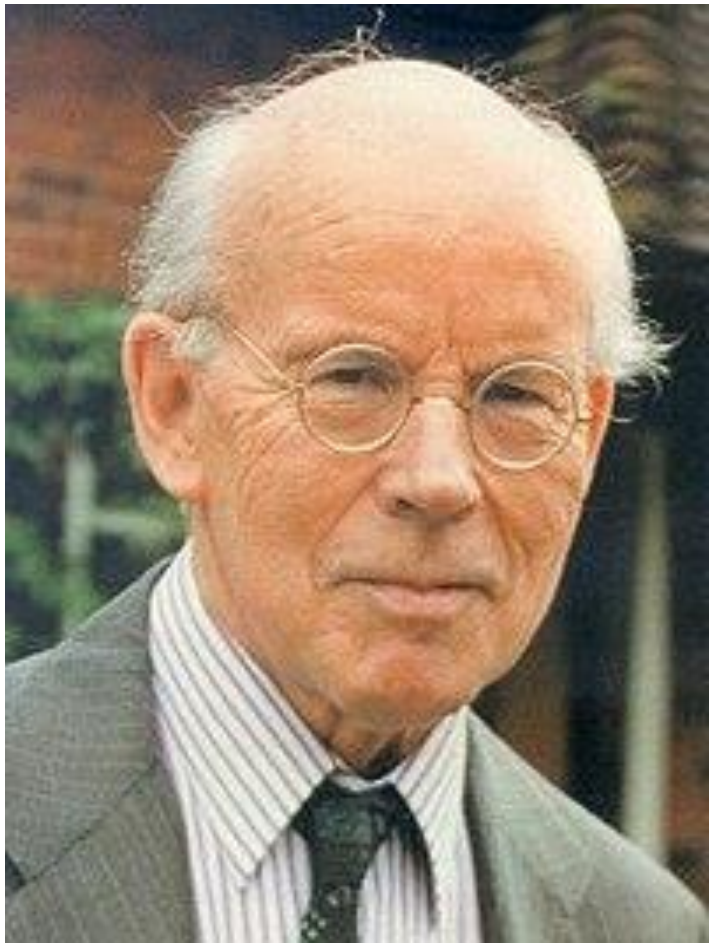
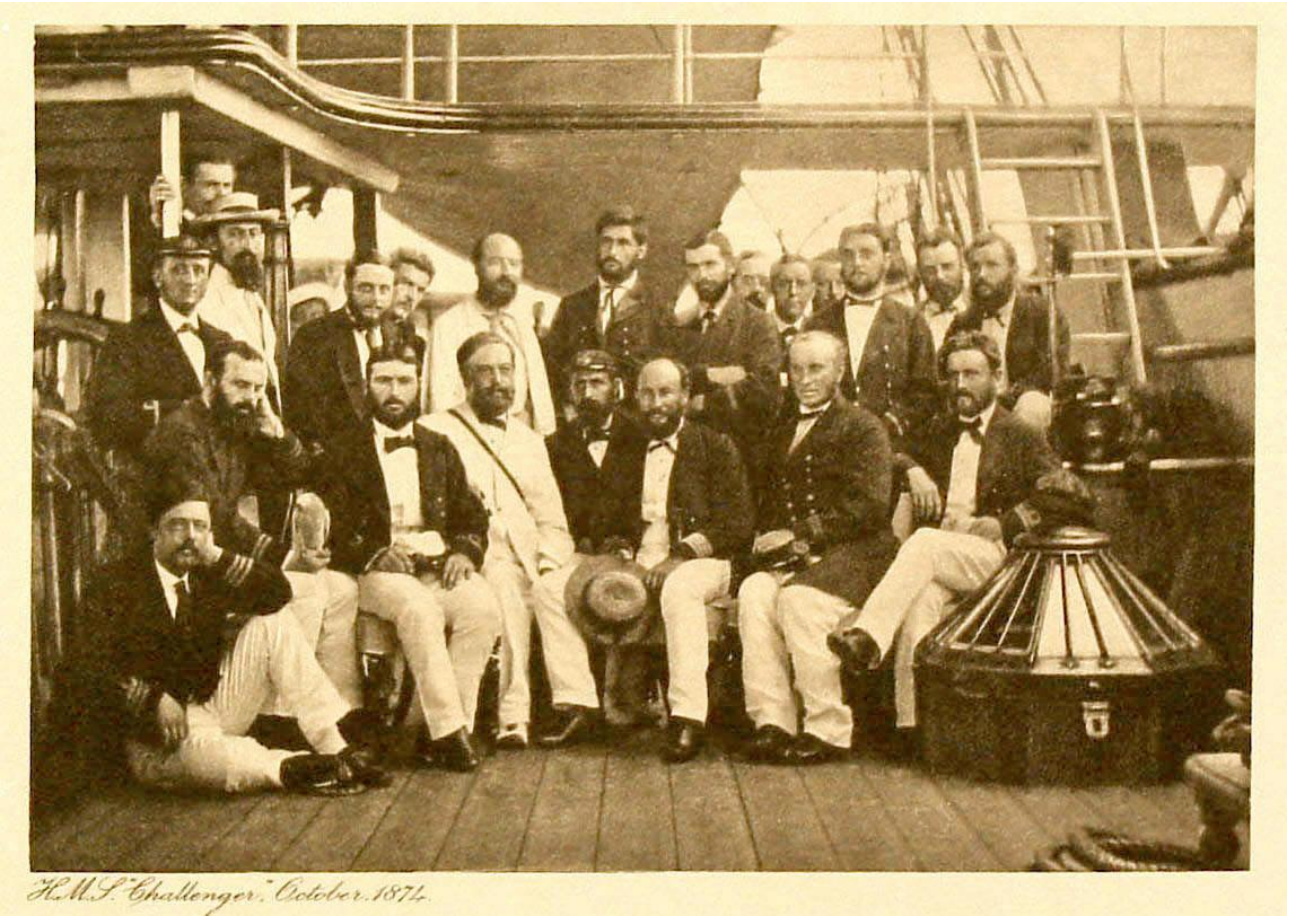
Henry Tizard, J P V Madsen, David Rivett & George Julius with A Richardson, CSIR Execs.



Thomas Henry Tizard FRS, Sir Peter Tizard. Greenwich Hospital.

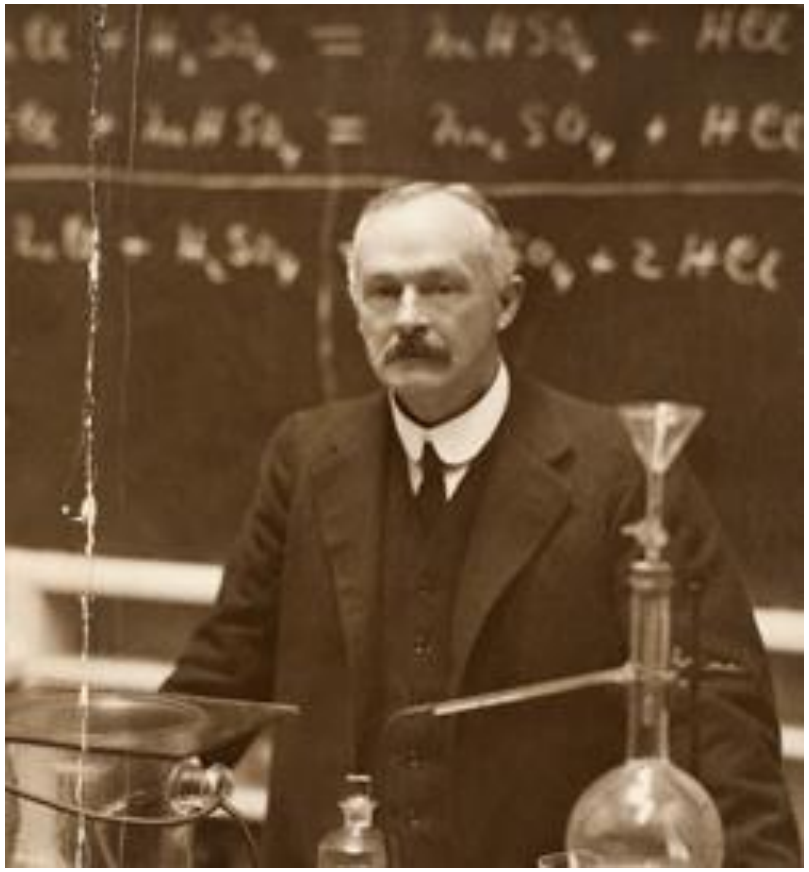


Challenger Expedition 1874.



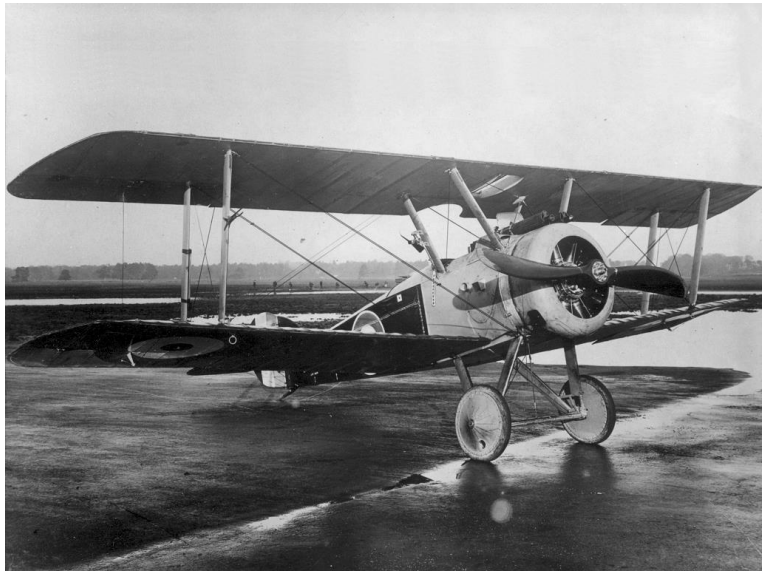
Australia BA Meeting 1914.

Stella and David in Germany in 1909 when they announced their engagement.

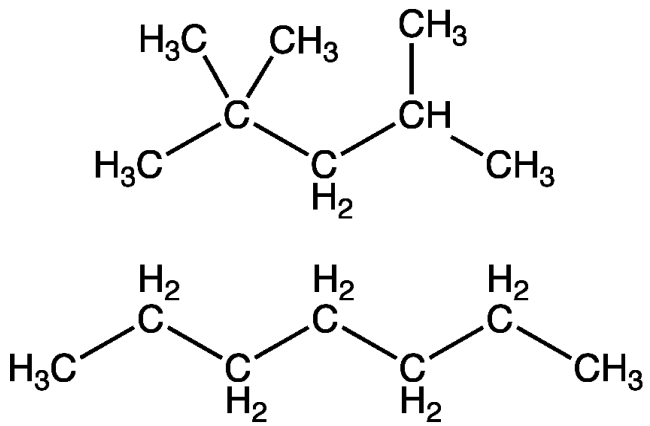


David Rivett 1908-1918.

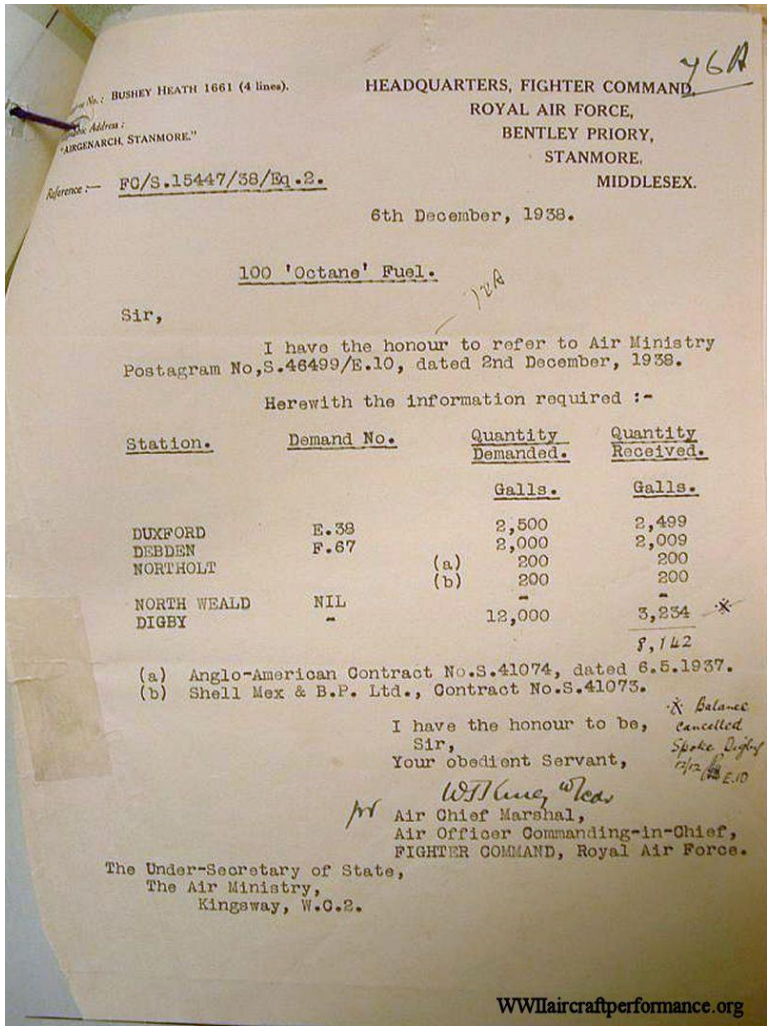
Henry Tizard & J P V Madsen 1914-18.



Toluene, Octane Rating- TetraEthylLead 1920's



RAF BAM100 Octane. 1938, B of B, WW2.



Telephone No.: BUSHEY HEATH 1661 (4 lines).
Telegraphic Address: "AIRGENARCH, STANMORE."

HEADQUARTERS, FIGHTER COMMAND,
ROYAL AIR FORCE,
BENTLEY PRIORY,
STANMORE,
MIDDLESEX.

Reference:— FC/S.15447/38/Eq.2.

6th December, 1938.

100 'Octane' Fuel.

Sir,

I have the honour to refer to Air Ministry Postagram No.S.46499/E.10, dated 2nd December, 1938.

Herewith the information required :-

Station.	Demand No.		Quantity Demanded. Galls.	Quantity Received. Galls.
DUXFORD	E.38		2,500	2,499
DEBDEN	F.67		2,000	2,009
NORTHOLT		(a)	200	200
		(b)	200	200
NORTH WEALD	NIL		-	-
DIGBY	-		12,000	3,234 *
				5,142

(a) Anglo-American Contract No.S.41074, dated 6.5.1937.
(b) Shell Mex & B.P. Ltd., Contract No.S.41073.

* Balance cancelled Spoke Digby 5/12/38 E.10

I have the honour to be,
Sir,
Your obedient Servant,

Air Chief Marshal,
Air Officer Commanding-in-Chief,
FIGHTER COMMAND, Royal Air Force.

The Under-Secretary of State,
The Air Ministry,
Kingsway, W.C.2.

WWIIaircraftperformance.org

(3699—806) Wt. 30136—2659 25,000 10/39 T.S. 700

Appendi

OPERATIONS RECORD BOOK.

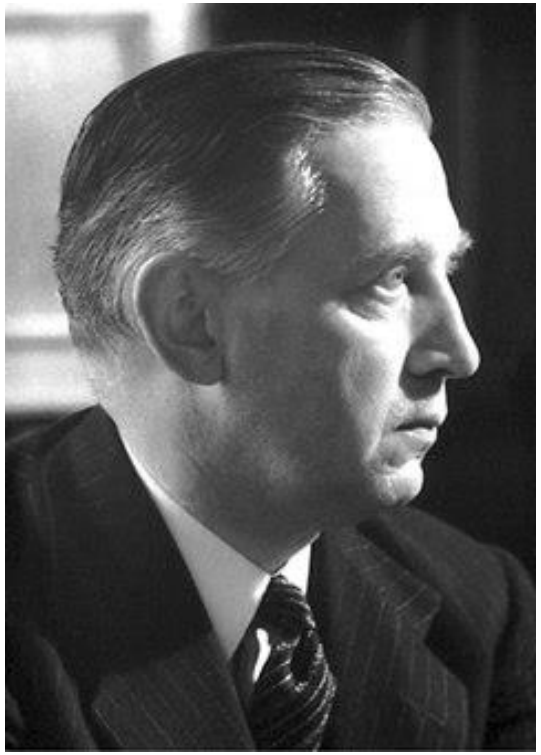
DETAIL OF WORK CARRIED OUT.

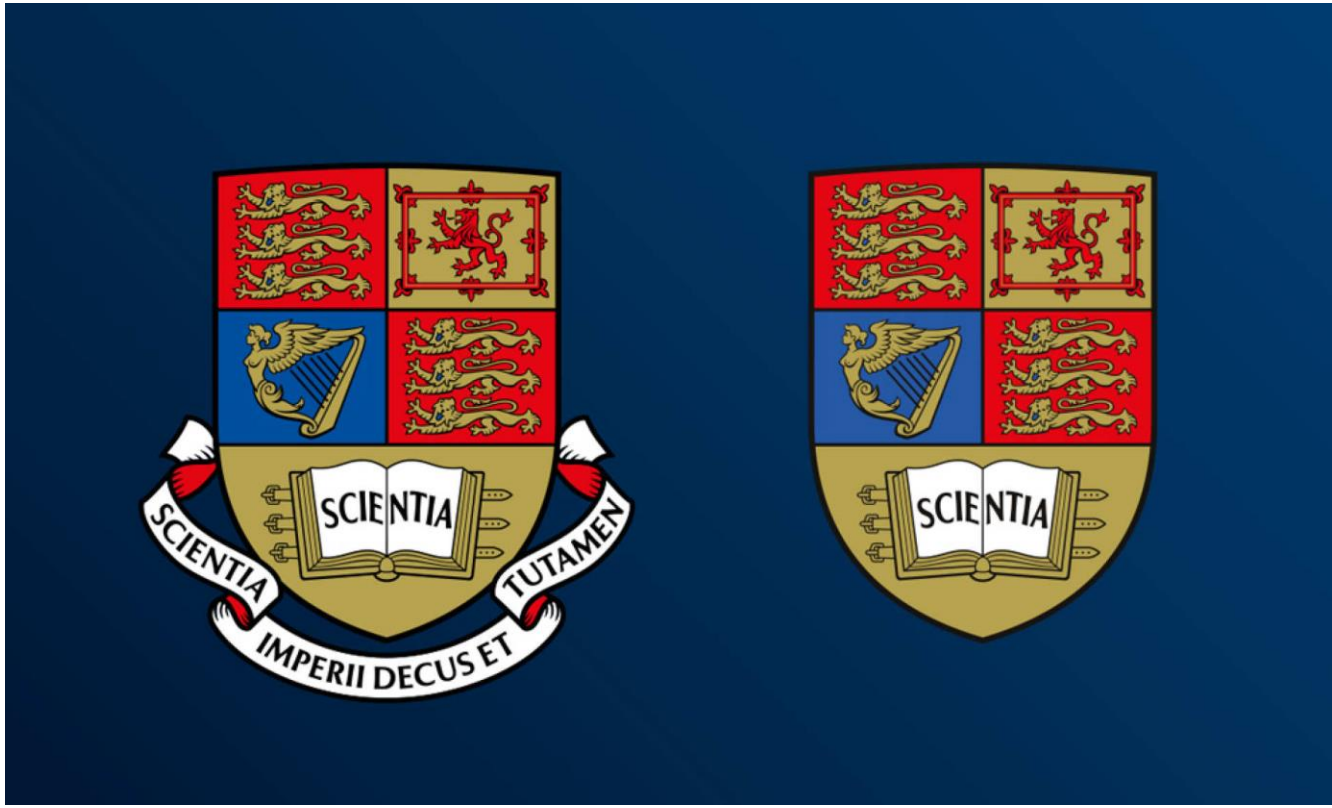
From 1800 hrs 15 / 5 / 40 to 1800 hrs 16 / 5 / 40 By No.74 Squadron, Hornchurch.Essex.

Aircraft Type and No.	Crew.	Duty.	Time Up.	Time Down.	Remarks.
~~Spitfire I.~~					
K.9992	P/L. Crosby.		1300	1505	Patrol as ordered.
K.9951	F/O.Mungo-Park.		1300	1505	" " "
K.9875	Sgt. Bushell.		1300	1505	" " "
K.9871	F/S. Mayne.		1240	1345	Patrol as ordered.
K.9862	F/O. Hoare.		1240	1345	" " "
K.9931	Sgt. Skinner.		1240	1345	" " "
N.3091	F/O. Measures.		1315	1405	Standing Patrol.
K.9867	P/O. Cobden.		1315	1405	" "
K.9957	P/O. Aubert.		1315	1405	" "
K.9952	P/O. Freeborn.		1355	1355	Air Test.
K.9873	Sgt. Flinders.		1540	1600	From Hornchurch to Rochford after Inspecti and change to 100 Oct. Fuel.

RAF 100 Octane Fuel Trucks. US 150 Octane. Mid-1944.

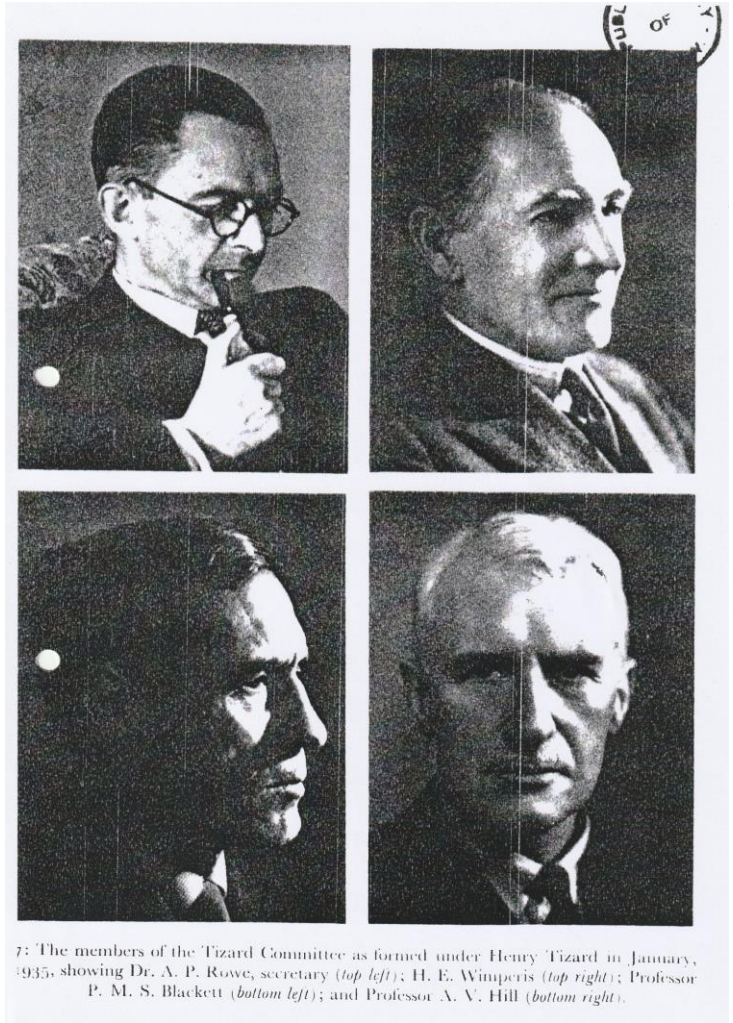
UK Radio Research Board 1928- Tizard at Imperial College 1929-1942. Adml.Sir Henry Jackson FRS & Edward Appleton.FRS.





RRB (UK & Aust.) Watson-Watt. Leonard Huxley.

Tizard Committee 1935.(Scientific Survey of Air Defence).



7: The members of the Tizard Committee as formed under Henry Tizard in January, 1935, showing Dr. A. P. Rowe, secretary (*top left*); H. E. Wimperis (*top right*); Professor P. M. S. Blackett (*bottom left*); and Professor A. V. Hill (*bottom right*).

COPY. 161 St.James' Court,
S.W.1.

18.6.36.

Dear Lindemann,

No doubt you already know that as a result of your personal criticisms to Winston Churchill he made a written attack on the Research Committee without taking the trouble to ascertain my views first. I was obliged to answer this categorically, whereupon he followed up in Committee with other wild criticisms presumably based on information from you. Needless to say I have no objection to your discussing with him the work of our Committee - on the contrary everyone concerned would welcome this if the object were to produce fresh ideas and constructive suggestions. But if the only result is to produce ill-founded criticisms then I am bound to say that however good your ultimate motives are, the only effect of your actions is to retard progress. I should really enjoy working with you if you were ready to work as a member of a team, but if you are playing another game I don't think it is possible for us to go on collaborating without continual friction. I have told Swinton this - so you ought to know.

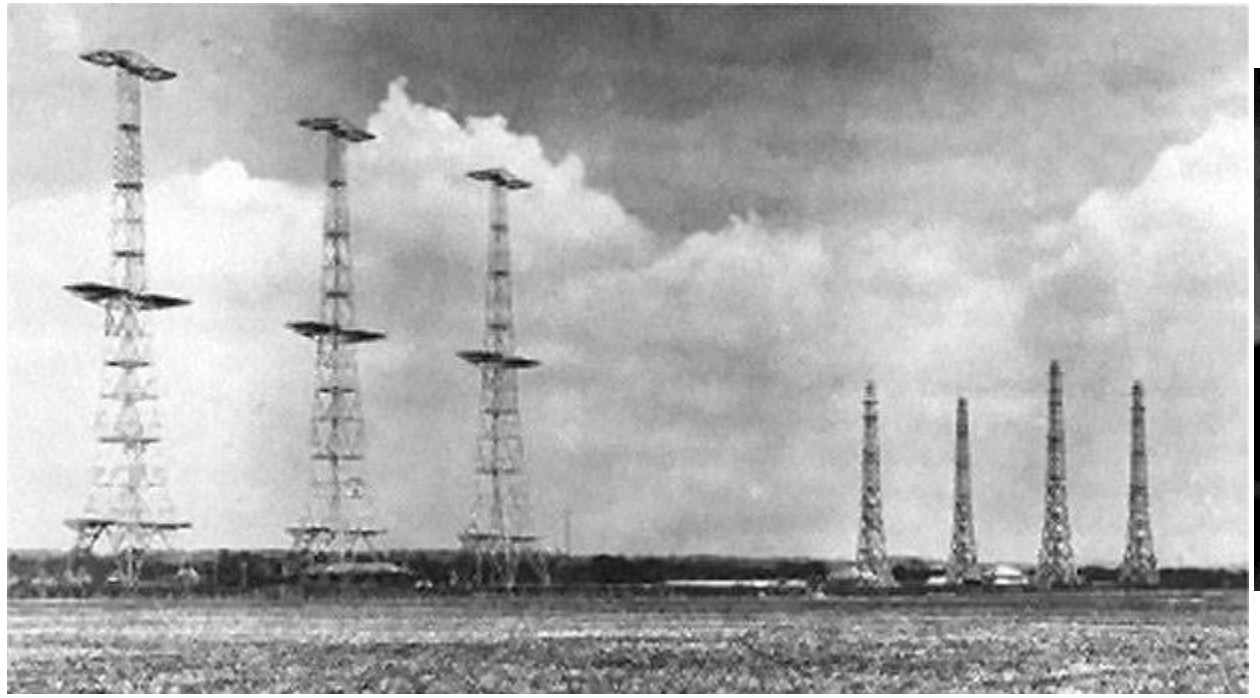
I wish we could have settled such differences of opinion that exist in a friendly manner in our own Committee, but you have made this very difficult, if not impossible.

I am writing a general statement about the policy underlying the priority attached to different items of our work. I will let you have this next week. If agreed by members it will be circulated to the G.I.D.Committee.

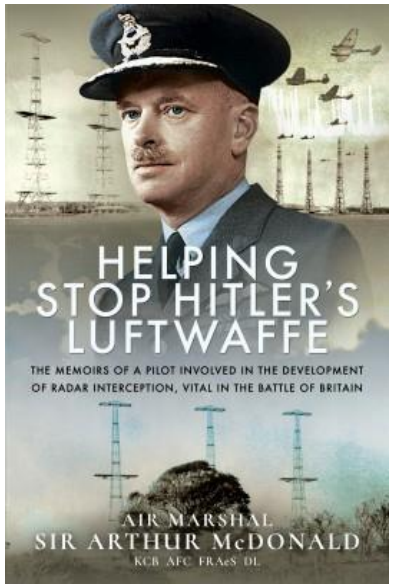
Yours sincerely,

(signed) H.T.Tizard.

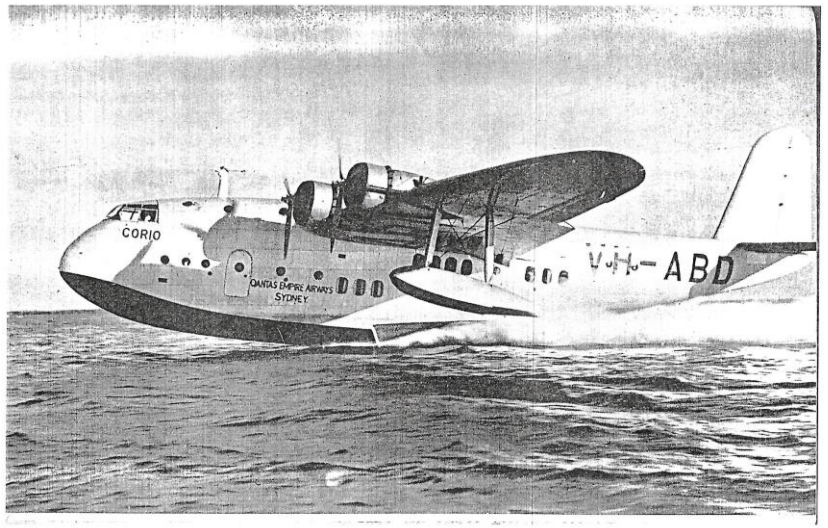
Biggin Hill Experiment 1936.



Biggin Hill Experiment. Dowding System.



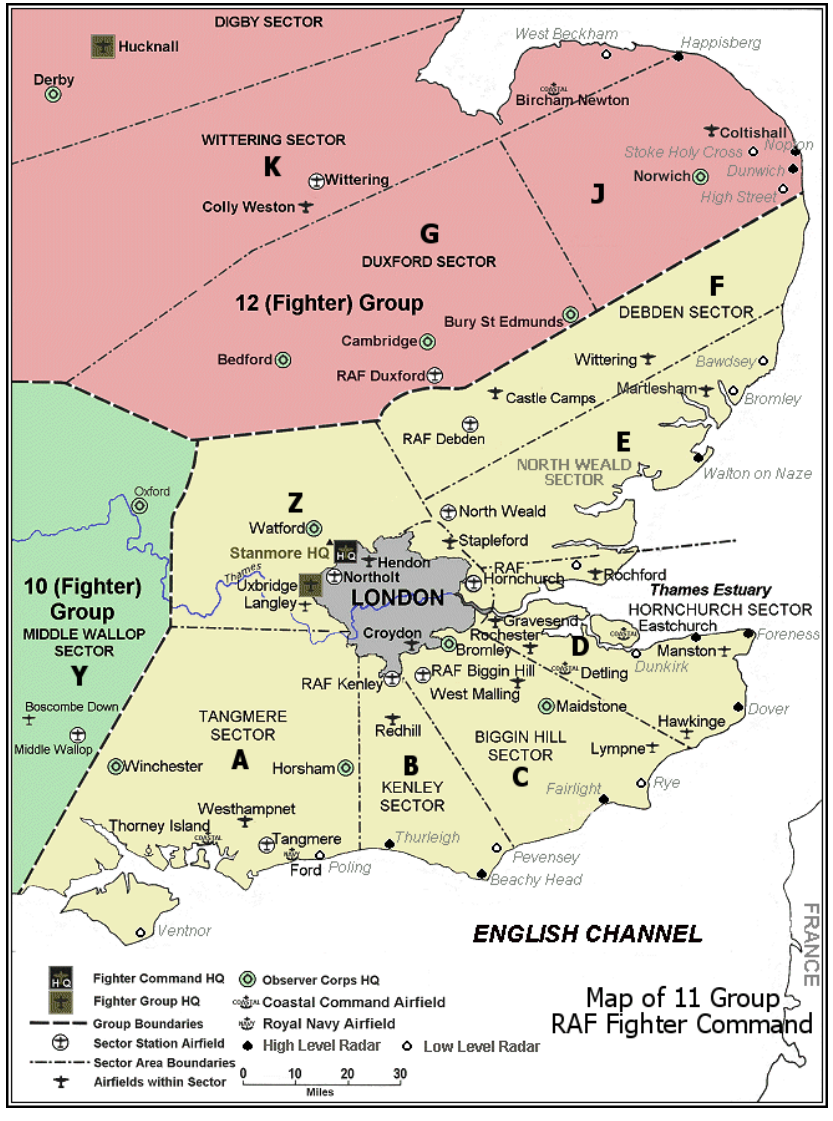
Watson-Watt. 1939.



The Deputy Chief of Air Staff and I discussed doing this, and it was arranged that the Secretary of State should meet the High Commissioners in London to tell them about R.D.F. At a meeting with them which I attended on 24 February 1939 he made a "most secret" statement of which the text is of historic interest. It was agreed that High Commissioners should cable their governments suggesting that a physicist should be sent to U.K. at an early date to study a security device connected with air defence. With pleasing foresight, Canada and Australia both sent radio-physicists who had worked with me at Radio Research Station Slough; Dr. J.T. Henderson had studied the Instantaneous Visual Radio Direction Finder there and had then used a copy built by us for his researches in Canada, Dr. D.F. Martyn had been attached to us, to familiarize himself with all our radio research work, on his appointment, from Glasgow University, to the Radiophysics Laboratory of the Australian Government's Council for Scientific and Industrial Research. New Zealand sent Dr. Ernest Marsden, Secretary of its Department of Scientific and Industrial Research, and a former researcher under Rutherford. Marsden had lit one of the very earliest beacons that were to illuminate the long road to the release of nuclear energy. South Africa appointed Major General Hoare and Major Wilmott.

The pleasure of discussing R.D.F. with these old and new friends was soon to be supplemented by the privilege of demonstrating to, and discussion with, Professor Sir John Madsen of the University of Sydney, and subsequently with distinguished visitors at ministerial level, S.M. Bruce and Richard Casey of Australia, Walter Nash and Peter Fraser from New Zealand, General "Andy" MacNaughton and (later) C.D. Howe from Canada. We drew a great deal of encouragement and inspiration from all of them, and the war effort benefited very notably by contributions, to radar development, production and application, which were made by workers in and from all four of these commonwealth countries.

Battle of Britain 11 Group. Sir Keith Park.



11 Goup B of B Plotting Table, Uxbridge.

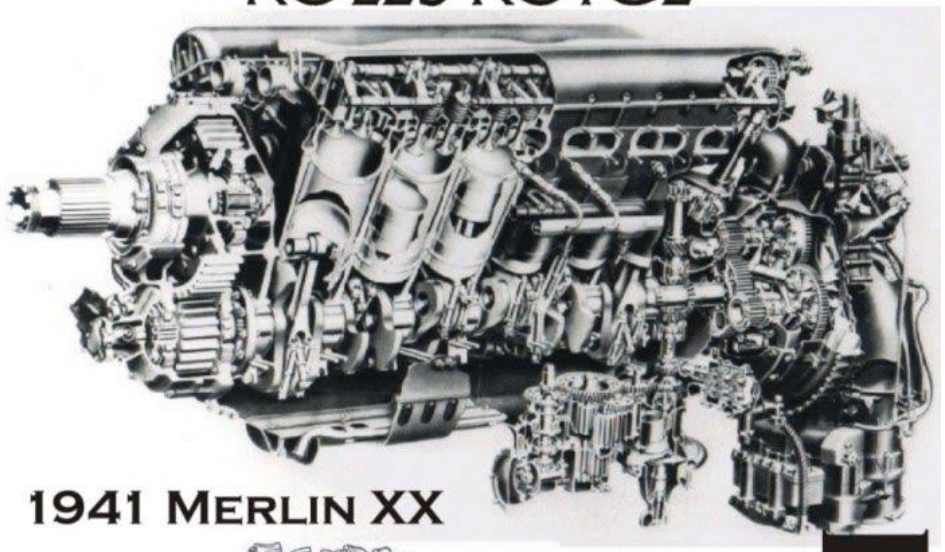
Constant Speed Propellers & Rotol, B of B.
Sqdn Ldr. Desmond Cooke. Beatrice Shilling of RAE.

Biggin Hill B of B. Hurricane.

B of B. Spitfire.(“Dowding Spread”-750 feet.) Point Harmonisation.

B of B Merlin Engine. Bentley Prior.

ROLLS-ROYCE



1941 MERLIN XX

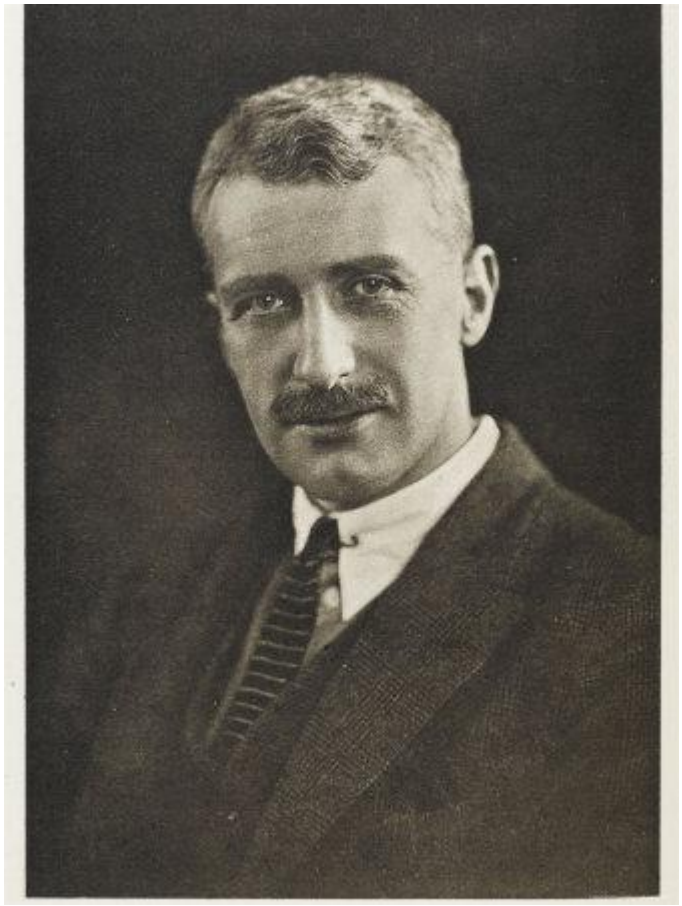
BUILT IN MARCH 1941 AT GLASGOW. FITTED TO BRISTOL BEAUFIGHTER IIF, SERIAL NO R2335, AND WAS USED BY THE FIGHTER INTERCEPTION UNIT TO ASSIST IN THE DEVELOPMENT OF RADAR.

V12 LIQUID-COOLED ENGINE WITH 48 VALVES OPERATED BY OVERHEAD CAMSHAFTS, SODIUM-COOLED EXHAUST VALVES. ALL-ALUMINIUM CONSTRUCTION WITH STEEL CRANKSHAFT AND CON-RODS. BORE AND STROKE ARE 5.4" AND 6", CAPACITY 27 LITRES. POWER IS 1280 BHP AT 10,000FT, AT 3000 RPM. THE 10.2" DIA CENTRIFUGAL SUPERCHARGER RUNS AT 8.15 OR 9.49 TIMES ENGINE SPEED AND MAXIMUM 12 LBS OF BOOST PRESSURE. THE AIRSCREW RUNS AT 0.42 TIMES ENGINE SPEED. FUEL IS 100 OCTANE AVGAS AT A MAXIMUM 3 GALLONS PER MINUTE! THE ENGINE WEIGHS 1450LB (658KG) GIVING A VERY HIGH POWER-TO-WEIGHT RATIO.

MERLIN

German Messerschmitt Me bf 109 E. 1940.(DB 601 V12 Engine, Direct Fuel Injection. 92 Octane).

Tizard Mission to US & Canada August 1940. Archibald Hill FRS.



Frisch-Peierls Super Bomb memorandum. Mark Oliphant.FRS.

U

~~Strictly confidential~~ 2

DECLASSIFIED

On the construction of a "super-bomb", based on a nuclear chain reaction in uranium.

The possible construction of "super-bombs" based on a nuclear chain reaction in uranium has been discussed a great deal and arguments have been brought forward which seemed to excluse this possibility. We wish here to point out and discuss a possibility which seems to have been overlooked in these earlier discussions.

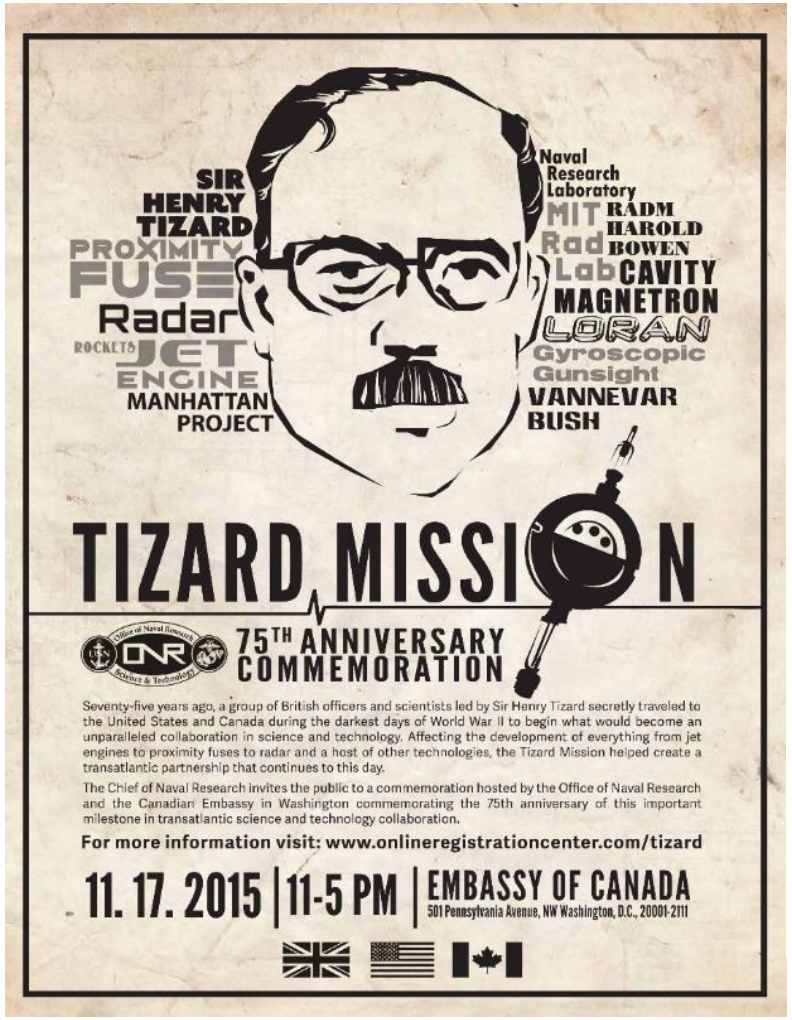
Uranium consists essentially of two isotopes, U_{238} (99.3%) and U_{235} (0.7%). If a uranium nucleus is hit by a neutron, three processes are possible: (1) scattering, whereby the neutron changes direction and, if its energy is above about o.1 MeV, loses energy; (2) capture, when the neutron is taken up by the nucleus; and (3) fission, i.e. the nucleus breaks up into two nuclei of comparable size, with the liberation of an energy of about 200 MeV.

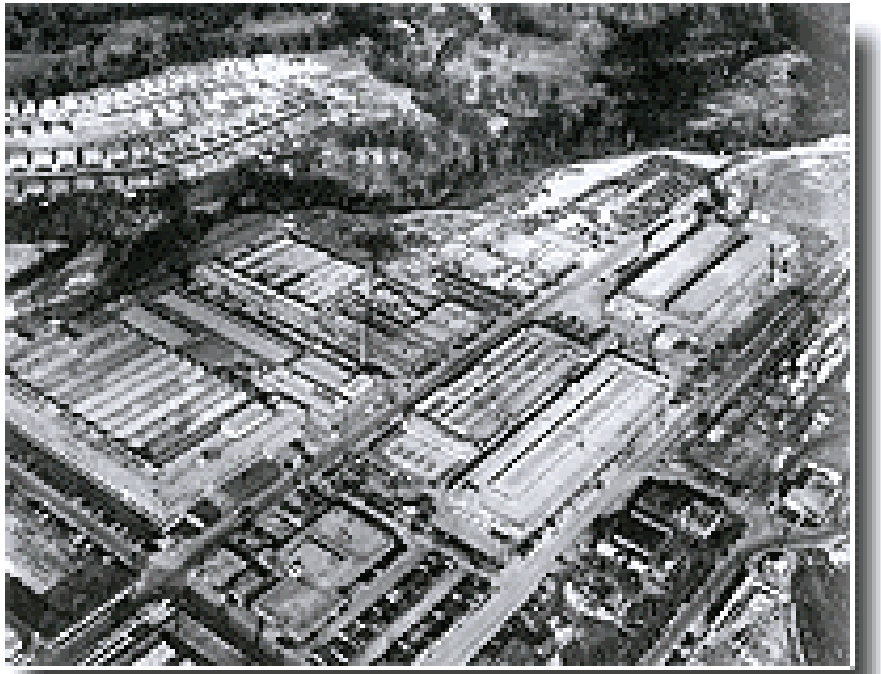
The possibility of a chain reaction is given by the fact that neutrons are emitted in the fission and the number of these neutrons per fission is greater than one. The most probable value for this figure seems to be 2.3 , from two independent determinations.

However, it has been shown that even in a large block of ordinary uranium no chain reaction would take place since too many neutrons would be slowed down by inelastic scattering into the energy region where they are strongly absorbed by U_{238}.

Several people have tried to make chain reaction possible by mixing the uranium with water, which reduces the energy of the neutrons still further and thereby increases their efficiency again. It seems fairly certain, however, that even then it is impossible to sustain a chain reaction.

Tizard Mission in Canada.





Research Enterprises Ltd.
(1944)

JPV Madsen Scientific Liaison to US. 1941.

Australian Legation,
Washington, D.C.,
May 15th, 1941.

Sir,

I have the honour to inform you that my Government has recently given consideration to the necessity for maintaining the closest possible liaison with Great Britain, Canada and the United States of America regarding scientific matters connected with problems of defence.

The Commonwealth Government, which has already established close scientific liaison with the United Kingdom Government, is convinced that the Australian war effort can be substantially increased if the scientific liaison already established by Australia with Great Britain can be extended to Canada and the United States.

In this connection it is understood that, following upon the arrival in North America of a scientific delegation from Great Britain led by Sir Henry Tizard, the necessary steps have been taken to establish full cooperation of this kind between Great Britain, Canada, and the United States.

In the hope that the United States Government may feel able to extend to Australia the facilities for more direct scientific contact which have already been granted to Canada, my Government has appointed Professor J.P.V. Madsen of the University of Sydney, to direct Scientific Research Liaison for Australia. Professor Madsen has now arrived in Washington and is ready to proceed with the establishment of the necessary Australian scientific organisation in America as soon as the formal assent of the United States

The Honourable
Cordell Hull,
Secretary of State of the United States,
Washington, D.C.

...fic Radio Research Board

The Author :

G. H. Munro, M.Sc., is a graduate of the University of New Zealand.

After graduation, as a National Research Scholar, he carried out radio research in New Zealand, which led to one of the earliest estimates of the height of the Heaviside Layer.

He then joined the British Radio Research Board and worked for three years, mainly with R. H. Barfield on radio field strength surveys and direction finding.

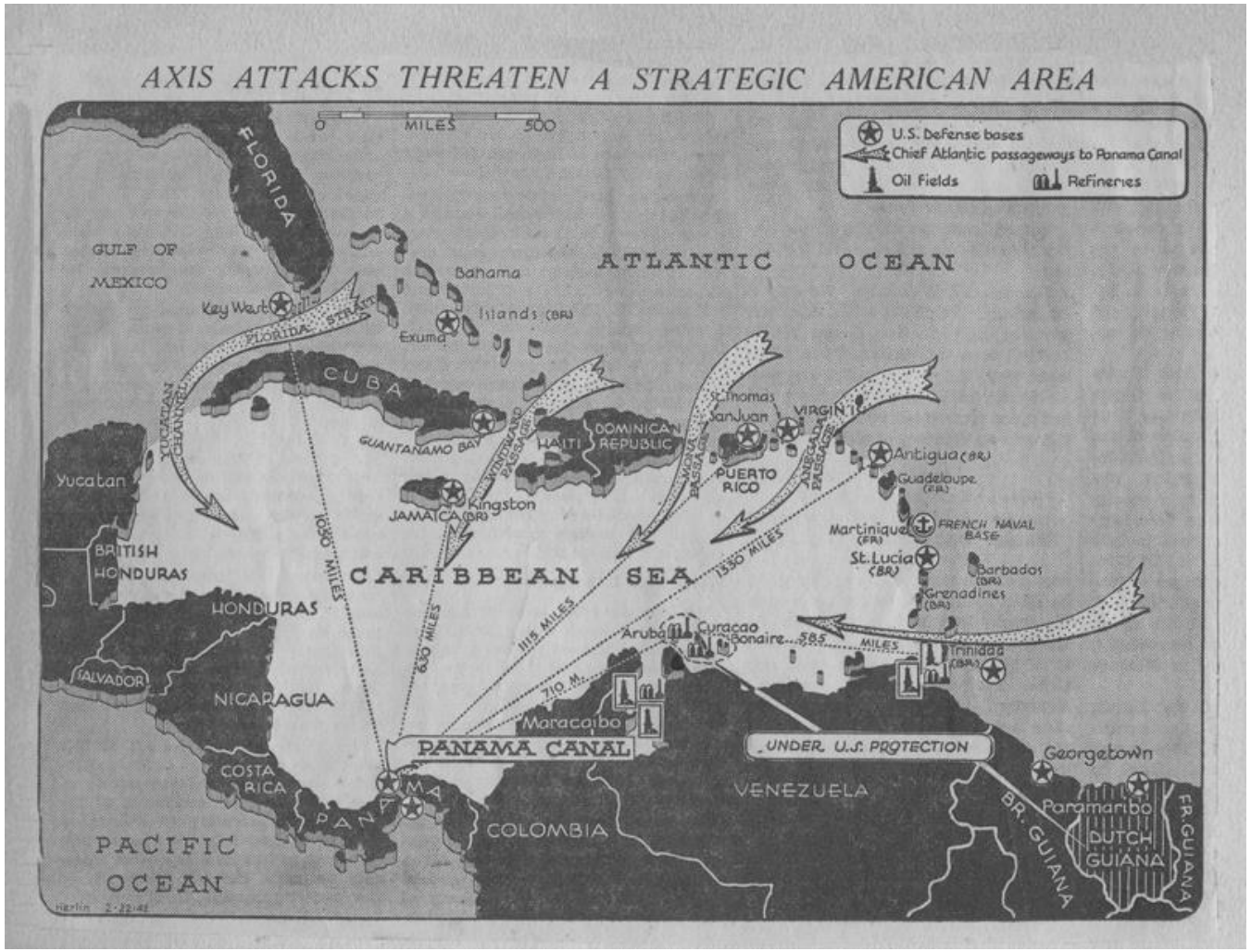
In 1929 he joined the Australian Radio Research Board of C.S.I.R.O., working first in Melbourne on the investigation of atmospherics and subsequently in Sydney on ionosphere investigations.

During the war he joined the Radiophysics Laboratory and then went abroad as Australia's first Scientific Liaison Officer, pioneering the Liaison Offices in London in 1940, and in Washington, D.C., U.S.A., in 1941. In Washington he was accorded the diplomatic status of Attache to the Australian Legation. As part of his duties, he represented Australia on a number of war-time scientific committees, in particular the Radio Propagation Committee.

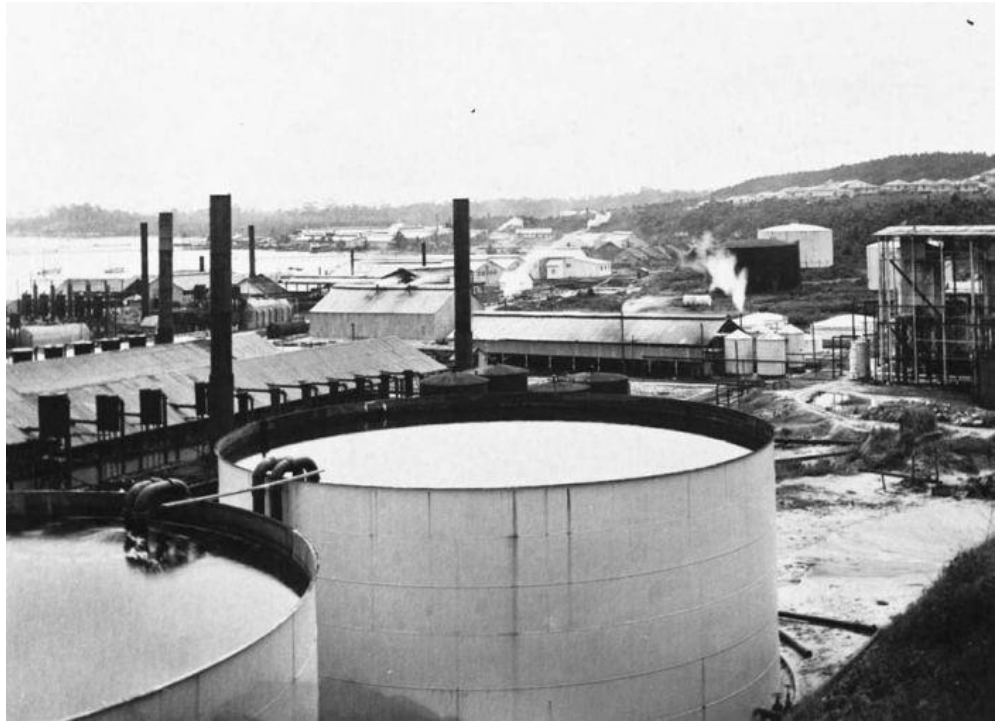
Mr. Munro returned to Australia in 1945 and in 1946 rejoined the Radiophysics Laboratory. In 1947 he was transferred back to the Radio Research Board as Officer-in-Charge of the Sydney Section, to resume fundamental investigations of the ionosphere.

UK Aviation Fuel WW2. Heysham, Abadan.

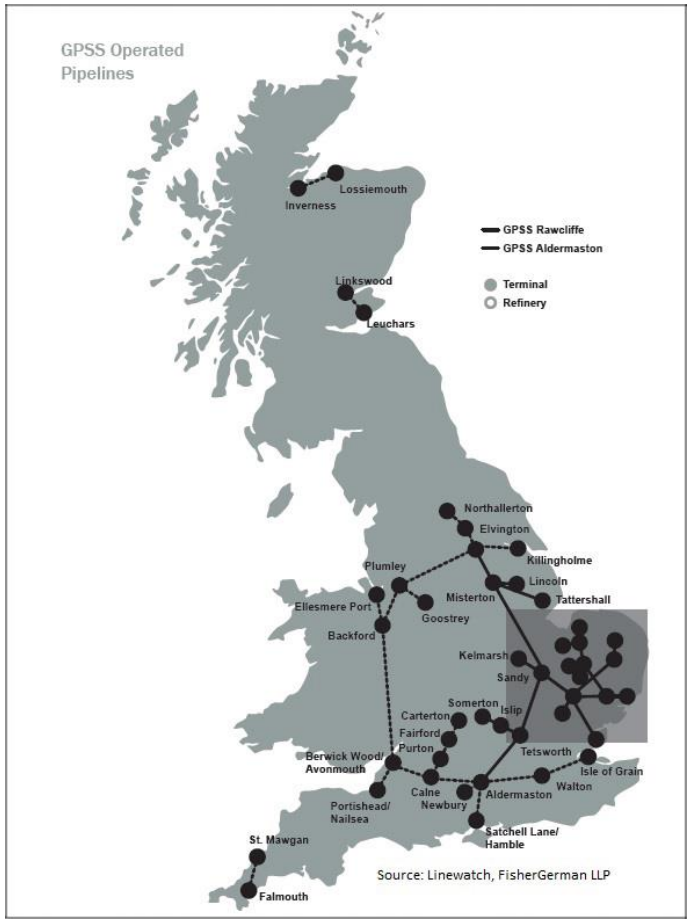
Aruba Aviation Fuel, Haifa Oil.

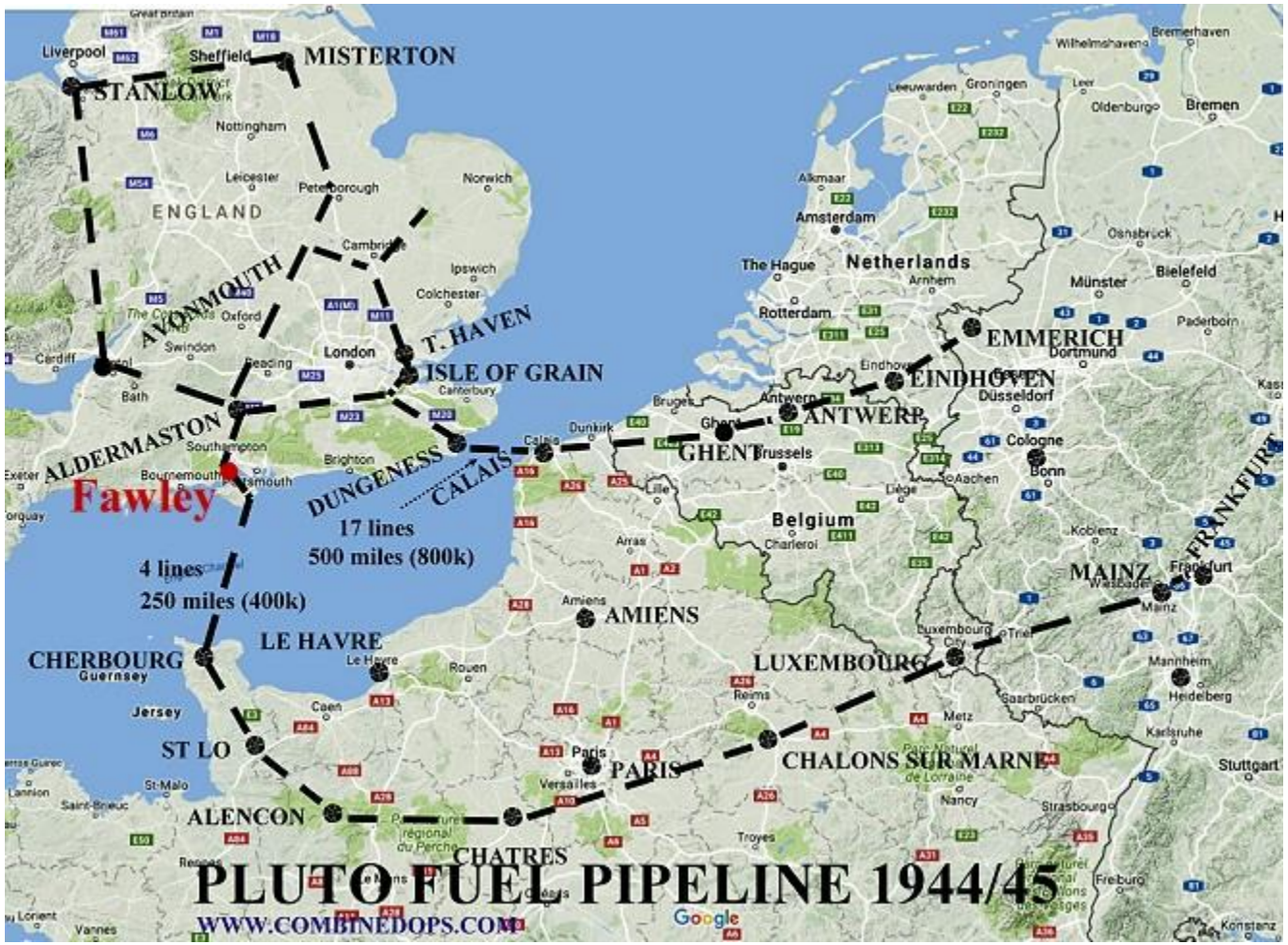


Shell Oil Borneo: Balikpapan “Ploesti of Pacific”.(Malaya Latex)

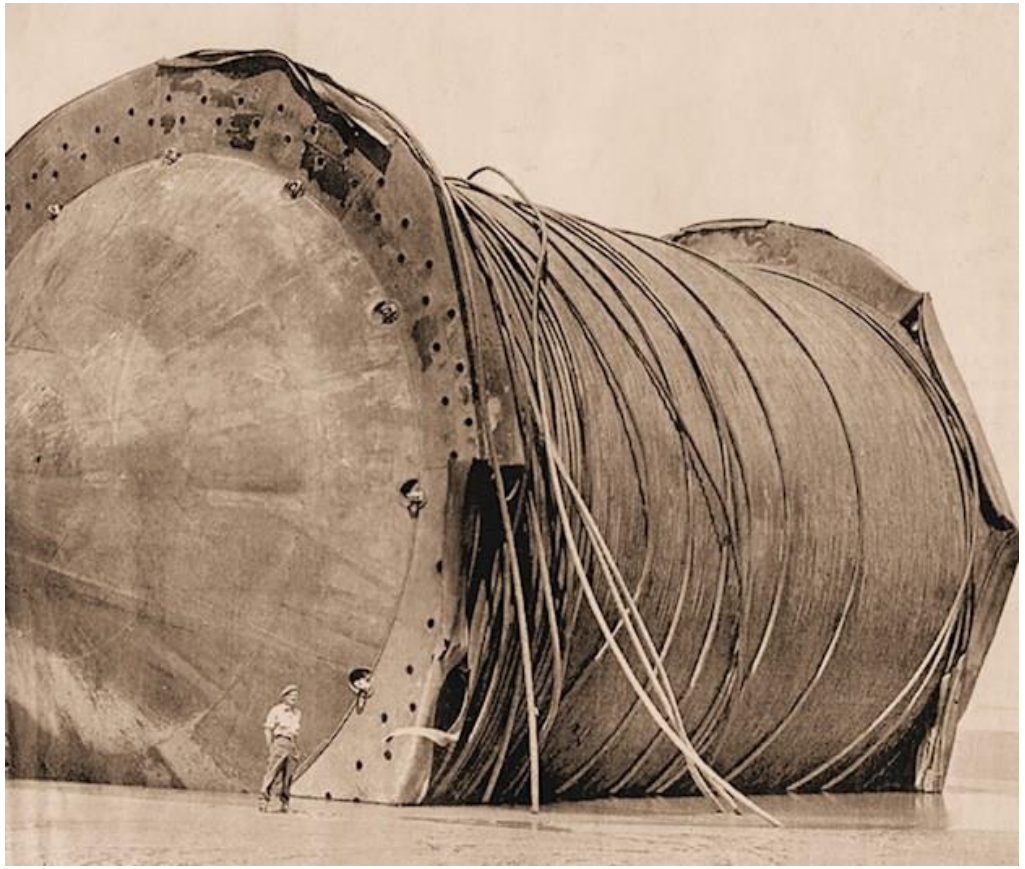


UK GPSS (Govt.Pipeline & Storage) & Pluto.



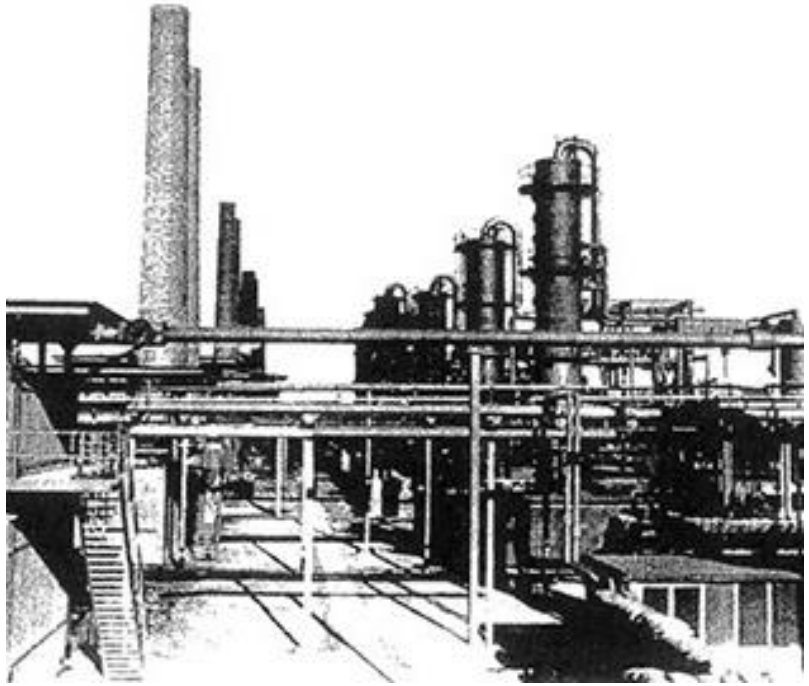


UK Pluto & Conundrum 1944.



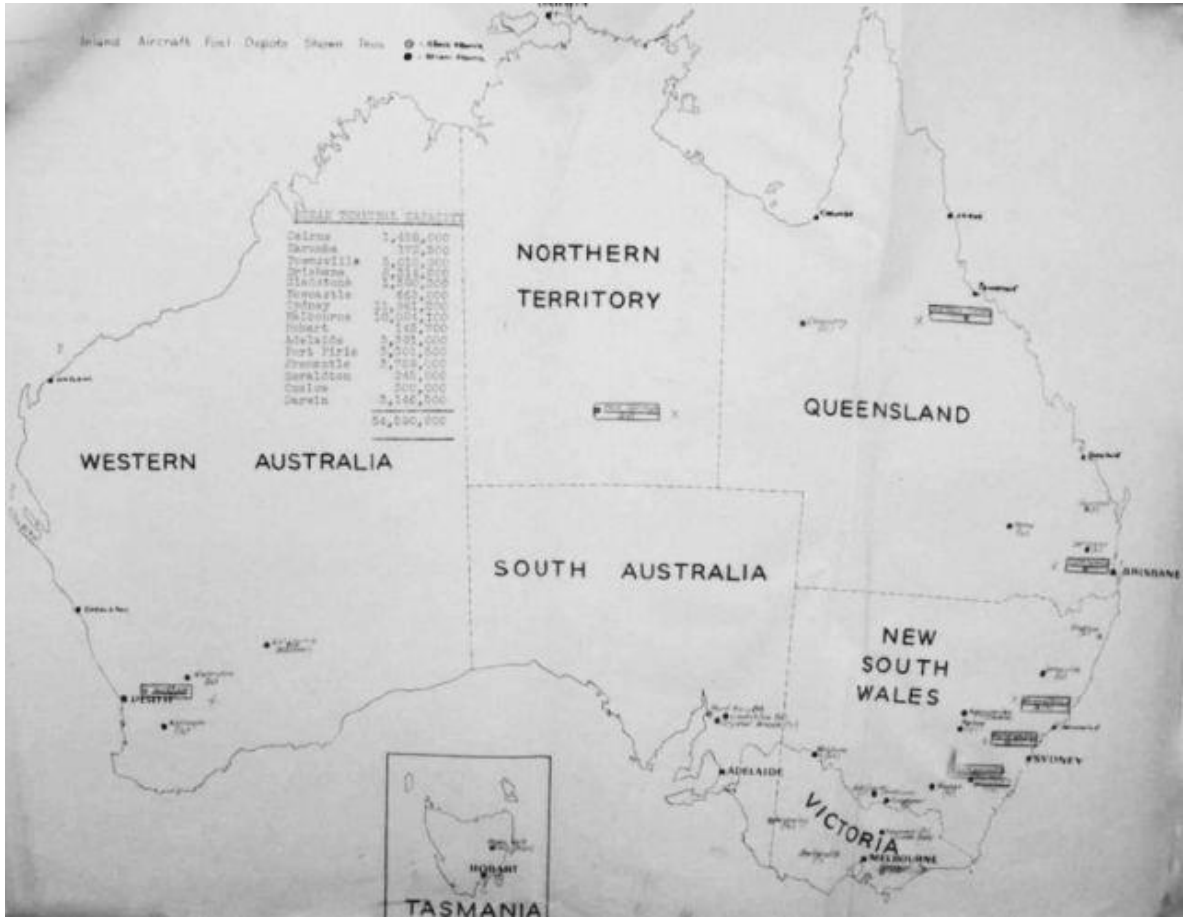
US Aviation Fuel Distribution. Hand Pump at Henderson Field -Guadalcanal.

German Synthetic Fuel, “Jerry Can”



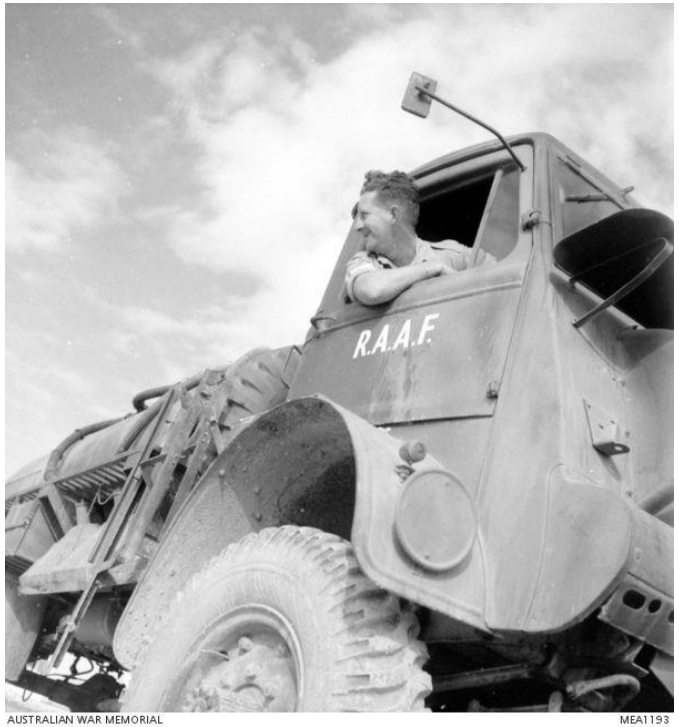
Japanese Aviation Fuel for Zero.

Australian Inland Aviation Fuel Depots & Supply.1943. Shell Clyde Refinery Pre-1942.



WW2 Australian Aviation 100 Octane.
B 17 & P-40 KittyHawk.(TetraEthylLead additive).

Australian Fuel Ration. RAAF in Middle East & Beaufighter.



AUSTRALIAN WAR MEMORIAL MEA1193

Sir Ben Lockspeiser FRS, 1948. CSIRO.

CSIRO

CSIRO 1949-Ben Chifley, Ian Clunies Ross, Frederick White.FRS. Clement Attlee, R G Casey .

Sir Henry Tizard FRS, J P V Madsen & Sir David Rivett FRS (1908-1949).

R.W.Madsen -October 2020.

Introduction.

The connection of Sir Henry Tizard (1885-1959) to Australian science dates back to 1908 when he & Sir David Rivett (1885-1961) were studying Chemistry at Magdalen College, Oxford while David was on a Rhodes Scholarship. Over the next 40 years both were to become leading science administrators in the UK & Australia, & Henry Tizard with his considerable interest in Australia & Canada provided valuable assistance to Sir John Madsen (1879-1969) at the Australian Radio Research Board, & the Radiophysics Laboratory (1941-1945) in WW2 & also to the Australian Prime Minister Ben Chifley (1885-1951) in 1948 when Chifley was devising legislation for the formation of CSIRO in 1949 which followed on from the CSIR organisation founded in 1927 in which David Rivett led with George Julius (1873-1946) as Chairman.

Tizard's interest in Australia was greatly influenced by his journey on the EURIPIDES in 1914 in the company of many leading English scientists (including Ernest Rutherford [1871-1937]) to attend the 84th BA Meetings (British Association for the Advancement of Science) held across Australia in August just at the time War was declared. The friendships Tizard made were of considerable assistance throughout his career & came about by the cancellation of a delegate to the Meeting & Tizard came as a substitute where the Australian Commonwealth Government paid for the passage in order to bring leading scientists to Australia as organised by David Rivett who was Secretary to the Australian Organising Committee.

There appear to be four distinct phases in Tizard's work for the UK Air & Defense ministries between 1920 & 1952:

- In 1920 the identification with Shell that the best aviation fuel for aircraft engines was Toluene & Tizard devised a grading system (octane number from 1932) relative to Toluene. The BAM100 100 octane aviation fuel for the RAF used in the Battle of Britain (July-September 1940) was crucial.
- In 1935-37 as Chairman of the Committee for the Scientific Survey for the Defence of Britain RDF was identified as the best means of avoiding standing patrols to obtain warning & carried out the "Biggin Hill Experiment" in 1936-37 to devise an operational system ("Dowding System") over the next 2 years to be ready for the expected German onslaught which was defeated by the slimmest of margins.
- In August 1940 he led the "Tizard Mission" to Canada & the US with all Britain's wartime secrets to be given with no strings attached, & included the high frequency cavity magnetron for radar which he had encouraged Mark Oliphant to work on at Birmingham University. JPVM led the Australian Scientific Liaison Mission to the US from May 1941 as a direct follow on from the 1940 Tizard Mission.
- Post War from 1946 to 1952 Tizard was Chairman of Committees within the Ministry of Defense dealing with Defense Research Policy & Science (but initially not including work on atomic weapons).

Besides Tizard's 1914 visit to Australia he came to Australia at the invitation of the Australian Government in 1943 & 1948 & he also met (with Sir Ben Lockspeiser FRS [1891-1990]) with PM Ben Chifley in London on July 13, 1948 to explain the UK approach to work of a secret defense nature in Government Departments & Universities which was a matter of pressing concern for Chifley.

Slide 1. Sir Henry Tizard, J P V Madsen & David Rivett.

All three were very much a product of the universities they trained & worked at & the coat of arms of Oxford, Sydney & Melbourne Universities are shown. The coat of Arms of the Royal Society is also shown. Both Tizard & JPVM were First Class in Mathematics at University.

Slide 2. Henry Tizard (Getty Image), **J P V Madsen, David Rivett** (Centre), **George Julius** (left), **& Arnold Richardson** (CSIR Chief Executive 1946-49).

Slide 3. Thomas Henry Tizard FRS (1839-1924), Sir Peter Tizard (1916-1993), Greenwich Hospital.

Thomas Henry Tizard (Henry Tizard's father)was educated at the Royal Hospital School Greenwich noted for its advanced mathematical training & he entered the RN in 1854. In 1872 he transferred to HMS Challenger which had been obtained by the Royal Society & equipped for scientific survey & exploration. He stayed with Challenger until 1876 when she was paid off & then spent 3 years assisting in writing up the narrative of the expedition. In 1879 he took charge of the Home Survey for 9 years & wrote many scientific papers & was elected FRS in 1891. He married in 1881 & had 5 children (1 son-Sir Henry).

Sir Peter Tizard was Henry's eldest son who qualified as a doctor in 1941 & served in North Africa & Sicily (1942-46) & became a very highly regarded paediatrician at Oxford University.

Slide 4. Challenger Expedition 1874. (Expedition 1872-1876).

The RS expedition of over 70,000 nautical miles doing survey & exploration work obtained 4,000 previously unknown species from around the globe. The award of CB (Companion of the Order of the Bath) was made to Thomas Henry in 1899 & also to Henry Thomas Tizard in 1927.

Slide 5. Australia BA Meeting 1914. RMS Euripides, Ernest Rutherford, BA Melbourne Ticket to Meeting.

Some 300 British (& even some German) scientists left England by ships (Euripides & Orvieto) for the 84 th British Association Science Meeting officially opened in Adelaide on August 8, 1914, 4 days after War had been declared in Europe. Chemist Orme Masson from Melbourne University was Chairman of the Organising Committee from around 1910 & David Rivett the organising Secretary for Meetings held in Adelaide (4 days), Melbourne (7 days), Sydney (7 days) & Brisbane (4 days) funded jointly by the Commonwealth & State Governments. Some 5,000 Australians enrolled as local members of the BA to attend lectures, discussions, visits to Universities, observatories, museums & excursions to points of interest. A very wide range of subjects was included including Maths, Physics, Chemistry & Biology. Ernest Rutherford was probably the most famous scientist to attend (he travelled out on the Euripides, a new Harland & Wolffe ship) & JPVM attended the meetings in Sydney.

Slide 6. David Rivett 1908-1918. (Svente Arrhenius [1859-1927] Left., **Orme Masson [1858-1937], Stella Deakin [1886-1976])**

David Rivett was the 2nd of seven surviving children to Albert (1855-1934) & Elizabeth a pacifist Congregational Minister living in country Victoria in the 1890's at Yarrawonga, Beechworth & Albury. The children were brought up with a distinctive self reliance & a necessity to compete for school scholarships & prizes which led to David's entry to Wesley College in Melbourne in 1899 & from there obtained a scholarship to Melbourne University's Chemistry School in 1903 under Orme Masson who was probably the most influential adviser, teacher & friend of David's lifetime.. In 1905 he graduated with 1st Class Honours in Chemistry & in 1907 received a Rhodes Scholarship to Oxford

where he spent 3 years mainly doing research work at the bench shared with Henry Tizard at Magdalen College. From July 1910 for 6 months David had the very good fortune to be allowed to work with the very famous Nobel Prize winning physical chemist Svente Arrhenius at the Nobel Institute of Physical Chemistry near Stockholm. David returned to Melbourne in February 1911 & married Stella Deakin (a research Chemist & daughter of a former Aust. PM Alfred Deakin) in November having returned to Chemistry at Melbourne University.

For 15 months through 1913 David was the organising Secretary for the 84th British Association for the Advancement of Science & involved much travelling with Stella in England & the Australian capital cities making the arrangements for the very successful Meeting. For the next 2 years David carried the duties of Registrar of the AGH in St Kilda Rd & then answered a call from Britain for a chemist to work in a new Brunner Mond ammonium nitrate factory at Swindon ("Stratton Works") 100 miles from London with Stella remaining in Melbourne. The new factory used ammonium sulphate & sodium nitrate whereas the other Brunner Mond factory at Plumley used calcium nitrate. David obtained a Patent in May 1918 (No. 8228/1918) for improvements in the production of ammonium nitrate. In 1918 where David was the process manager at Swindon, 24,000 tons of ammonium nitrate was produced to be used in Amatol. Brunner Mond in 1926 became one of the founding companies in ICI.

Slide 7. Henry Tizard & J P V Madsen 1914-18.

Henry Tizard returned to England from Australia in early October & after a brief time with the Royal Garrison Artillery arranged to transfer to the Royal Flying Corps to undertake experimental work at the Central Flying School. He gained permission to learn to fly (3 ½ hours dual, 2 hours solo) & in January 1916 became a fully qualified pilot, which he loved doing up to 15,000 feet especially in Be2C aircraft of the Royal Aircraft Factory. He stimulated development of better equipment for aircraft such as instruments for performance (speed, rate of climb & ceiling). At the end of 1915 Tizard met Bertram Hopkinson FRS [1874-1918] (a Cambridge Professor of Mechanical Sciences who had joined the War Office in Military Aeronautics) who made a permanent impression as to mature judgement & how to get the best out of people working under him, being advised rather than ordered. Hopkinson died tragically on August 26, 1918 when his Bristol Fighter crashed en route from Martlesham Heath to London & apparently became disorientated in cloud. Tizard flew a Sopwith "Dolphin" to France to be compared with S.E.5's & also met Trenchard.

In 1918 Tizard was invited by Hopkinson to go to London as his deputy as Assistant Controller Research & Experiment (firstly as a Major & then as Lt. Colonel.) An almost accidental discovery that Toluene from Burma could be used in aircraft fuel to give even better performance than the fuel derived from Pennsylvania Oil led to his continuing interest in fuels for aircraft engines. Tizard took over from Hopkinson until the end of the War & then returned to Oxford.

During WW1 JPVM was Chief Instructor & then Commanding Officer of the Engineer Officers Training School at Roseville & is especially noted for an excellent Military Display (including night trench fighting) held at the Roseville camp on December 1, 1917 between 3.00 pm & 10.00 pm.

Slide 8. Toluene, Octane Rating – TetraEthylLead 1920's.

Towards the end of 1918 it was jointly agreed between Henry Tizard, Dr. R Pye (Oxford University) & consulting Engineer Sir Harry Ricardo who obtained a 3 year research contract from Shell to investigate the properties of different aviation fuels. Starting in the summer of 1919 under terms of reference from Shell who provided financial backing, fuel samples & 2 research engines (a variable compression engine & another of Tizard's suggestion which could make one rapid stroke & then be

locked at top dead centre- the “Sphinx” it looked like). The laboratory was done at Ricardo’s Shoreham (a seaside town in West Sussex) factory & Tizard devised ingenious tests & was very astute in analyzing results & drawing from them the right conclusions. It was confirmed that the incidence of detonation was the most important single factor limiting the performance of the petrol engine & at Tizard’s suggestion this was expressed in terms of a Toluene Number .ie.the proportion of toluene (the least prone to detonate of any of the hydrocarbon fuels tested, which had to be added to heptane (the worst) to match the fuel under test, for a straight line relationship in blending of these two.(The Americans substituted iso-octane for toluene & the term ”octane number” has become universal).

The upper formula shown is iso-octane which has octane rating of 100 & the lower formula is n-heptane, octane rating 0. In 1935 the British owned Anglo-Iranian Oil Co. obtained iso-octane by the alkylation process.

On December 9, 1921,2 General Motors chemists (T.Midgels & C.Kettering) synthesised TetraEthylLead & tried it in their one cylinder laboratory engine & knocking abruptly disappeared. The Ëthyl”additive required in fuel was one part per thousand & cars started to fill up with Ethyl Gas on February 2, 1923 as per the photograph in Dayton Ohio.(The public health risk was not dealt with for 50 years- in 1924 dozens of employees at Standard Oil Refinery Bayway NJ were sick & 5 died after handling the additive).T.E.L was a vital component of high octane aviation fuel in WW2 used by all sides, Allied & Axis.

[The Refiners Oil Co. Ethyl Gas. Anti-knock gasoline. Product of General Motors Research Corporation.]

<u>Slide 9.</u> RAF BAM 100 Octane December 1938, Battle of Britain, WW2.

The RAF receipt of December 2, 1938 is for 8,142 gallons of 100 Octane fuel from Anglo-American (ie. Esso-contract of August 6, 1937) & Shell Mex/ BP. The Operations Record on May 15, 1940 is for the conversion of Spitfire 1 to 100 Octane fuel at Hornchurch. Independent of US experiments, from 1936 Anglo-Iranian Oil had been developing another (ie. not low benzole) high octane leaded fuel suitable for British aviation based on high-benzole Venezualan crude oil with iso-octane from their British refinery at Abadan, near the Persian Gulf. Bulk supply contracts were placed by the Air Ministry in 1937 for this fuel & put into wide spread use in the RAF in March 1940 (it was dyed green to distinguish it from 87 octane dyed blue).

By the end of the Battle of Britain, in November 1940, UK supplies of high octane aviation fuel were derived from 3 Esso refineries handling Venezualan oil (2 in the US & 1 in the Caribbean, Aruba-about 45%), the Anglo-Iranian oil refinery at Abadan (25%), & Shell refineries in Borneo (30%). (The Anglo-Iranian Oil Company (BP) had been granted a long term concession in 1933 for a 20% share of the profit from Abadan to Iran).

In November 1940 “Flight Magazine” (published since 1909) reported that a large number of enemy engines had been captured & many were of recent manufacture & only of short use. All the German engines for military operation were found to contain 92 octane leaded fuel in the tanks. The DB 601A (Daimler Benz V12 engine) used in the ME109 fighter was designed for 87 octane so higher grade fuel was apparently not yet short.

<u>Slide 10.</u> RAF 100 Octane Fuel Trucks. US 150 Octane Truck-mid 1944.

The standard 100/130 grade fuel was used up until mid 1944 when the higher grade 100/150 started to come into use especially for the Merlin engine P-51 fighters & other fighters. A necessary

component of the 150 fuel was xylidine (an acutely toxic chemical) which was drummed for shipment. The use of higher octane fuel for existing engines benefited by increasing the pressure delivered by the superchargers. After the war, an examination of German aviation fuel production indicated that Germany had very similar octane levels.

<u>Slide 11.</u> UK Radio Research Board 1928- Tizard at Imperial College 1929-42. Admiral Sir Henry Jackson FRS (1855-1929) & Edward Appleton.(1892-1965) FRS.

In September 1920 Tizard left Oxford to join the newly founded D.S.I.R (Department of Scientific & Industrial Research) set up as a reaction to German pre-eminence in science prior to the War, especially in Chemistry. The idea was to co-ordinate the scientific work of the Defence & Civil Departments via 4 co-ordinating Research Boards (Chemistry, Physics, Engineering & Radio Research). Tizard's role was to take charge of these Boards, however the original terms of reference given to the Boards needed to be modified to abandon the co-ordinating functions & have Directors of Scientific Research in each of the Services. Admiral Sir Henry Jackson (1855-1929) FRS the pioneer of radio services in the RN from 1895-1900, was the first Chairman of the RRB (1920-1929) where Robert Watson-Watt was the Director at the Research Station Slough doing work on atmospheric interference with radio transmissions, direction finding & radio frequency measurement. Tizard took a keen interest in the RRB & in 1935 it was this work which led to RDF/radar.

In 1928 a selection panel, arranged by JPVM, consisting of Ernest Rutherford (Cambridge), Henry Tizard (DSIR) & Edward Appleton (1892-1965) was to choose 4 physicists to join the Australian RRB viz. D F Martyn, George Munro, Leonard Huxley & A L Green for initial contracts of 3 years in the very difficult period of the Great Depression. On his tour to England & America in 1927 JPVM was also able to attend a meeting of the UK RRB & was offered a copy of their current research programme. Appleton was Professor at Kings College London & worked on investigations of the ionosphere for which he received the 1947 Nobel Prize in Physics.

In 1929 Tizard became the Rector (ie. Chief Executive)of the Imperial College in London founded by Royal Charter in 1907 merging the Royal School of Mines & Royal College of Science & others, until 1942 & during this time continued his roles with the Air Ministry on Committees dealing with the Air Defence of the UK. In later years the University coat of arms was modified to be less Imperial but still very much a research University.

<u>Slide 12.</u> RRB (UK & Aust.) Watson-Watt (1892-1973), Leonard Huxley (1902-1988).

Radio Research, Australia1927-1939 (1974 Academy of Science paper by Sir Frederick White FRS & Sir Leonard Huxley) deals fully with the pioneering work led by JPVM as Chairman of the Aust. RRB especially concerning the ionosphere but so willingly initially assisted by Watson Watt & the polarisation work of Dr. A. L Green who had worked with Appleton at King's College on regions of the ionosphere. Leonard Huxley, whilst not appointed with any special radio experience he was to succeed JPVM as Chairman of the RRB in 1958 & became the Vice Chancellor of the Australian National University 1960-67.

<u>Slide 13.</u> Tizard Committee 1935. (Scientific Survey of Air Defence).

"Taffy" Bowen in his book "Radar Days" explains that the 1st meeting of the Tizard Committee was in January 1935 to consider effective means to defeat the expected bomber onslaught using carefully husbanded anti-aircraft fire & fighter intercepts to prevent the bomber "always getting through". The prior experience of Committee members from WW1 (Hill in the Army as an artillery officer, Blackett in the Navy & Tizard in aeronautics) were complementary & Watson-Watt's famous

memorandum was submitted to the Air Ministry on February 12, 1935.very soon after the Committee's 1st meeting.

From top left in the photographs: Dr. A.P.Rowe (1898-1976) (Secretary & personal assistant to Harry Wimperis). Harry Wimperis (1876-1960) a personal friend of Tizard's (& also Rutherford's) & 1st . Director of Scientific Research at the Air Ministry, Prof. P.M.S. Blackett FRS (1897-1974) (on Rutherford's nuclear team at Cambridge) & Prof. A.V. Hill FRS (1886-1977)(a Nobel Prize winning Physiologist).

Churchill had got Frederick Lindeman onto the Committee to achieve his ends of anti-Hitler measures but the well known disruption is set out in Tizard's letter of June 1936 & the Committee had to be reformed without Lindeman who was replaced by Appleton when Blackett & Hill resigned.

Wimperis on his retirement in 1937 from the Air Ministry was invited by the Australian Government to come & advise on the steps needed to set up an aircraft industry in Australia in response to the Japanese threat . JPVM in Melbourne was drawn aside by Wimperis to ask if he had any idea what air defence measures might be happening in the UK & JPVM said he thought radio location was being developed which was a matter of great consternation to Wimperis as all the work on RDF in the UK was "Most Secret".

In 1946 A. P. Rowe came to Australia as Chief Scientific Adviser on the British rocket programme & for 10 years from 1948 was Vice-Chancellor of the University of Adelaide.

<u>Slide 14.</u> Biggin Hill Experiment 1936.

In December 1935 the Air Staff asked for 1,000,000 pounds to build a set of 5 Chain Home stations to provide air warning over the approaches to the Thames estuary, which went ahead to the credit of the secretary of State for Air, Lord Swinton. Tizard realised it was necessary to have a co-ordinated system to best use the RDF warning information & instigated the "Biggin Hill Experiment" over 7 months from the Summer of 1946. Hugh Dowding had become C in C of Fighter Command on July 6, 1936 & 4 key RAF personnel became engaged (Wing Cmdr. E O Grenfell [1890-1964], A. McDonald [1903-1996], Sqdn.Ldr R L Ragg [1901-1973] a navigation expert, W P G Pretty [1909-1975]) & Dr. B G Dickins (1904?-) an operations research civilian scientist. "Biggin on the Bump" was to become a severely attacked station in the Battle of Britain & was central to the defence of London. It was much later that low flying tactics by the Germans in coming up to London were considered & the CHL set on 1.5 mtrs as an adapted air-borne set were quickly installed on tall towers. In carrying out the experiment & devising tactics, it may be that the use of escorting fighters in large numbers (coming from as close as Calais) above the bomber raiders was not understood.

<u>Slide 15.</u> Biggin Hill Experiment- "Dowding System".

Quite apart from the filtering of radar & Observer Corps plots & Controller direction by R/T to pilots, an essential component of the Dowding System was that airfields of fighters, Hurricanes & Spitfires, who were engaged with enemy planes needed to be protected. 11 Group sectors were set up to defend London & 12 Group was to protect the airfields, but it appears that this did not always happen due to the ambitious commander of 12 Group, Leigh-Mallory.. The interchange of Squadrons between Groups & to different airfields to allow recuperation & refreshing of resources was a feature of Dowdings husbanding approach.

The Gloster Gauntlet was used to make intercepts on unsuspecting planes but it was flying at a much slower speed than those which were experienced in the Battle of Britain=300 mph +. The basic system was ready by early 1939 & from August 11, 1939 Bomber Command was asked to do mock

attacks from France & reports from 11 Group were enthusiastic with intercepts being made on the coast. Attacks by the Luftwaffe on the Chain Home stations were at times crucial with a 100 mile gap being experienced in radar cover before stations were brought back on air but if these attacks on radar stations & airfields had continued the outcome of the Battle of Britain may well have been different. In clear weather with little or no cloud, raiders came over at such high altitude were almost invisible even to binoculars, with hundreds of aircraft flying in excess of 300 mph.

Slide 16. Watson-Watt 1939.

Sir Robert Watson-Watt in his account of British RDF/Radar "3 Steps to Victory" has a chapter "Sharing the Common Wealth" in which he describes how Britain decided to disclose its RDF secrets to 4 Commonwealth countries (Australia, Canada, New Zealand & Sth. Africa) in February 1939. D F Martyn from the Aust. RRB spent several months in England becoming familiar with the work that had been done, placing orders for equipment & arranging copies of plans & circuit diagrams & on his return, based on the information obtained, JPVM submitted a proposal to David Rivett at CSIR which was submitted to PM Robert Menzies which was adopted. This plan involved a Radiophysics Laboratory attached to the CSIR Standards Laboratory at Sydney University with an overseeing Radiophysics Advisory Board with JPVM as Chairman. In late December 1939 it was necessary for JPVM himself (accompanied by George Munro to stay in England on Liaison work) to fly (from Sydney on Qantas Corio) to England & revise the arrangements now that England was at War with Germany. This new plan was worked out by JPVM with Watson-Watt & submitted to Sir Philip Joubert de la Ferte & the Secretary of State for Air in January 1940. There was also a security problem that JPVM had to first resolve with Watson-Watt first. During the War JPVM kept in contact with New Zealand (& arranged for Fred White to come across from Christchurch in April 1941 to take over from Martyn at the RPL), was in contact with R G Casey at the Australian Legation in Washington in May 1941 & subsequently with S M Bruce in London.

Slide 17. Battle of Britain 11 Group. Sir Keith Park (1892-1975).

Air Vice Marshall Keith Park, a New Zealander, was in charge of 11 Group during the Battle of Britain (August 8th to end of October 1940) & worked in close concert with his C in C, Air Chief Marshal Sir Hugh "Stuffy"Dowding bearing the brunt of the Luftwaffe attacks. Park was noted for his hands on approach using his own Hurricane to keep familiar with the conditions his pilots were experiencing & also at critical times being at RAF Uxbridge the HQ & nerve centre of 11 Group. It appears that a grave injustice was done to both Dowding & Park at the end of the Battle of Britain in moving them to less onerous roles & only on subsequent review was the significance of their work appreciated. Park's tactics were for the Hurricanes to go after the bombers, protect the bases & don't go over the Channel & for the Spitfires to go after the Me Bf 109's. Spitfires to get higher than ME 109's & have them looking in the sun. There were several crucial days in the Battle including the 12th & 13 th August when 4 radar stations were attacked followed by the major " Eagle Day" assault. The German finger 4 tactic (2 pairs of aircraft) at the outset, having been learnt in Spain, exposed a flaw in the RAF Flight/Section formation which could be surprised by the ME 109's escorting bombers at the higher ceiling. Sailor Malan's (1910-1963) solution of "fours in line astern" came to be generally in use in Fighter Command. Several significant features effecting the Battle were on the RAF side: 300 fighter pilots had been lost in Hurricanes in France & the Low Countries & 800 RAF personnel lost during the evacuation from St Nazaire on HMT Lancastria (June 17), the Merlin Carburettor starved fuel in a dive & this afforded Me109's a means to escape, 100 octane fuel was introduced in the RAF from around March 1940 & constant speed propellers converted in Hurricanes & Spitfires by the end of July significantly improved the performance of some 1,051 RAF aircraft. On the German side the short range & approx.. 1 hour flying time from Calais of the Me109's only gave about 10 minutes of

actual fighting, a lack of appreciation of the significance of the RAF radar & the adverse interference by Hitler & Goering at crucial times. Other adverse factors for the Luftwaffe was the poor performance of the other German fighter the ME110 & the vulnerable Stuka, but it appears the Luftwaffe had a good sea rescue in the Channel & twin cannons very effective & straight ahead shooting. The total RAF losses in the Battle were 1,012 aircraft & 537 airmen whilst the Luftwaffe lost over 2,000 aircraft & 2,662 airmen. In early 1940 Dowding had arranged for 2 inch bullet proof glass be installed in his fighters.

Slide 18. 11 Group Battle of Britain Plotting Table, Uxbridge.

The "Battle of Britain Bunker" ie. RAF Fighter Command's No. 11 Group Operations Room preserved as Winston Churchill saw it on 15 September, 1940. The total number of RAF Squadrons engaged in the Battle of Britain appears to be 18 Spitfire, 36 Hurricane & 12 other including Auxiliaries (eg. Beaufighters). Typically a Sqdn would consist of 16 aircraft with 12 being available while 4 were being serviced.

Slide 19. Sqdn Leader Desmond Cooke (1907-1940), Constant Speed Propellers & Rotol, Battle of Britain & Beatrice Shilling (1909-1990) RAE-1941.

Rotol was formed in 1937 as a joint venture between Rolls Royce & Bristol which introduced a long line of innovative variable pitch propeller designs. At the time of Dunkirk operational Spitfires & Hurricanes had to make do with the De-Havilland 2-pitch propeller & it was only from June 1940 that Spitfires being built had Rotol propellers. Sqdn Ldr Desmond Cooke was the driving force behind the conversion, starting from June 15, of Spitfires & Hurricanes to constant speed operation. Conversion to constant speed propeller enabled the change of blade angle or pitch, automatically according to varying flight conditions while the engine speed remained the same, maximising propeller, engine & fuel economy & offering hands off operation in combat. It was Cooke's idea to have a conversion kit which De-Havilland were able to quickly make & on June 15 a trial of this kit was done in a Spitfire & it was found that the performance was as good as the Rotol (take off in 225 yds instead of 320 yds, climb to 20,000 feet in 7 minutes 42 seconds instead of 11 minutes 8 seconds & could fly as high as 39,000 ft instead of 32,000 ft) .Manouverability was also improved.. On Tuesday June 25. 609 Sqdn at Hornchurch was converted & as a most urgent order, all done on a verbal undertaking, De-Havilland (Hatfield) produced kits & assisted in the installation to 1,051 aircraft by August 16. Cooke was tragically killed on July 8, 1940, 3 days before his wedding.

Beatrice "Tilly" Shilling at RAE Farnborough in early 1941 invented a thimble shaped brass flow restrictor fitting (later a flat washer) for the Merlin carburettor to overcome the negative-g fuel starvation problem & she was involved in installing it in all the Merlin fighter engines in early 1941 which made her immensely popular with the RAF pilots. In 1943 2 new carburettors were devised for the Merlin (the Luftwaffe was using fuel injection in its engines).

Slide 20. Hurricane at Biggin Hill , Battle of Britain.

The Hurricane was a slightly heavier fighter & more numerous than the Spitfire, made of wood & fabric with a thicker wing which allowed it to turn well & have a stable gun platform. Linatex fuel tanks with expanding rubber coating helped reduce the fire risk. Whilst given the role of attacking German bombers, it could destroy an Me109 especially at lower altitudes. In the cockpit the reflector gun sight can be seen & also the vital Boost Gauge for use of around 5 minutes is shown. It appears that Hurricanes accounted for 55% of the German Battle of Britain losses possibly due to the alignment of the guns in the wings. Biggin Hill was severely attacked on August 18 (500 bombs in 10

minutes) & on September 1 received 6th attack in 3 days. In the last 10 days the RAF had lost 10% of Fighter Command. It typically took 35 minutes to refuel & reload a fighter.

Slide 21. Spitfire in Battle of Britain & Point Harmonisation-the "Dowding Spread"-750 feet.

Early in the War Dowding favoured a shot gun like "pattern harmonisation" of the 4 Browning .303 [7.7mm] in guns (a lightweight gun fired hydraulically at 1,150 rounds/minute & muzzle velocity of 2,660 ft/sec) in each wing of the Spitfires & Hurricanes (Germany had learnt of this & put heavier 20 mm guns in their fighters). The multiple guns were to fire into a rectangle or circle about 12 ft by 8 ft at 750 ft called the "Dowding Spread" so that a mediocre pilot could obtain a hit, but it was found early on that too many German bombers were successfully disengaging after taking many rounds of dispersed fire. In mid 1940 it was decided to test a much tighter pattern as a "point harmonisation" converging at 750 ft & by September 1940 better results were reported. The guns in the Spitfire were relatively far apart whereas the Hurricane guns were closely spaced. In the ME 109 the main guns were located within the engine cowling & fired straight ahead. The Spitfire cockpit shown (Getty image) has the reflector gun sight introduced in 1938.

Slide 22. Merlin Engine & Bentley Prior- Battle of Britain.

Bentley Prior was the Fighter Command HQ during WW2 & where Dowding had his office to carry out an immense workload with Operations & Filter Rooms, & his further planning for night fighting operations.

The Merlin specifications shown indicate the 100 Octane fuel used at the maximum rate of 3 gallons per minute.

Slide 23. German Messerschmitt Me bf 109 E, 1940. (DB 601 V12 Engine, Direct Fuel Injection, 92 Octane).

An Me bf 109E was captured intact on November 22, 1939 in France when the German pilot mistakenly landed on a French airfield on the west bank of the Rhine. The French evaluated the new Daimler Benz engine etc. & on May 2, 1940 lent the aircraft to the British at Amiens & was handed over to RAE Farnborough (renumbered as AE 479) . In June 1940, after being stripped down & reassembled, was extensively compared to the Spitfire Mk2 & were found to have very similar performance but with the major exception of the Merlin carburettor G-force problem where the Me 109 could pull up much more sharply from a steep dive. By way of comparison it was also reported that the cockpit was smaller than the Spit, pilot vision was poorer & the gunsight was a reflector job, not much different from our own. The smell in the aircraft, as noted in all German aircraft, was unpleasant like an empty beer barrel, not like the RAF.

The Daimler-Benz engine was 33.9 litres (Merlin 27 litres) with 2 spark plugs & injection pumps neatly arranged in 4 groups of 3. The propeller was constant speed & guns were 7.92 mm (4,000 rounds total) & 2 X 20 mm cannon (60 round drum magazines).

On August 15, 1940 ("Black Thursday") the Luftwaffe flew 2,000 sorties & lost 75 aircraft (the RAF flew 974 sorties & lost 34 aircraft). Apart from the Me109's there were Me110 twin engine fighter bombers, the Dornier Do 17 "Flying Pencil", Heinkel He 111 with the greenhouse nose & the Junkers JU 88 with varying cruising speeds from 163 mph to 290 mph.

After the Battle of Britain, Germany extended its own Freya radar network in the box like Kammhuber Line with sector controls using the Wurzburg Giant & small dish Type A Wurzburg's extending from Denmark to Switzerland. The Focke-Wulf fighter FW 190 became operational in

August 1940 with its 41.8 ltr BMW 14 cylinder radial engine noted also for its single lever engine & performance control unit. It had a greater range than the ME 109.

Slide 24. Tizard Mission to the US & Canada August 1940. Archibald Hill FRS.

A lesson of the First World War for scientists in the UK at the Royal Society especially, was that much better & timely use of scientists in an anticipated war with Germany was essential. In 1917 Rutherford joined a Mission of English & French engineers, chemists & physicists to the US & they placed all the anti-submarine plans in progress before the leading scientific men & they in turn entered with whole hearted enthusiasm in their further development, using the vast resources at their disposal. Sir William Bragg (1862-1942) who was President of the Royal Society (1935-1940) at a time when Germany was pursuing its nefarious plans was well aware of the need to foster the best possible scientific co-operation with US Institutions. The Royal Society drew up a list of scientists available for War work & Archibald Hill (Independent MP for Cambridge University 1940-45) was the RS representative with the Ministry of Labour. In early 1940 Hill went to a post in the UK Embassy in Washington to discreetly as possible find out the state of US scientific developments especially as regards air defence. Hill had reported back that there was an immense fund of goodwill in scientific circles in the US & Canada, but how to capitalise on it ?.

Once again in his book "Radar Days" Taffy Bowen describes the events leading up to the creation of the Tizard Mission based on agreement between Churchill & Roosevelt in mid July.1940 & then subsequently the Mission itself, of which he was the Radar representative dealing with the 10 cm cavity magnetron, which was to be a spectacular success. The original magnetron taken to the US is in the Museum in Canada for the National Research Council.

In 1947 Tizard was awarded the US Medal of Merit which was the highest civilian decoration of the US for exceptional meritorious acts during WW2 to assist the efforts of the UN.

Slide 25. Frisch-Peierls Super Bomb Memorandum (March 1940). Mark Oliphant (1901-2000) FRS.

Otto Frisch (1905-1974) FRS, Rudolf Peierls (1907-1995) FRS.

After Rutherford died in 1937 Oliphant moved to Birmingham University & with Tizard's encouragement to work on high frequency radar valves he obtained a Navy contract & started on Klystrons as a transmitter & he had John Randall (1905-1984) FRS & Harry Boot (1917-1983) work on a receiver but it is well known they first needed a 10 cm source & this was their discovery of the cavity magnetron in February 1940. Also in Oliphant's Physics Dept were the 2 German expatriates Otto Frisch (1904-1974) FRS & Rudolf Peierls (1907-1995) FRS who in March 1940 produced a memorandum setting out the technical ideas behind a super bomb based on a nuclear reaction & this was part of the Tizard Mission material handled by Sir John Cockcroft (1897-1967) FRS. The memorandum was 1st shown to Tizard as Chairman of the Scientific Survey Committee & a special sub committee was set up known as MAUD which produced a final report in July 1941 concluding that with a relatively small amount of uranium a powerful bomb could be built by 1943, which if that was the case, urgent effort was needed to beat the Germans to it. A copy was sent to America & some time later Oliphant was given the job of following this up on the pretext of radar work but found he needed to stimulate interest as a matter of urgency. It appears that Tizard was personally sceptical of the bomb being produced within the duration of the War.

Slide 26. Tizard Mission in Canada.

A 75th anniversary commemoration of the Tizard Mission was organised at the Canadian Embassy in Washington in 2015 & the range of technical materials disclosed including jet engine design,

proximity fuse & gyroscopic gunsight are identified along with radar (10 cm & 1.5 mtr ASV) are noted .

On August 16, 1940 Tizard visited Canada visiting the National Research Council & spoke to PM McKenzie King & other politicians. Over the next 3 days he surveyed Canadian research facilities. With Cockroft, after returning from America they found that a site had been chosen at Leaside for a large factory complex (Research Enterprises Ltd) initially working on ASV radar production but to quickly grow to 7,500 employees in factory space of 70,000 sq. mtrs. Optical work was carried out including binoculars & telescopic sights for the Lee Enfield 303.

Slide 27. J.P.V. Madsen Scientific Liaison to the US, May 1941.

As a follow on to the Tizard Commission, JPVM conceived the idea that Australia should participate with the US & Britain in the exchange of scientific material during the War & in fact should undertake this role himself & travelled by Clipper flying boat to reach Washington where R G Casey (1890-1976) headed the Australian Legation & who wrote to Cordell Hull the US Secretary of State requesting that JPVM be accepted as the Director of the Australian Scientific Liaison Mission in May 1941. JPVM arranged for George Munro (1901-1994) to come over from England & be based in Washington principally to facilitate the transfer by diplomatic bag ,material coming from Australian physicists embedded in MIT involved with 10 cm work. Joe Pawsey (1908-1962) initially travelled from RPL Sydney to Boston to augment details coming from the UK on 10 cm RN sets. JPVM continued to London & carried out the Scientific Liaison there until returning to Washington at the end of November 1941. In London he stayed with W H Bragg at the RI. The role of Scientific Liaison at the Australian Embassy in Washington has continued after the War. George Munro had worked at the UK RRB before coming to Australia in 1929 & had been principally involved with Dr. R.H Barfield who was responsible for the lead in Direction Finding work held by Britain at the start of the War.

Slide 28. UK Aviation Fuel WW2. Heysham, Abadan.

In 1938 the total refining capacity in the UK was 4.21 mil. tons pa from 8 major refineries (& 3 smaller plants) operated by Shell, Anglo-Iranian & Esso located in Essex (1.4 mt),Hampshire (0.7 mt),Cheshire (0.75 mt) & Scotland, Wales. Oil production at this time from US sources was 172.9 mt pa (Iran 10.4, Iraq 4.2 & Romania 6.6). The total Allied tanker fleet in September 1939 was 1,445 (10.16 mil. tons) & despite losses of 378 tankers over the next 3 years, with new ships being built in the US & UK the tanker fleet at the end of 1943 was 1,488 (10.97 mt).

Synthetic fuel in the UK was produced from 1935 at the Billingham Chemical Plant (in the NE of England) by the Bergius hydrogenation process (Germany used the Fischer-Tropsch process) using catalysts made in the ICI Clitheroe Govt. shadow factory. The site for the Heysham Aviation Fuel Works was chosen by the Air Ministry to supplement North American supplies of aviation gasoline using coke from the Durham coal field & imported gas oil. HAFL was operated by Trimpell Ltd (a joint venture of Trinidad Oil, ICI & Royal Dutch Shell) using the hydrogenation process designed to produce 300,000 tons pa. of petrol & 50,000 tons of iso-octane used directly as 100 octane fuel & also to enrich 87 octane fuel. Iso octane from Heysham started in October 1941. In 1944 Heysham produced 344,000 tons of petrol & 55,000 tons of iso octane. (also 22,000 tons of ammonia) for distribution by road, rail & sea. In 1942 the UK was importing 80% of aviation gas from US sources.

The Abadan refinery run by Anglo-Iranian (BP) in the Persian Gulf under a 1933 Concession was secured in August 1941 by British (HMAS Yarra was also involved) & Russian forces to prevent Germany using a combination of military & political means to get this valuable source of oil which was stopped by the Stalingrad defeat & also of Rommel in North Africa.

Slide 29. Aruba Aviation Fuel, Haifa Oil.

The Esso Lago refinery on the Dutch Caribbean Island of Aruba just off the coast of Venezuela from 1932 owned by Standard Oil of New Jersey was a very big source of aviation fuel for the Allies in WW2. In 1945 the operation shipped refined oil from the 1 billionth barrel of oil brought by tanker from Maracaibo in Venezuela. (The Shell Ëagle" plant at Aruba stopped production in 1942 as it did not produce aviation gas). On February 16, 1942 U-Boats attacked several tankers at Aruba causing disruption. It appears that tankers would travel from Aruba to Halifax & join convoys to the UK. In 1942, tanker losses to U-Boats in the eastern seaboard were 43 & in the Gulf of Mexico 99.

The Kirkuk-Haifa oil pipeline supplied oil to the Haifa refinery in British Palestine (between 1935-48.)for subsequent shipment. The pipeline was only 12 inch in diameter over 942 km & it took oil 10 days to travel the full length. (the subsequent Trans -Arabian pipeline 1,214 km to Sidon was 30 inch diameter & modern pipelines are 42 inch).

Slide 30. Shell Oil Borneo: Balikpapan "Ploesti of Pacific"- Malaya Latex.

The principal objective of the Japanese attacks in December 1941 was to get hold of the Dutch oilfields in Borneo & Sumatra. In August 1941 the British plan in the face of this expected aggression was to reduce output by 70% & also to plan for the destruction of the facilities. The Japanese landed forces between December 16, 1941 & January 17, 1942 in Borneo, Sumatra & Tarakan & in the last instance executing Dutch POW's who had destroyed the oil fields. Balikpapan's Pandansari was a modern refinery & essential for the distillation of aviation gas & 2nd only to Sumatra's Palembang production. The Borneo oil was light enough for the IJN to burn it directly in ship's boilers but due to sulphur build up the boilers became brittle & ruined. On May 17, 1942 the USN sank a Japanese transport carrying a large number of oil technicians to revive the refining facilities at Miri & Balikpapan & also Palembang, & this no doubt caused a delay in restoring oil production capacity. Increasing Japanese tanker losses taking oil back to Japan as the War progressed severely hampered her naval & air operations.

The Shell Refinery in Sydney at Clyde used oil from Borneo & was shut down in 1942.

The loss to Japan of the Malayan Latex plantations for making rubber was also a very significant factor & in the US a crash programme by chemists in the tyre companies to jointly develop synthetic rubber as the GR-S (Government Rubber-Styrene) General Purpose Rubber was carried out.

Slide 31. UK GPSS (Govt. Pipeline & Storage) & PLUTO. (1941-1944).

It was realised in 1936 that the UK only had 10 days of aviation fuel under wartime conditions in storage which needed to be greatly increased & additional tanks were built partially underground & were available for the Battle of Britain. Starting in 1941 a secret underground pipeline joining Liverpool's Stanlaw Refinery with Bristol's Avonmouth Docks was laid to ensure fuel distribution irrespective of the port oil was actually landed & was operational in 1942. Working secretly at night a further underground system of pipes to deliver avgas from the 2 western ports to RAF airfields in the Midlands, the South & East of England. This was further expanded to 8 counties to use the new Lancasters & yet again for the USAF airfields. The diameter of the pipe appears to be 30 inches.

In 1942 a proposal by A Hartley Chief Engineer of Anglo-Iranian that an adapted submarine telephone cable could be used from the 73 miles from the Isle of Wight to Cherbourg in the D-Day operations was accepted. It appears that only 8% of the fuel used by the Allies from D-Day to V-E Day was delivered by PLUTO (Pipeline Under the Ocean).

Slide 32. UK Pluto & Conundrum.

A cross section of PLUTO pipe is shown with Conundrum, the giant reel which was used to deliver & lay the submarine pipeline.

Slide 33. US Aviation Fuel Distribution. Hand Pump at Henderson Field, Guadalcanal.

Distribution of avgas to US aircraft, depending on the prevailing conditions, could be from tankers as large as those shown down to the 44 gal drums supplied at the crucial Henderson Field on Guadalcanal in 1942.

Slide 34. German Synthetic Fuel, "Jerry Can".

In 1935 I G Farbin obtained a licence to produce TetraEthylLead (T.E.L) for high 87 octane fuel & built a factory in 1936 at Gapel (near Berlin-100 tons/month) & in 1938 obtained 500 tons of T.E.L surreptitiously from Standard Oil before Hitler''s invasion of Czechoslovakia, & secretly completing a second new plant at Frose (near Magdeburg- 300 tons/month) in 1938. T.E.L requires a corrective agent, Ethylene Dibromide, & a plant was built at Tomesch, near Hamburg. From 1942 actual stock of T.E.L on hand was approx.. 3,000 tons with monthly consumption of 500 tons/ month & production (including a small amount from a French plant) of 450+ tons/month, & although they were vulnerable targets they were not attacked specifically. An additive sprayed into Luftwaffe aircraft superchargers was MW50 (a mixture of 50% methanol, 49.5% water & 0.5% Schutzol 39 anti freeze). [Allied additives such as MMA -mono methyl annilise-appear only to be included in the fuel mix & not sprayed this way]. No new T.E.L plants were brought into production after the War started although plans were initiated.

By 1943 Germany had 9 Fischer-Tropsch plants for synthetic oil production from Ruhr coal (Scholven, Leuna, Bohlen, Magdeburg, Zeitz, Gelsenkirchen, Welheim ,Wesseling & Politz on the Baltic (shown in the slide)).& production had grown to 36 million barrels p.a.(2.02 mil tons) from 10 mil. in 1938 & represented 50% of Germany's total demand (up from 22% in 1938). Romania was the major source of natural oil but it was not until May 12, 1944 that Allied raids on 5 hydrogenation plants severely reduced avgas production (down by 90% & causing rationing) & when the German attempt to gain Baku oil had failed in September 1942. The Politz plant built by I.G Farbin in 1937 was to eventually to produce 15% of Germany's total consumption of synthetic fuel. Total oil demand in 1938 In Germany was 45 million barrels (6.3 mil. tons) & 71 mil barrels (9.9 mil. tons).in 1943. Germany had a fuel grading & colour system (B4=87 octane, C3=100 Octane) to indicate the fuel as being synthetic or natural.

The ME 109 shown is being refuelled by hand in Russia. The German "Jerry Can" was copied almost identically by the Allies.

Slide 35. Japanese Aviation Fuel for Zero.

The Nakajima Sakae 14 cylinder 27.9 ltr radial engine was designed to run on 92 octane fuel. At the Japanese airfields operating in Rabaul, aircraft were reportedly often being fuelled by hand pump from drums. The Japanese photo of a tanker does not identify where it was taken but does seem to be unusual, perhaps trying to get set up for fuel at Guadalcanal or Lae . The reflector gun sight can be seen in the cockpit. Supply of aviation fuel to Japanese Army & Navy airfields was severely limited by the sinking of tankers & cargo ships by the US amounting to some 2,346 ships (8.6 mil tons) during the War.

Slide 36. Australian Inland Aviation Fuel Depots & Supply 1943. Shell Clyde Refinery Pre-1942.

At the outset of the War in 1939 Australia only had limited refining capacity (2 refineries including Shell at Clyde in Sydney dependent on Borneo oil) & so the expected demand of the RAAF was going to be met by imports. As a matter of policy it was decided Australia should have storage tanks for 6 months supply of the RAAF requirements which were initially specified as for 12-19 squadrons which were needed to train 14,000 airman for the European theatre which grew to 32 Squadrons. As time progressed this 6 month requirement grew from an initial combined Australian capacity in Qld, NSW & Vic of 1.8 mil. gals to 3.2 mil gals ,up to December 1941, & then to 15 mil gals & even further as USAF planes arrived & the total was 50 mil gals. Benzole from Australian steel works was shipped to the US for high octane avgas production.

The number of storage locations chosen was based on the need to have rail access & then good distribution channels to take avgas by drum to airfields. A storage depot had a number of steel tanks of different size but including 120,000-200,000 gal capacity & a 40,000 gal mixing tank with a storage building to store drums of T.E.L, plus the associate pipes & pumps. The steel needed (54 tons /tank) fortunately was available from Australian mills & as happened in Qld additional road tankers (208), fuel specific railway cars (80), & additional locomotives (10) were needed to move 1.6 mil gals each month. Six depots (underground & camouflaged) in Qld were at Toowoomba, Gayndah, Charters Towers, Yarramin, Roma & Cloncurry. The total number of depots from 1942 grew from 12 to 31. (Tanks at Northam in WA are shown). In NSW depots were at Cootamundra, Muswellbrook, Grafton & Wallerawang.

Slide 37. WW2 Australian Aviation 100 octane. B17 & P-40 Kittyhawk (T.E.L additive).

Drums of RAAF avgas were used in Allison V12 engines (Kittyhawk), Pratt & Whitney R-1830 Twin Wasp radial (Liberator & Beaufort, PB-Y Catalina) & Wright R-1820 Cyclone radial (B-17). The Kittyhawk strategy at Darwin against the raiding Japanese bombers & Zeros was to take advantage of the radar warning & get to a maximum height & then dive down into the raiders & break them up which proved very effective. In the case of the P & W R-1830, it could be that it was designed to run on 87 octane (the later R-2000 an upgraded R-1830 in 1942 was designed this way for fear that 100 octane would fall short but this fear was groundless). Catalinas to Australia were in the 1st batch to use 100 octane.

Slide 38. Australian Fuel Ration. RAAF Middle East & Beaufighter.

The RAAF was flying Kittyhawks in North Africa where pilots gained experience before coming back to the SWPA. Fuel rationing in Australia during the War & for some years after involved a scheme of ration coupons which were for only very small quantities of petrol. UK foreign exchange restrictions affecting Australian petrol availability post war caused a lot of angst.

Slide 39. Sir Ben Lockspeiser FRS, 1948. CSIRO.

Prime minister S M Bruce brought in legislation in 1926 to form CSIR (Council for Scientific & Industrial Research) with better funding than its predecessors (Advisory Council of Science& Industry [1916-1920] & the Commonwealth Institute of Science & Industry [1920-1926]) involving Gerald Lightfoot (1877-1966), a 1st Class honours Mechanical Science graduate from Cambridge in 1898. David Rivett became Chief Executive of CSIR in 1927 with Lightfoot a very loyal Secretary (1926-1944) & member of CSIR Council. JPVM submitted 2 proposals to CSIR in 1927 to form an Australian Radio Research Board & also a Standards Laboratory having gained wide support, including that of Chairman George Julius. JPVM's 2 proposals were the only non-primary industry one's made at this time. The RRB proposal went ahead straight away & the Standards Laboratory some years later & both came together in 1939 at the NSL/RPL laboratory building in the grounds of Sydney University.

In late 1943 Henry Tizard came to Australia at the suggestion of CSIR to look at research laboratories & advise the Government. On his return to England he advised "Taffy Bowen" that Sydney was a good place where his services could be used having just returned from the Tizard Mission to the US.

In 1946 at the Royal Society Commonwealth Conference in London Tizard pointed out the role of the King's Privy Council whereby the UK Council of Scientific & Industrial Research was under the control of the KPC & that its operations were not to be confined to the UK. The KPC was an administrative link between the Monarch & the government of the day, holding limited formal functions but presided over now by the Queen.

Secrecy during the War with Australian RDF/radar was something JPVM had to give during a personal undertaking to Watson-Watt at Harrogate in January 1940 & this responsibility was always something which weighed heavily on him during the War. In the post war CSIR era, the policy direction taken (based on the lessons of WW2) was that military science of a secret nature should not be done by CSIR but by separate Govt. Departments.

In June 1948, PM Ben Chifley visited London to explain that CSIRO (Commonwealth Science & Industrial Research Organisation) would be established to allay concerns that Australia was a security risk for UK & US military secrets which apparently were being withheld. In London, Chifley was referred to meet with Sir Henry Tizard (Chairman of the Defense Science Research Policy Committee- excluding atomic weapons) & Sir Ben Lockspeiser FRS (1890-1990) (Chief Scientist of the Ministry of Supply which was involved with secret UK military projects. -During the War at RAE, Lockspeiser had devised the searchlight altimeter for the Dambusters). Both Tizard & Lockspeiser were invited to come to Australia later in 1948 to explain the UK approach to secret work & the related documents are held in the Department of Defense files for Sir Frederick Shedden (1893-1971).

The CSIRO legislation was passed in 1949 with Sir Ian Clunies Ross as Chairman with Frederick White dealing with secondary industries. The personal attacks in Parliament against David Rivett by the Liberal Party Opposition exploiting a perceived weakness in Labor were viewed with abhorrence by the entire CSIR scientific community. Labor lost the 1949 election & Cold War politics was to remain for many years to come, but with CSIRO working under its political masters on non-military scientific work.

<u>Slide 40.</u> CSIRO 1949- Ben Chifley, Ian Clunies Ross, Frederick White FRS, Clement Attlee, R G Casey.

The photographs shown here are Ben Chifley (1885-1951) with Clement Attlee (1883-1967) the UK PM who kept secret the UK post war atomic bomb work for many years, Frederick White FRS (1905-1994) with JPVM & Sir Edward Appleton at URSI 1952,& also, David Rivett, R G Casey (1890-1976), Ian Clunies Ross (1899-1959) & Hedley Marston (1900-1965).