A story of ionospheric research in NZ

and its connection to radar astronomy

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The road to wartime radar and post-war radio astronomy

- The state of radio in NZ in the 1930s

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- At Jodrell Bank after the war

The state of radio in NZ in the 1930s

By 1939 radio technology was well developed, as radio broadcasting, international telegraphy and telephony, even TV in some countries. There were many skilled technicians in industry and government departments, and many experienced radio hams

Why was WW2 radar such a powerful boost to radio astronomy after the war ?

The two techniques were basically doing the same thing - extracting as much information as possible from the weak signals from distant objects.

Radars observe weak echoes from distant objects and astronomers observe cosmic noise from very distant objects.

They both need aerials with a large collecting area and very sensitive receivers

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- What happened in NZ ?
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- It was staffed by excellent people
- It was shut down in January 1946
- Staff dispersed to radar and other activities

Introduction to the jargon

When dealing with electromagnetic waves (light, radio, etc.)

SIZE MATTERS

- relative to wavelength

The most basic aerial is a piece of wire half a wavelength long, called a half-wave dipole. It can absorb or radiate radio waves.

Arrays of dipoles can be used to make the beam narrower

$$\lambda \ (\textit{wavelength in metres}) = \frac{300}{\textit{frequency}(MHz)}$$

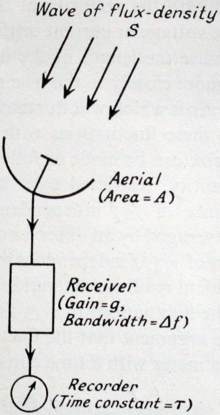


FIG. 15. A simple receiving equipment.

The extreme short wave end of the radio spectrum, below about 30 cm, is relatively free from man-made interference. Thus the radiation from most

A wavelength of 30cm corresponds to a frequency of 1000MHz = 1GHz

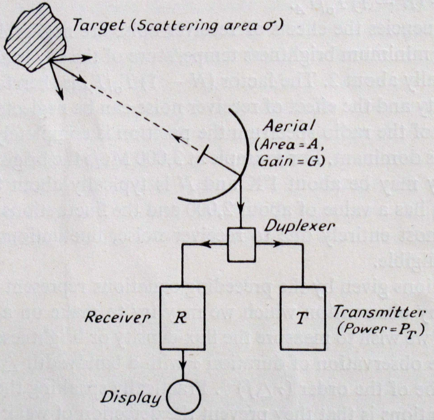
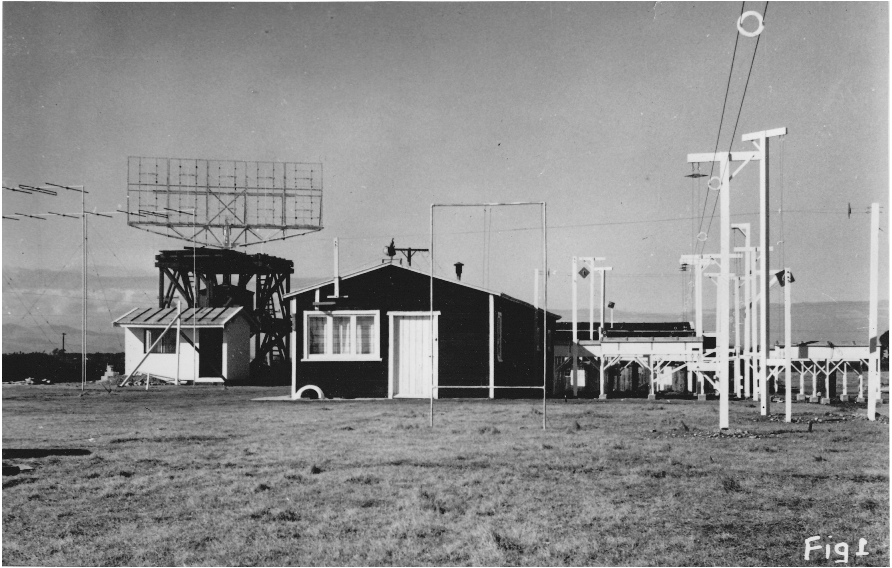


FIG. 16. Simple outline of a radar system.

If the maximum range of the radar is reached when P_R, the received power is equal to P_{min} the minimum detectable power, then

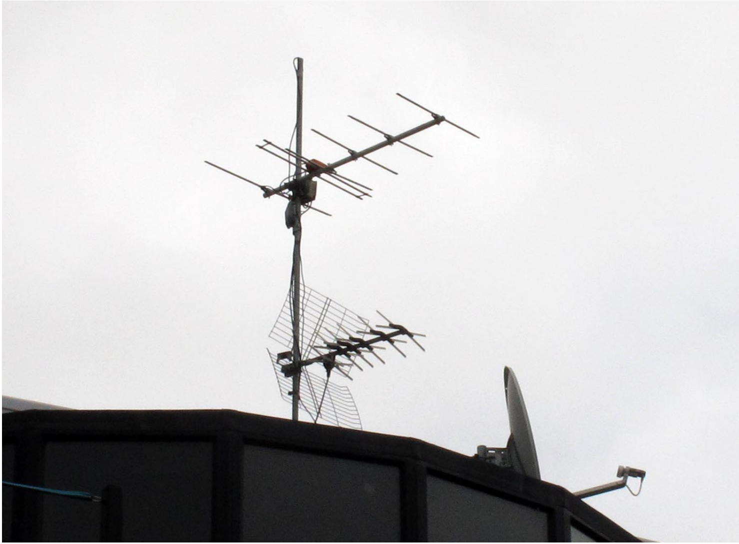
The Duplexer is also called a T/R (Transmit/Receive) switch

Hanbury Brown and Lovell (1957)



Old Rolleston field station, University of Canterbury

Dick Manchester's multi-frequency Yagis at Rolleston



Domestic Yagis and reflectors

Early NZ ionosphere research

In 1921 Rutherford arranged for the UK Radio Research Board (of which he was a foundation member) to lend radio equipment for field strength and direction finding measurements to Professor Burbidge at Auckland University (College)

1924: the Wellington College Wireless Club was established by Fred White. One of the other members was Bill Pickering. The boys built their own transmitter.

These two boys had very successful careers: Sir Frederick White, head of CSIRO Australia. Sir William Pickering of the US Jet Propulsion Laboratory.

1925: Appleton and Barnett (MSc Otago) of the Cavendish Laboratory had confirmed the existence of the ionosphere using a primitive form of FM radar.

1926: Breit and Tuve of the Carnegie Institution of Washington also confirmed the existence of the ionosphere, using a pulsed transmitter.

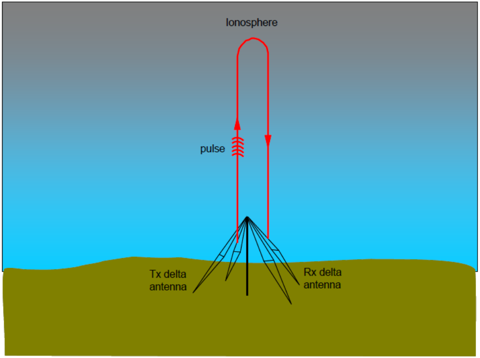


Figure 1.4 *Ionosonde operation.*

George Munro used the Auckland University College radio equipment for his MSc research in 1923 and later, in December 1925 used it to measure the height (91km) of the ionosphere, the first ionospheric measurement made in NZ.

He used the fact that when the sun's energy hits the atmosphere, the free electrons released will change the strength of the radio waves.

He measured the strength of signals from a spark transmitter in Wellington on 500kHz.

1929 White completed an MSc at Victoria University (College) in Wellington.

1930 White went to the Cavendish Laboratory and started his PhD with Ratcliffe.

1932 when his Cambridge scholarship ran out he moved to King's College, London, with Appleton, as Assistant Lecturer in Physics.

He completed his PhD in 1934.

At Victoria University (Wellington) George Peddie had built a manually tuned pulse ionosonde and made observations from June 1935 to December 1936.

The transmitter and receiver had to be manually tuned together over a range of frequencies.

January 1937: Fred White began his appointment as Professor of Physics at Canterbury University (College)

John Banwell had been a lecturer in the department for some time and became White's assistant in research

He also was a radio ham, and was a founder member of the NZ Amateur Radio Emergency Corps when it was formed after the 1931 Napier Earthquake. He was the AREC Christchurch Equipment Supervisor and all the Section's portable radio equipment was designed and built by him

Banwell built a manually tuned ionosonde which was operating by October 1937. They also ordered an automatic ionosonde from Australia, in operation by April 1938

Subsequently they published White, Banwell and Peddie (1940) on F2 ionisation over NZ

1939

1939 Feb 25 High Commissioner for New Zealand in London conveys request of Secretary of State for Air that a skilled physicist go to Britain for instructions in new defence device.

1939 Apr 29 Dr E. Marsden, Secretary, DSIR, New Zealand arrives in Britain for training. He visited the RAF radar site at Bawdsey and went on sea trials of radar on HMS Rodney

Source: DSIR Narrative WW2 No. 3: Radar

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- **Radio section at Wellington East Post Office (Charles Watson-Munro)**
- **Physics Department at Canterbury University College (Fred White)**
- **In November 1941 these two were combined as the DSIR Radio Development Laboratory, with a related laboratory in Auckland**

“development, production, fitting and training programme was carried out at a time when there were very few radar components available in NZ, test and training equipment was practically nil, and immense effort and time was spent in scrounging and adapting materials and components.”

Source: DSIR WW2 Radar Narrative p.380

No. 8

The intelligent and simple solution to a problem using only material available at that time

1939 August: John Banwell left Christchurch to start a PhD in ionospheric physics with Ratcliffe at the Cavendish Laboratory.

This was not good timing

1939 September 3 World War 2 started

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They were immediately co-opted to the staff of what became the Telecommunications Research Establishment (TRE).

Auckland Star, Volume LXXI, Issue 46, 23 February 1940, Page 8

STILL SECRET.

BRITISH TACTICS.

DAMAGE TO THE GRAF SPEE.

GERMAN GUNNERY ACCURATE

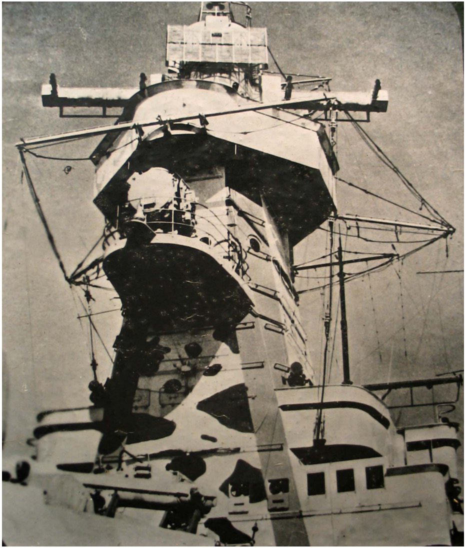
Chatting informally with Press representatives in his stateroom on arrival this morning, Captain Parry said that so far the Admiralty had not released the official dispatches, and therefore his account of the action in which the Achilles was engaged in December necessarily could not be full. "Probably the Admiralty will not make the story known in all its detail until the war is over," he added.

Captain Parry said the German gunnery was very accurate.

Captain Parry on the Battle of the River Plate 13 December 1939

Toby Harper was an officer on Achilles who before the war had been a radio engineer at the Dollis Hill Research Laboratory of the British Post Office.

When the Graf Spee was in Montevideo harbour for temporary shelter after the battle he saw something he immediately recognised



Graf spee in Montevideo after the battle
Seetakt radar installed in January 1938, f=500MHz, 60 cm

Source: HMS Collingwood

1939 October White had begun development of a 66 cm (450MHz) naval radar in the Physics Department at Canterbury University College.

Due to security problems this work was transferred to "the green shed" at Wigram RNZAF base by February 1940

In May the experimental SS radar was installed on ACHILLES

Toby Harper joined this group in June

Early British radar

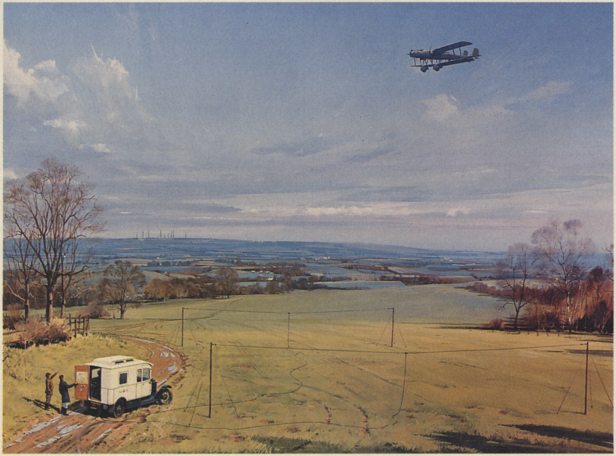


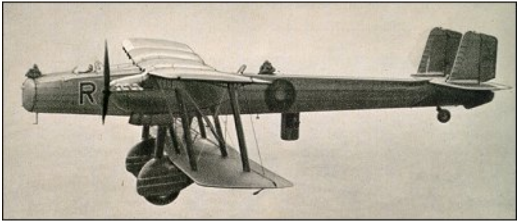
Fig.1.2: An artist's impression, drawn from a sketch by Arnold Wilkins, of the Daventry experiment which heralded the birth of radar in the United Kingdom (Courtesy GEC-Marconi).

20 ELECTRONICS Australia, July 1996

Artist's impression of original Daventry reflection test, February 26 1935
BBC short-wave transmitter in 49 metre band (6MHz)

Source: Electronics Australia July 1996

Nowadays most radars use wavelengths of 10 cm or less. Why did early British radars use such long wavelengths (low frequencies) ?



The Heyford bomber they used for initial tests in 1935 had a wing span of 23m so a radar operating on a wavelength of 46m (6.5MHz) should produce a stronger echo

.... and they were in a hurry

In November 1932, the Prime Minister Stanley Baldwin summed up the position in a gloomy, but realistic, assessment:

" the bomber will always get through."

Source: Bragg (2002)

Beginning in 1936 the RAF conducted several operations to find out how to use the radar early warning of hostile aircraft to direct fighters to intercept them. The RAF control station was the Biggin Hill base. It quickly became obvious that the whole sequence of operations, on a time scale of minutes, required

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- quick assessment of radar observations,
- very rapid communication to the central control at Biggin Hill
- and rapid and reliable communication with the fighters

These air exercises were continued over the next two years and were collectively called the Biggin Hill experiments

They are now recognised as the first example of what has become a new science

Operations Research

“During a visit to Bawdsey in about 1938, Lord Rutherford suggested that a better method of calibration would be to use the echo from a dipole hung from a balloon flown from a ship at sea. This method was adopted with great success and used up to the outbreak of war ....”

Source: The Birth of British Radar, Latham and Stobbs, 2011

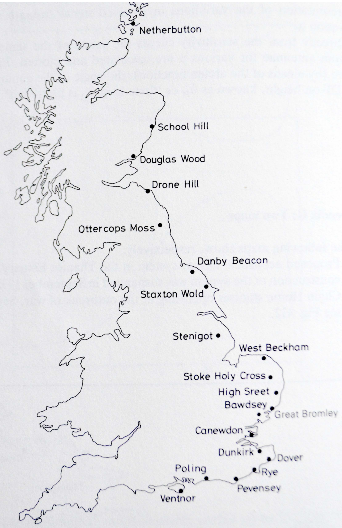
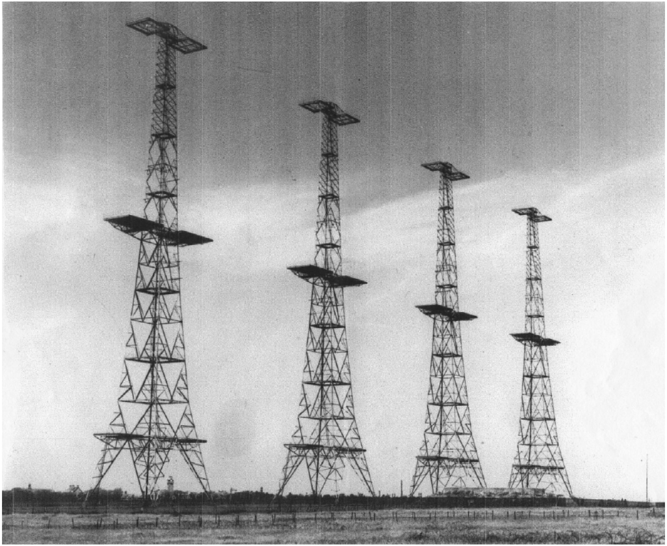


Fig. G2 *Map: Chain Home stations*

Chain Home stations operating in September 1939

Source: Swords (1986)



Chain Home transmitting aerials,
f=22-27MHz, λ=14-11m

Source: (web) Putley

Marsden went on sea trials on HMS Rodney

HMS Rodney later in the war,
Type 279 f=40MHz λ=7.5m installed in October 1938

1940 January: the Physics Departments at Auckland and Canterbury began teaching modified physics courses to emphasize the topics of electronics and electromagnetic waves now required for designing and using radars.

Graduates from these courses became the scientists on RDL's staff

Clif Ellyett had replaced John Banwell on the Canterbury Physics staff and taught the wartime radar courses

1941: A request came from Appleton in Britain to revive and expand the NZ ionosonde network to help with predictions of radio wave propagation.

Much of the original White and Banwell equipment was still in existence at Canterbury so the new DSIR Ionosphere Section was established there, under the leadership of Clif Ellyett

When the ionosonde chain was complete the following operational recorders were at

1. **Lincoln, Christchurch**
2. **Campbell Island**
3. **Kermadec Islands**
4. **Fiji**
5. **Rarotonga**
6. **Pitcairn Island**

1942 April 23 Elizabeth Alexander was appointed as Head of the Operations Research Section at the Radio Development Laboratory and "commenced work at the Laboratory ... and from then until the end of the war directed the Operational Research Section, accomplishing much with scant resources"

Elizabeth Alexander was assisted by "Bob Unwin an RDL physicist with considerable experience in installing, aligning, and operating radar sets and in the instruction of Service observers"

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- **Anomalous propagation**

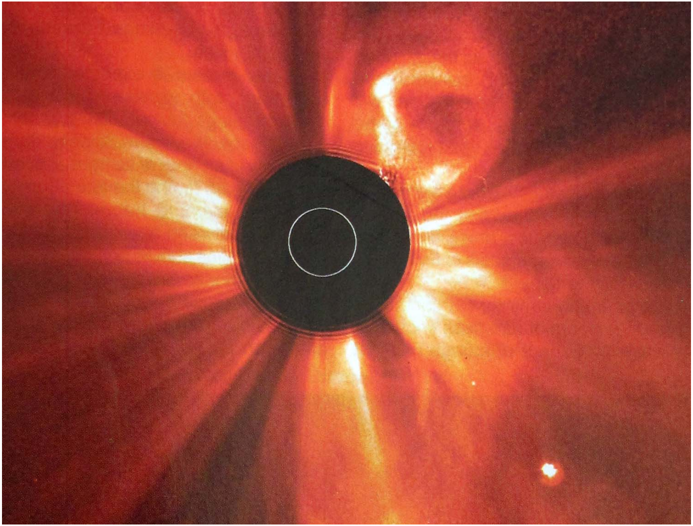


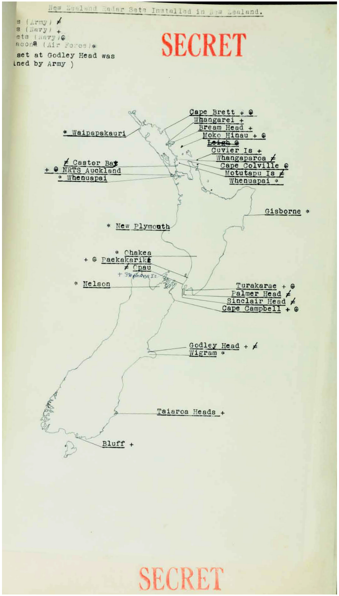
Image from STEREO Ahead spacecraft with coronograph November 2-4 2012

Source: NASA/STEREO via CQ1301

Qty	For Royal Navy and Royal New Zealand Navy:	Date of Supply
12	Coast Warning (CW) metric type sets	1941-42
12	Ship Warning (SW) sets, plus	1941-42
3	Non-standard laboratory-built sets	
24	Ship Warning Gunnery (SWG) sets, plus	1940-42
3	non-standard laboratory-built sets	
9	Coast Warning centimetric type (ME I) sets	1942-43
5	Mobile Coast Watching centimetric type (ME I) sets	1943
4	Plan Position Indication panels to give improved performance to Admiralty 270 sets on New Zealand vessels (centimetric type ME 4)	1944
4	Mobile Coast Watching centimetric type sets (ME IA) for British Pacific Fleet (also two retained in New Zealand)	1945*
	Radar test equipment	1941-45

72 RDL sets for RN and RNZN

Source: DSIR WW2 Radar Narrative



NZ CW radar sets installed in NZ

Source: DSIR WW2 Radar Narrative

For New Zealand Army:

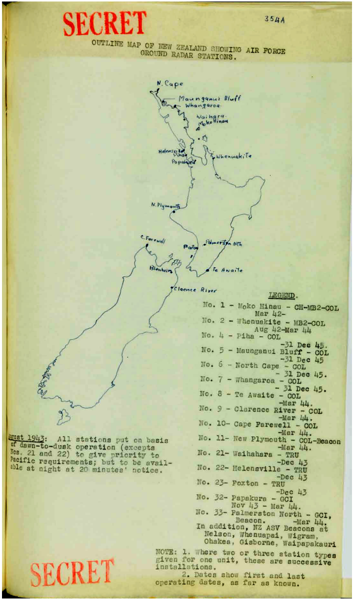
10	Coast Defence Gunnery metric type (CD) sets	1940-42
1	Mobile Coast Watching centimetric type (ME I) set	1943
	Radar test equipment	1941-45

For Royal New Zealand Air Force:

	Aircraft to surface vessel detection (ASV) sets (TR101)	1940-41
	Long Range and Homing aerials for use with British ASV sets	
	Fitting British ASV sets to RNZAF aircraft	
2	British Ground Control of Interception (GCI) equipments engineered into mobile form	
21	Navigational aid (ASV) Beacons (TR102)	
	Radar test equipment.	

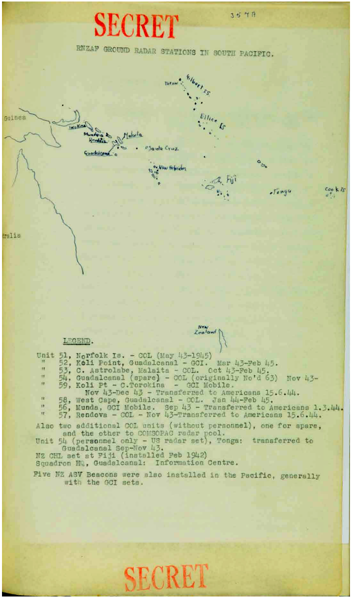
10 + (20+21) RDL sets for NZ Army and RNZAF

Source: DSIR WW2 Radar Narrative



RNZAF CW radar sets installed in NZ

Source: DSIR WW2 Radar Narrative



SECRET

RNZAF GROUND RADAR STATIONS IN SOUTH PACIFIC.

LEGEND.

Unit 51, Norfolk Is. - COL (May 43-1945)
" 52, Koli Point, Guadalcanal - GCI. Mar 43-Feb 45.
" 53, C. Astrolabe, Malaita - COL. Oct 43-Feb 45.
" 54, Guadalcanal (spare) - COL (originally No'd 63) Nov 43-
" 59, Koli Pt - C.Torokina - GCI Mobile.
Nov 43-Dec 43 - Transferred to Americans 15.6.44.
" 58, West Cape, Guadalcanal - COL. Jan 44-Feb 45.
" 56, Munda, GCI Mobile. Sep 43 - Transferred to Americans 1.3.44.
" 57, Rendova - COL - Nov 43-Transferred to Americans 15.6.44.

Also two additional COL units (without personnel), one for spare, and the other to COMSOPAC radar pool.
Unit 54 (personnel only - US radar set), Tonga: transferred to Guadalcanal Sep-Nov 43.
NZ CHL set at Fiji (installed Feb 1942)
Squadron HQ, Guadalcanal: Information Centre.

Five NZ ASV Beacons were also installed in the Pacific, generally with the GCI sets.

SECRET

RNZAF CW+GCI radar sets installed in the South Pacific

Source: DSIR WW2 Radar Narrative

	United States Forces in Pacific:	Date of Supply
6	Mobile Long Range Air Warning sets (LRAW) (each accompanied by an RDL physicist)	1943-44
1	Speech Secrecy Unit for Communications work	1944
	Technical assistance and equipment for operational radio countermeasures (RCM)	
	Radar test equipment	1943-44

6 RDL sets for US Navy Argus Units in Pacific

Source: DSIR WW2 Radar Narrative

At Jodrell Bank after the war

At the end of the war Banwell started thinking about his next career move. Before leaving TRE he had mentioned to Ian Coop that geophysical prospecting using sound waves looked interesting

He eventually moved to Jodrell Bank and began research with Lovell's meteor radars, intending to do a PhD -
as did Clif Ellyett in 1947

In the previous chapter I described the situation in the summer of 1946 when it was realized that a large improvement in the sensitivity of our equipment would be needed if there was to be any hope of proceeding with the cosmic-ray experiment. The easiest solution seemed to be to improve the receiver, but Banwell said this would make only a small difference because the limit would be set by cosmic noise. This phenomenon was soon to be the major concern of the research at Jodrell and, indeed, the primary reason for our continued development. It is therefore curious that Banwell's remark was the first I had heard of this subject.

Lovell learns about cosmic noise from Banwell

Source: Lovell (1990) p.163

1948 John Banwell returned to NZ and began geothermal research at Wairakei and Broadlands

the international organizations.

UNESCO was the first international organization to tackle the problem of the lack of local geothermists. In August 1968, it convened a "Group of Experts on Training in Geothermal Energy" in Paris, with the objective of defining the number and type of geothermists who would be needed in the next few years to implement the geothermal projects of the developing countries. The experts present at this meeting are a part of geothermal history: John Banwell, Robert Fournier d'Albe, Masami Hayakawa, Elena Lubimova, James McNitt, Marco P. Marchetti, Gudmundur Palmason and Ezio Tongiorgi. The main conclusions reached by the Group were:

Still an expert in his (different) field

Source: GHC Bulletin, December 1998

Thank you for watching and listening