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THE SHORT-LIVED CSIRO DIVISION OF RADIOPHYSICS FIELD STATION AT BANKSTOWN AERODROME IN SYDNEY

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Abstract: Between 1945 and 1961 the CSIRO Division of Radiophysics operated twenty-one field stations or remote sites in or near Sydney and Wollongong during the early development of radio astronomy in Australia. One of these field stations operated at Bankstown Aerodrome from 1947 to 1948. To date, the existence of this field station has mostly escaped documentation in the historical record. This short paper gives an overview of the work carried out at this field station in the context of the early development of Australian radio astronomy.

Keywords: CSIRO Division of Radiophysics, Bankstown field station, interferometer, R.F. Treharne, A.G. Little

1 INTRODUCTION

The Australian Council of Scientific and Industrial Research (CSIR)[1] formed the Division of Radiophysics (henceforth RP) in 1939 to exploit the development of radar secrets shared by the British Government. Immediately following WWII, the focus of RP deliberately shifted to a range of peacetime activities, including the investigation of sources of radio frequency 'noise' reported at a variety of radar and other sites across the world during WWII (Sullivan, 2009). The leader of this work was Dr Joseph Lade Pawsey (1908–1962, Christiansen and Mills, 1964), who should be recognised as the 'founding father' of Australian radio astronomy.

RP operated twenty-one field stations and remote sites during the period 1945–1961 (see Orchiston and Slee, 2017), and the geographical distribution of these is shown in Figure 1. One of the field stations (number 21) was at Bankstown Aerodrome, and operated from around June 1947 to July 1948. This research paper discusses for the first time the work that was carried out at this short-lived little-known field station and introduces the two radio engineers who were based there.

2 BACKGROUND ON THE BANKSTOWN SITE

Bankstown is a suburb of Sydney located approximately 20 km to the south-west of the Sydney central business district, and was named after Sir Joseph Banks in 1795 following European settlement of the Sydney region (Flinders, 1814). As early as 1929 it was identified as a site for a

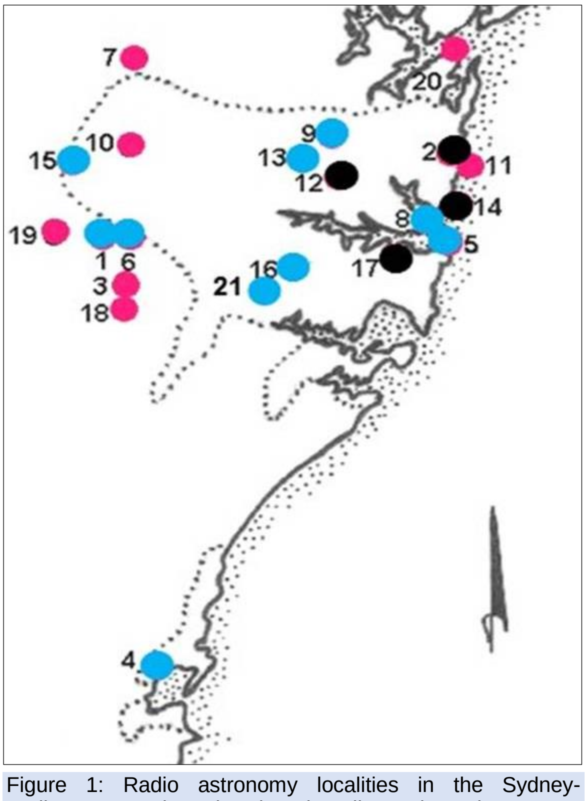

Figure 1: Radio astronomy localities in the Sydney-Wollongong region; the dotted outlines show the current approximate boundaries of Greater Sydney and Greater Wollongong. Key. Field stations: blue; remote sites: red; other sites: black. 1 = Badgerys Creek, 2 = Collaroy, 3 = Cumberland Park, 4 = Dapto, 5 = Dover Heights, 6 = Fleurs, 7 = Freeman's Reach, 8 = Georges Heights, 9 = Hornsby Valley, 10 = Llandilo, 11 = Long Reef, 12 = Marsfield (ATNF Headquarters), 13 = Murraybank, 14 = North Head, 15 = Penrith, 16 = Potts Hill, 17 = Radiophysics Laboratory (Sydney University grounds), 18 = Rossmore, 19 = Wallacia, 20 = West Head, 21 = Bankstown Aerodrome. For scale: from Dapto (site 4) to Dover Heights (site 5), as the crow flies, is 88 km (map: Wayne Orchiston).

Figure 2: Bankstown Aerodrome in 1945 (courtesy: Royal Navy Research Archive).

potential training airfield (Matts and Lockley, 2009). In 1940, 255 hectares of land were acquired by the Federal Government to establish a Royal Australian Air Force (RAAF) base. During WWII the RAAF base was also home to the United States Army Air Corps and a Royal Naval Fleet Air Arm Station (MHS Nabberly). In 1942, de Havilland established an aircraft manufacturing plant on the site to produce Mosquito aircraft.

Immediately following WWII the focus of activity at the airfield switched to the disposal of military aircraft and equipment. It was during this period, before the official 1 November 1948 handover of the airport to the Department of Civil Aviation, that some 18 hangars and 16 huts were hired out to a range of enterprises, including the CSIR. This is how RP's little-known Bankstown Aerodrome field station was formed.[2] Figure 2 shows the appearance of the aerodrome in 1945,

Figure 3: Ross F. Treharne in 1951 (after Morton, 1989: 197).

not long before RP moved on site. Unfortunately, there is no record of which buildings were occupied by RP at the Aerodrome during their short stay there.

3 IMPROVED INTERFEROMETRY

By June 1947, RP had established a blossoming line of research in both solar (Orchiston et al., 2006) and cosmic noise investigations (Robertson et al., 2014), for which it would soon achieve world supremacy (Sullivan, 2017). Early high-resolution observations were obtained using a sea-cliff interferometry technique first described by McCready et al. (1947) for solar observations. Their paper also outlined for the first time the use of the Fourier transformation for the image reconstruction from interferometer data, a technique that underpins all modern radio astronomy imaging. The sea-cliff interferometer, however, had some severe limitations (see Bolton and Slee, 1953). Interference fringes only occurred while the source was close to the horizon, either rising or setting, and was therefore subject to refraction errors, while to vary the observational baseline required finding a new cliff site. These limitations were well understood, and RP was also aware of the work underway at Cambridge, England, using a Michelson (spaced) interferometer technique (see Ryle and Vonberg, 1946).

Figure 4: Alec Little at Potts Hill field station in 1948 (courtesy: CSIRO Radio Astronomy Image Archive).

The minutes of the RP Solar Noise Group meeting of 6 June (Pawsey, 1947) record a new 'proposed investigation' into improved interferometry. While the sea-cliff interferometry technique was successful at locating the positions of persistent radio sources as they moved through the aerial beam due to the Earth's rotation, it was unsuited to locating short-duration sources, such as those associated with solar bursts. The development of the new interferometer was to be led by Ross Fredrind Treharne (1919–1982), and the objective was

> To make equipment capable of yielding interference patterns in a fraction of a second with a view to extending this technique to [solar] bursts. Initial ideas are to use manual phase variation to aerials connected by a transmission line. Frequency 100 Mc/s. (ibid.).

Treharne (Figure 3) had completed a double Bachelor of Science-Bachelor of Engineering degree at the University of Sydney, graduating in 1943 together with Bernard Mills (1920–2011, Frater et al., 2013) and Ronald Bracewell (1921–2007, Thompson and Frater, 2010), both of whom would go on to achieve international prominence as radio astronomers (see Frater et al., 2017). Treharne began his career with Amalgamated Wireless Australasia (A.W.A.) and in 1942 joined RP (see Treharne, 1983: 153 for a short biography). The first reference to Treharne joining Pawsey's group appears in the minutes of the RP propagation committee meeting of 10 September 1946, when he began part-time work on ionospheric investigations. But by June 1947, he was leading the equipment development for the new interferometer.

In the minutes of the Solar Noise Group meeting of 23 September 1947, Treharne, who had now also been joined by a Research Assistant, Alec Little (1925–1985; Figure 4; Mills, 1985), provided a comprehensive overview of his program:

> SOLAR INTERFEROMETRY PROGRAM – Bankstown.
>
> (R.F. Treharne & A. Little)
>
> General Aim.
>
> To establish interference methods of determining the distribution of sources of cosmic radio frequency radiation with particular reference to the sun.
>
> Physical Applications.
>
> In particular, the following physical applications appear to arise from such methods:-
>
> 1. Determination of the actual size of sources of "burst" or short duration radiation

at a frequency of 100 Mc/s and correlation with optical frequency sources. In particular, confirmation or otherwise of the hypothesis that "burst" radiation sources on the surface of the sun are of smaller size than the source which gives rise to the "general enhanced level" of the disturbed sun.

2. Location of sources of "burst" radiation at [a] frequency of 100 Mc/s and correlation with the position of optical sources. In particular, confirmation or otherwise of the hypothesis that burst radiation emanates from positions on the sun corresponding to positions of optical sunspots. Furthermore, correlation of high-intensity short duration "outbursts" with the appearance of "flares" may be possible.

3. Determination of distribution of solar sources of "enhanced general level" radiation of frequency 100 Mc/s and correlation with optical spots.

4. Determination of distribution of thermal radiation from the "quiet" sun at a frequency of 100 Mc/s and correlation with Dr Martyn's theoretical distribution.

5. Determination of polarisation of thermal level of "quiet" sun by suppressing radiation received from one solar magnetic theory.

6. Determination of the size of the source of cosmic radiation "Cygnus" at 100 Mc/s.

7. Determination of the sizes of circumpolar cosmic sources of 100 Mc/s radiation.

8. Extension of experiments to other radio frequencies such as 65, 200, 1200 and 3000 Mc/s.

Technique.

The technique of interferometry to be employed rests largely on the use of two or more aerials at various points on the earth's surface separated by distances chosen to give the desired interference pattern in space. Then by varying the phase difference between the signals received from the aerials taken two at a time and recording the resultant amplitude as a function of phase displacement the necessary information can be deduced.

The first experiment to be carried out consists of setting up a two aerial interferometer operating on a frequency of 100 Mc/s as shown diagrammatically in Figure SK(E)3363 [not included in archives].

In the first instance, the aerials will be so placed as to give an angular nul separation of about one degree. Continuous 360 degree per cycle 25 cycles per second automatic phase changing will be obtained by using remote frequency converter units at each aerial fed by a common local oscillator (see Figure). The phase of this local oscillator will be varied continually by means of a rotating transmission line phase shifter of approximately 180^{o} electrical length synchronised to the 50 c/s mains [power source].

The resultant noise amplitude of 2 Megacycles bandwidth will be detected and integrated over a time interval of 4 × 10^{-3} seconds and displayed on a 25 c/s time sweep oscillography.

Visual display methods will be used at first, and photographic recording, at a rate determined after visual inspection of the desired phenomena, will be used.

The conflicting bandwidth requirements imposed by signal path difference and by phase scanning rate have been taken into account in planning this experiment.

Drift Interferometry.

It is proposed to adapt the system of SK(E)3363 for very slowly varying phenomena by using the natural drift of the sun [as the Earth rotates] to produce the interference patterns and to record them by Esterline Angus mechanical recorders. In this case, the phase shifter and oscillograph are not used.

Extensions of Technique.

Extensions of the technique will be guided largely by experience but will probably fall into the following groups:-

(i) Calibration of system in phase and amplitude to permit both size and absolute position to be established.

(ii) Extension to more than two aerials to give higher accuracy, two-dimensional positions for point sources or plane distribution for multiple sources.

Immediate plans.

The equipment indicated in SK(E)3363 is under construction and will be tested at the laboratory. The system will be set up at the Bankstown field station. It is hoped that:-

(i) Interference patterns from bursts will be observed and the size determined.

(ii) Drift interference patterns from enhanced general level will be observed.

(iii) An experimental technique of phase calibration established to enable absolute positions to be determined.

(Note by Dr Pawsey's on Treharne's programme:

This plan looks further ahead than the others. Many aspects will not be touched for some time, perhaps never.

Details of specific planning require discussion at intervals in the future).

By 16 October 1947, Treharne reported that the new interferometer was almost ready to begin preliminary testing. However, a complication had arisen as the building they were leasing at Bankstown Aerodrome had been sold. Fortunately, it appeared another building at the airfield would be available. By 14 November 1947, Treharne and Little reported obtaining drift interference patterns for the first time, while the phase shifter (Figure 5) was still under construction. As it transpired, these drift interference patterns were not real, but instead caused by gain fluctuations in the receiver due to problems with a power supply (McCready, 1947b). By 20 February 1948, Treharne reported that the build of practically all of the instrumentation was complete and that they would soon begin making observations.

Soon after the February report, problems appear to have occurred at the Bankstown field station. In a letter dated 24 March 1947 [likely an error as it should be 1948] to Pawsey (who was travelling in the USA), Lindsey McCready (1947a) wrote: "Bad news: Robbery and vandalism at Bankstown. Have now found another site for 100 Mc/s interferometer." In a letter to Pawsey dated 23 April 1948, McCready reported that they had found a new permanent and secure site at Potts Hill on the grounds of the

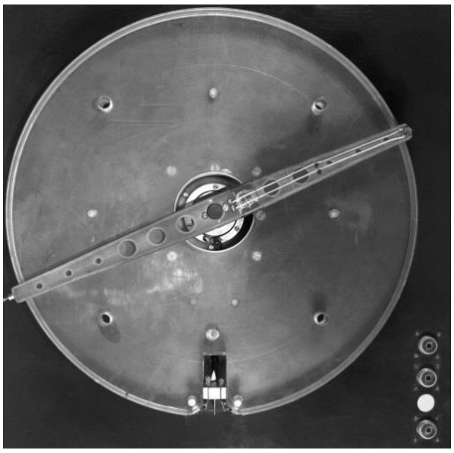

Figure 5: The phase-changer of the Swept Lobe Interferometer. The arm connected the inner and outer loops giving a phase change to the local oscillator that varied continuously over the electrical length for every rotation of the arm. The arm rotated at 1500 r.p.m. (courtesy: CSIRO Radio Astronomy Image Archive).

Sydney Water Board Potts Hill reservoirs. With the passage of time, Potts Hill would emerge as one of RP's most productive field stations (see (Wendt et al., 2011).

The problems with leasing arrangements and then theft and vandalism of equipment spelt the end for the Bankstown Aerodrome field station. It also marked the end of Treharne's involvement in radio astronomy. The minutes of the Propagation Committee meeting of 12 April 1948, show that leadership of the program transferred to Ruby Payne Scott (1912–1981, Goss and McGee, 2009). Treharne left RP and for a short period was a lecturer in Radio Engineering at Sydney Technical College before joining the Long-Range Weapons Establishment at Salisbury, South Australia, where he worked on military projects, becoming a pioneer in Australian Electronic Warfare. He was elected a Fellow of IREE Australia and received the IREE Norman W.V. Haynes Memorial Medal in 1958 for a paper on transistors. He retired from the Defence Research Centre in 1980 and passed away in Adelaide in 1982 (see Treharne, 1983: 153 for a short autobiography).

By July 1948 the Bankstown equipment was relocated to the new Potts Hill field station, where Payne-Scott and Little (1951) completed the development of what would become known as the Swept Lobe Interferometer (Figure 6). They achieved most of the goals set by Treharne in his ambitious programme in 1947 (Payne-Scott and Little, ibid.; 1952). Bernard Mills would also use this instrument for his introduction to interferometry and the investigation of discrete radio sources (Mills, 1952).

4 CONCLUDING REMARKS

While operating for only a short period, the interferometer developed and installed at Bankstown was a unique instrument and marked the first time an interferometer had been designed to sweep its lobe pattern using a mechanical phase shifter. The instrument was later fully described by Little and Payne-Scott (1951) and would influence other interferometer developments (see Wendt et al., 2011).

The use of the phase variation to produce a sweeping aerial beam was used by the group at Jodrell Bank to develop what they called, a 'Rotating-Lobe Interferometer' (Hanbury Brown et al., 1955). They adapted the technique used by Little and Payne-Scott and introduced the use of a phase-sensitive rectifier for their investigations of weak discrete sources. Bolton and Slee (1954) also reported the use of a similar technique, varying the relative phase of the local oscillator at two mixers to produce a "… moving lobe pattern."

The swept-lobe interferometer was an unprecedented instrument (Sullivan, 2009: 300). As Pawsey mentioned in his notes on Treharne's original proposal, "This plan looks further ahead than the others. Many aspects will not be touched for some time, perhaps never."

It is unclear why Treharne left RP in 1948. However, he went on to a successful career in military research.

5 NOTES

1. The CSIR became the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in 1949.
2. Other RP field stations founded at this time, or even earlier, were Dover Heights (number 5 in Figure 1), Georges Heights (number 8) and Hornsby Valley (number 9). While Dover

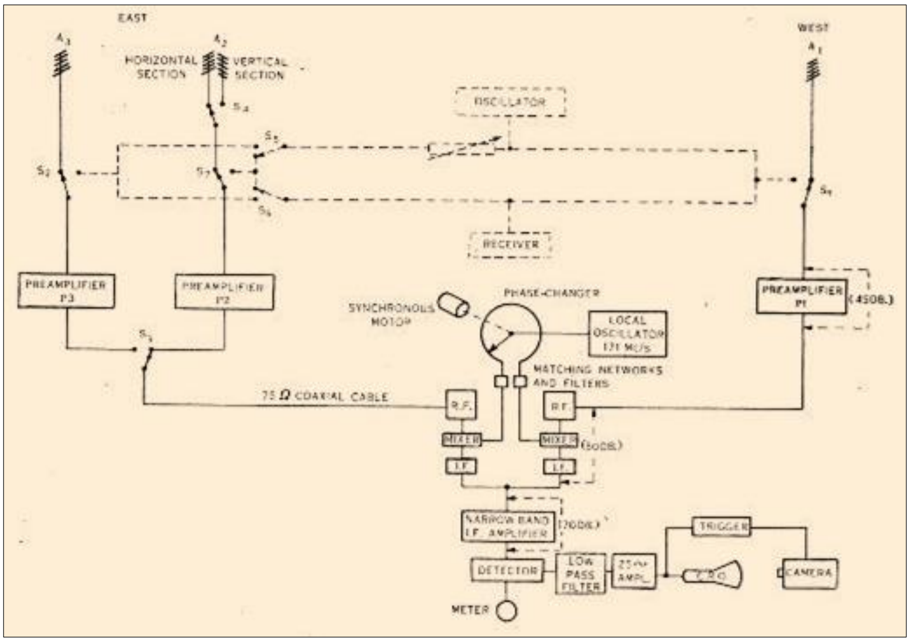

Figure 6: A schematic of the 97 MHz Swept-Lobe Interferometer. The interferometer had three Yagi aerials allowing two different baselines of 241 m and 40 m. The synchronous motor driving the phase-changer for the local oscillator is in the centre of the diagram (after Little and Payne-Scott, 1951: Figure 4).

Heights and Hornsby Valley went on to make important contributions to international radio astronomy (e.g. see Orchiston and Robertson, 2017; Orchiston and Slee, 2002; 2017: 502–511, 514–519; Orchiston et al., 2015; Robertson et al., 2010; 2014), like Bankstown Aerodrome the Georges Heights field station also was short-lived (but see Orchiston, 2004; Orchiston and Wendt, 2017; Wendt and Orchiston, 2018).

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