FIRST OBSERVATIONS OF JUPITER'S RADIO EMISSIONS IN FLORIDA

C. H. Barrow* and T. D. Carr†

Abstract

Following the discovery of Jupiter's decametric emission (DAM) in 1954 by Burke and Franklin [1955] and the subsequent confirmation from old 1950–51 records by Shain [1956], first observations were made at the University of Florida in 1957. These observations were made at 18 MHz using an eight-dipole broadside array, a short-wave communications receiver and pen-recorders. Fortuitously, 1957 represented a peak in what, for a while, became known as the jovian activity cycle until this was recognized as an effect of the declination of the planet at the time of observation. Thus the observations were remarkably successful. Histograms showed the periods of activity to be concentrated in two bands of System II central meridian longitude (CML) while the emission periods were randomly distributed in System I CML. The concentrations in System II became known, ambiguously, as "sources" and were later specified more precisely when System III CML, based upon many years of radio observations, was defined. Left- and right-hand components of polarization (LH) and (RH) were measured and the DAM was found to be predominantly RH polarized. First indications of fast pulses in the emission, subsequently known as S-bursts, were also found.

1 Introduction

Soon after the discovery of Jupiter's decametric radio emission by Burke and Franklin [1955] and the subsequent confirmation from old records by Shain [1956], Tom Carr and I arrived as graduate students at the University of Florida in Gainesville. Tom came from a background of university research in cosmic radiation and war-related research in government laboratories. I came as a Fulbright Scholar seeking a change from teaching in England. Both Alex Smith, our faculty research superviser, and Tom Carr wanted to become involved in radio astronomy but they were undecided as to how to begin, the resources then available being very limited. Fortunately, the annual URSI Meeting was being held in Gainesville at that time and Roger Gallet [1957] gave a paper on his

* *Max-Planck-Institute for Solar System Research, Copernicus, D-37191 Katlenburg-Lindau, Germany*
† *Department of Astronomy, University of Florida, Gainesville, Florida, USA*

pioneering work on the jovian radio emission. Talking with Alex, Tom and myself, after the meeting, he recommended further investigation of this radiation as the cheapest and most sure-fire way of beginning useful research in radio astronomy. We agreed and we set to work trying to acquire some background in an area new to us all. Tom had some knowledge of amateur radio and Alex was more interested in optical astronomy while I had no more than the interest and enthusiasm of an amateur astronomer.

2 Receiving equipment

With the aid of three technicians from the Physics Department, Tom and I constructed the first radio astronomy antenna in the state of Florida shown in Figure 1. This consisted of

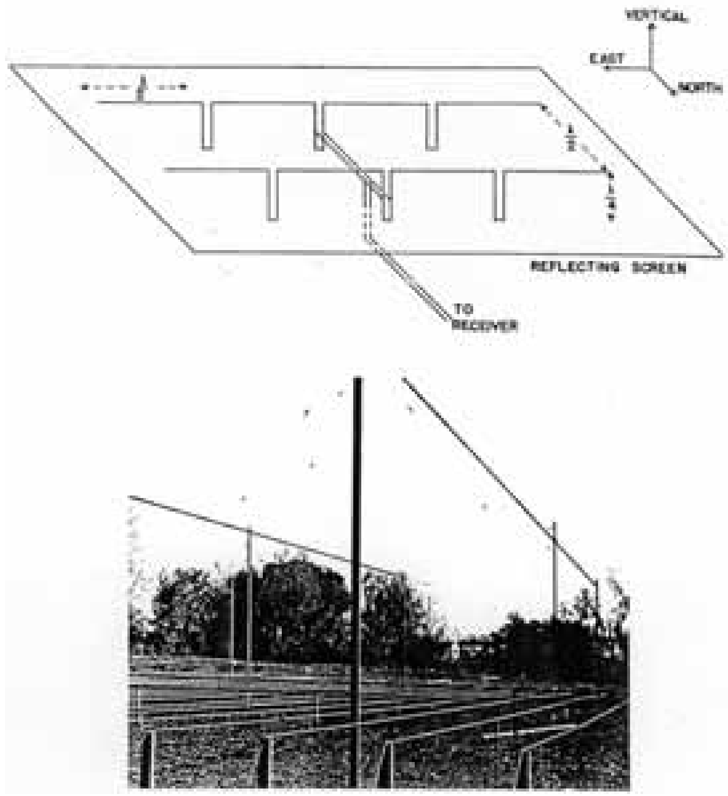


Figure 1: The 18 MHz broadside array, schematic (upper section) and photograph (lower section).

an 18 MHz double collinear broad-side array of eight half-wave dipoles oriented east-west. This gave an E-W beamwidth of about 35° to half-power points and allowed some four hours of drift observation each night. Tom and I have often reminisced on this project with some amusement. It was a measure of our naïvety that, although we realized that at 18 MHz a reflecting screen a quarter-wave below the dipoles need only consist of long parallel wires some 70 cm apart, it did not occur to us that these wires need only be laid along the ground to be effective, the site being fairly even and with a slight southward slope. Instead, we painstakingly mounted each thick aluminium wire on short posts having first removed the kinks by attaching one end of the wire to a tree and pulling on the other end which we attached to a small pick-up truck. The reflecting screen was about 37×25m in area and the wires were so carefully aligned that it was impossible to detect any appreciable irregularity when sighting diagonally across the array from one corner of the reflecting screen to the other. The dipoles were cut and adjusted with equal care using a standing wavemeter. It is hardly surprising that the final measurement yielded a standing wave ratio of just under 1.2 when 1.5 would have been quite acceptable. The dipoles in each collinear line were connected to each other by quarter-wave stubs. North-south steering of the reception beam was accomplished by moving the connecting point of the transmission line leading to the receiver along the line between the two collinear lines of dipoles, thus phasing the inputs from the two lines of dipoles.

The receiving equipment is shown in Figure 2. This equipment was installed in a small adjacent building which also housed an 8-inch refractor used as a teaching aid for an elementary astronomy course. The receiver was a Hallicrafters SX-62A short-wave communications receiver with the rectified audio output fed to an Esterline Angus pen-recorder, for general observation with a chart speed of 6 in/sec, and a Brush high-speed recorder and amplifier used only during periods of Jupiter activity. Calibration was with a home-made diode noise source.

Figure 2: The receiving equipment. The second receiver was used for time signals from WWV. The noise generator is on the extreme right-hand side.

3 Observations

Observations were conducted during the months adjacent to opposition so that Jupiter would be close to the meridian during the early morning hours when terrestrial interference was minimal. One of us, Tom, Alex or myself, would monitor the equipment each night using a routine that we developed for identifying the Jupiter radiation. This procedure, subsequently called "aural monitoring" by Alex, involved monitoring the Easterline Angus chart recorder and listening to the loud-speaker so as to distinguish Jupiter radiation from possible sources of interference, such as car ignition or static pulses, and tuning out distant stations that might appear close to the observing frequency. Although the procedure may sound somewhat subjective nowadays it proved to be remarkably effective. The Brush recorder would only be used during identified periods of Jupiter radiation. Some typical records are shown in Figure 3. Observing notes were kept in a log-book. a page of which is reproduced in Figure 4. First observations were made during the winter of 1956-7 when, as luck would have it, Jupiter was at a maximum of its "11-year activity cycle", now known to be an effect of the declination of the planet at the time of observation. We were much encouraged to to obtain a good set of observational data a little less than two years after the first observations of the Jupiter radiation published by Burke and Franklin [1956].

4 First results

Following the procedure introduced by Shain [1956], histograms of the periods of observation were constructed using the two central meridian longitude (CML) systems based upon rotation periods measured from optical observations; System I for the equatorial region of Jupiter and System II for the rest of the planet. In agreement with Shain, the activity was found to be concentrated in two bands of System II CML while the emission periods were randomly distributed in System I. The concentrations in System II became known, ambiguously, as "sources" and were later specified more precisely when System III CML, based upon many years of radio observations, was defined. Tom calculated a preliminary value for this [Carr et al., 1958] from the slow drift of the sources in System II CML. This is shown in Figure 5 together with the positions of the most conspicuous optical features which were, at first, thought to be associated with the radio emission. Polarization sense of the radiation was measured, using a simple arrangement of crossed Yagi antennas fed to two receivers via a hybrid ring as shown in Figure 6. These measurements indicated that the radiation was predominantly right-hand polarized and suggested the existence of a magnetic field on Jupiter. Fine structures in the radio emission, as shown in the lower section of Figure 3, gave the first indication of what became known as S-bursts, later to be studied with very high time resolution by the University of Florida group.

One other interesting result should be mentioned briefly. Several years later, observations at Florida State University, using an 18 MHz phase-switched interferometer [Ryle, 1952], yielded records of the type shown in Figure 7 [Barrow and Williams, 1967]. In some records a fringe system is clearly visible while in others, like the record for January 18, 1967, the emission appears as separated spikes to either side of the zero-centred baseline. The following question then arises: the Jupiter radiation is believed to be sporadic and so why do the interference fringes sometimes appear so clearly defined? Why does the pen not always return to the baseline? Does this mean that there is sometimes a continuum background emission? The question still awaits a definitive answer.

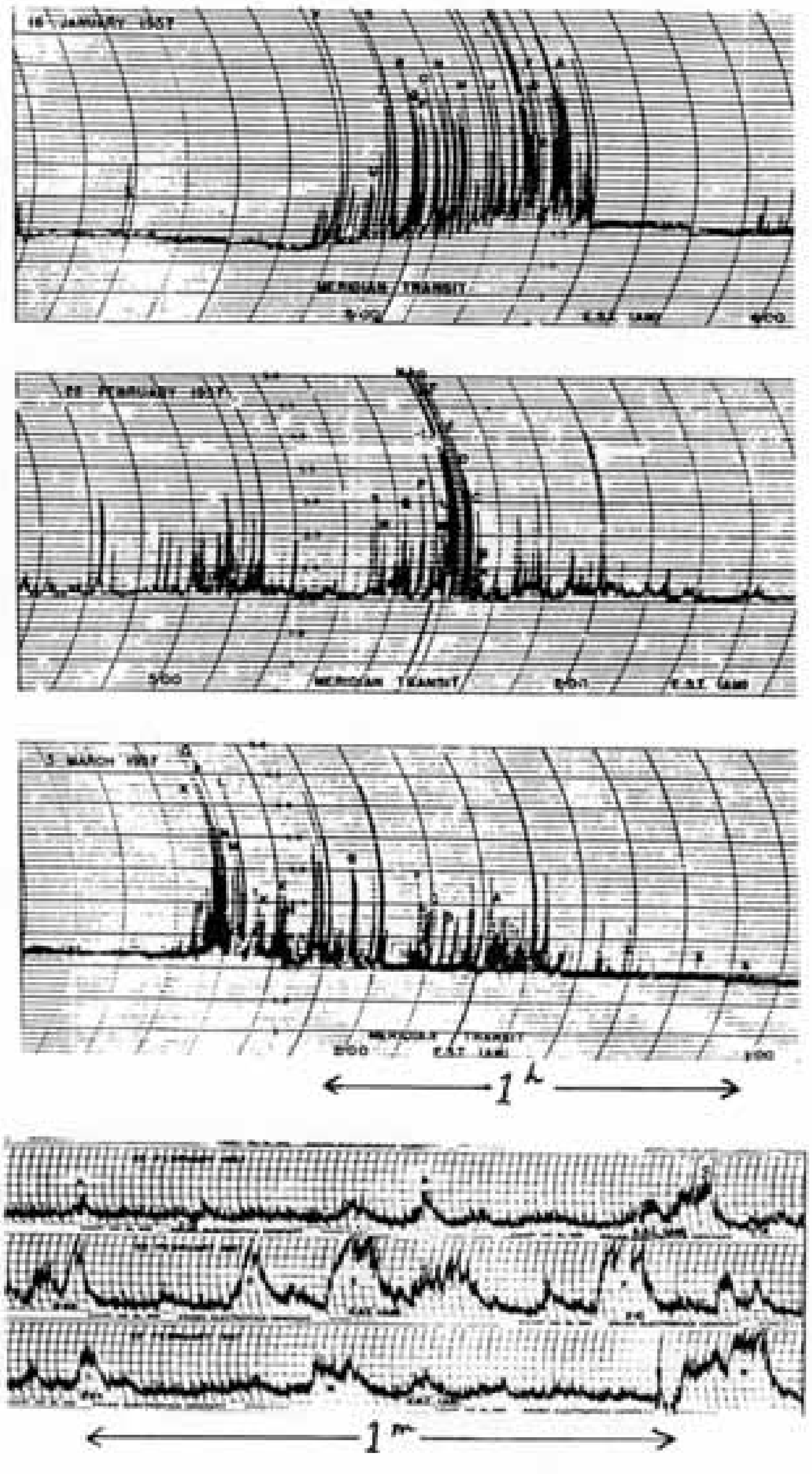
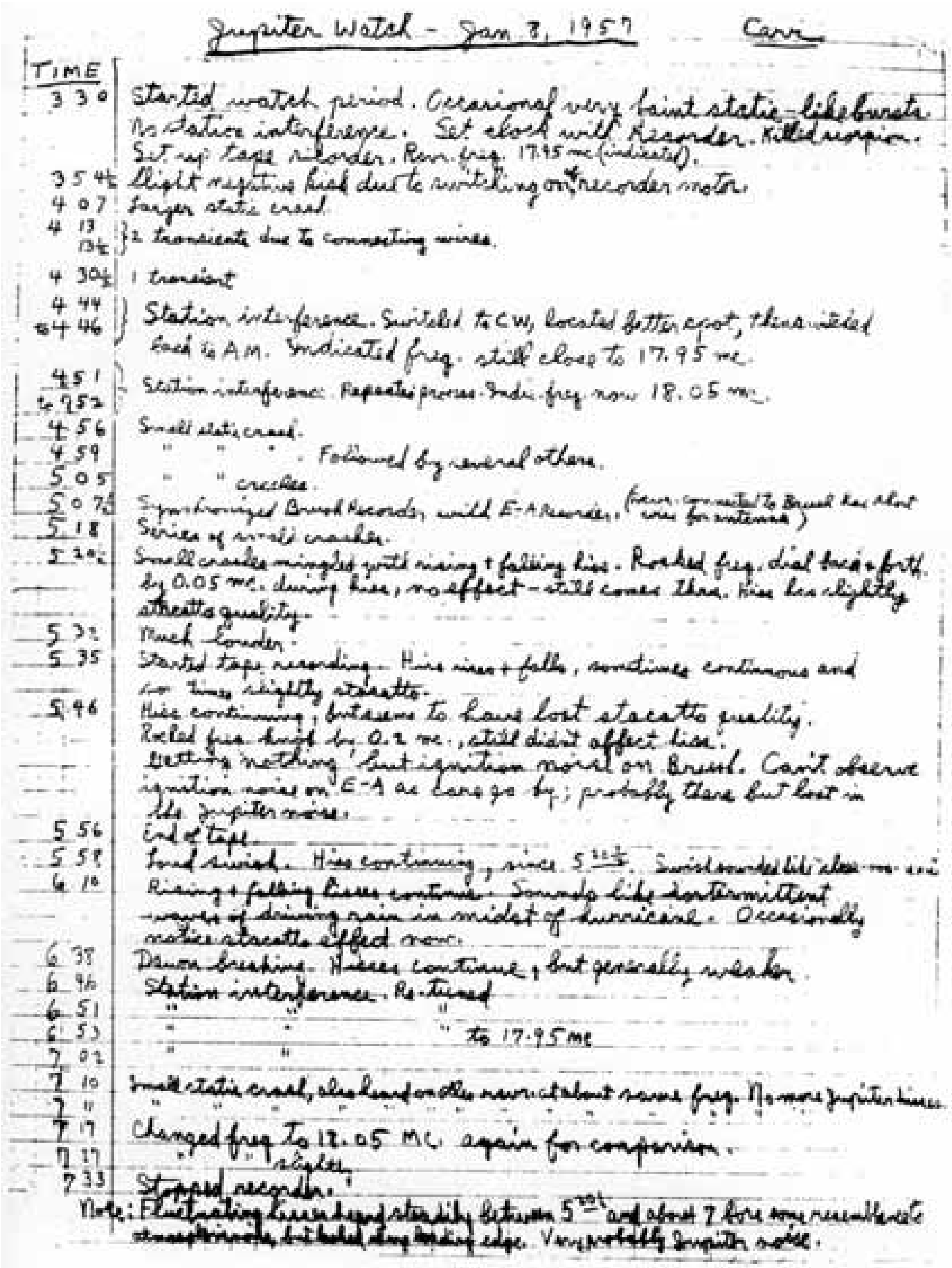


Figure 3: First observations of the Jupiter radiation by the Esterline Angus recorder (upper section) and the high-speed Brush recorder (lower section). First indications of fine structure in the Jupiter radiation can be seen in the Brush records.



Jupiter Watch - Jan 8, 1957 Carr

TIME

330 Started watch period. Occasional very faint static-like bursts. No station interference. Set clock with recorder. Killed scorpion. Set up tape recorder. Rcvr. freq. 17.95 mc (indicated).

354½ Slight negative kick due to switching on recorder motor.

407 Larger static crash.

413, 13½ 2 transients due to connecting wires.

430½ 1 transient

444, 446 Station interference. Switched to CW, located better spot, then switched back to AM. Indicated freq. still close to 17.95 mc.

451, 452 Station interference. Repeated process. Indic. freq. now 18.05 mc.

456 Small static crash.

459 " " " . Followed by several others.

505 " " crackles.

507½ Synchronized Brush Recorder with E-A Recorder. (Recvr. connected to Brush has short wire for antenna)

518 Series of small crackles.

520½ Small crackles mingled with rising + falling hiss. Rocked freq. dial back + forth by 0.05 mc. during hiss, no effect - still comes thru. Hiss has slightly staccato quality.

532 Much louder.

535 Started tape recording. Hiss rises + falls, sometimes continuous and at times slightly staccato.

546 Hiss continuing, but seems to have lost staccato quality. Rocked freq. knob by 0.2 mc., still didn't affect hiss. Getting nothing but ignition noise on Brush. Can't observe ignition noise on E-A as cars go by; probably there but lost in the Jupiter noise.

556 End of tape.

558 Loud swish. Hiss continuing, since 520½. Swish sounded like [illegible]

610 Rising + falling hisses continue. Sounds like intermittent waves of driving rain in midst of hurricane. Occasionally notice staccato effect now.

638 Dawn breaking. Hisses continue, but generally weaker.

646 Station interference. Re-tuned

651 " " "

653 " " " to 17.95 mc

702 " "

710 Small static crash, also heard on other receiver at about same freq. No more Jupiter hisses.

711 " " [illegible]

717 Changed freq to 18.05 mc again for comparison.

727 " " slight

733 Stopped recorder.

Note: Fluctuating hisses heard steadily between 520½ and about 7 bore some resemblance to [illegible] noise, but lacked sharp leading edge. Very probably Jupiter noise.

Figure 4: A page from the observers' log-book. Note that, at 0520, Tom refers to a "staccato quality" as a characteristic of the radiation. These must have been what are now known as S-bursts. Similarly the "rising and falling hisses" must have been L-bursts. Note also that a scorpion was killed inside the building at 0330; observing was not without its hazards!

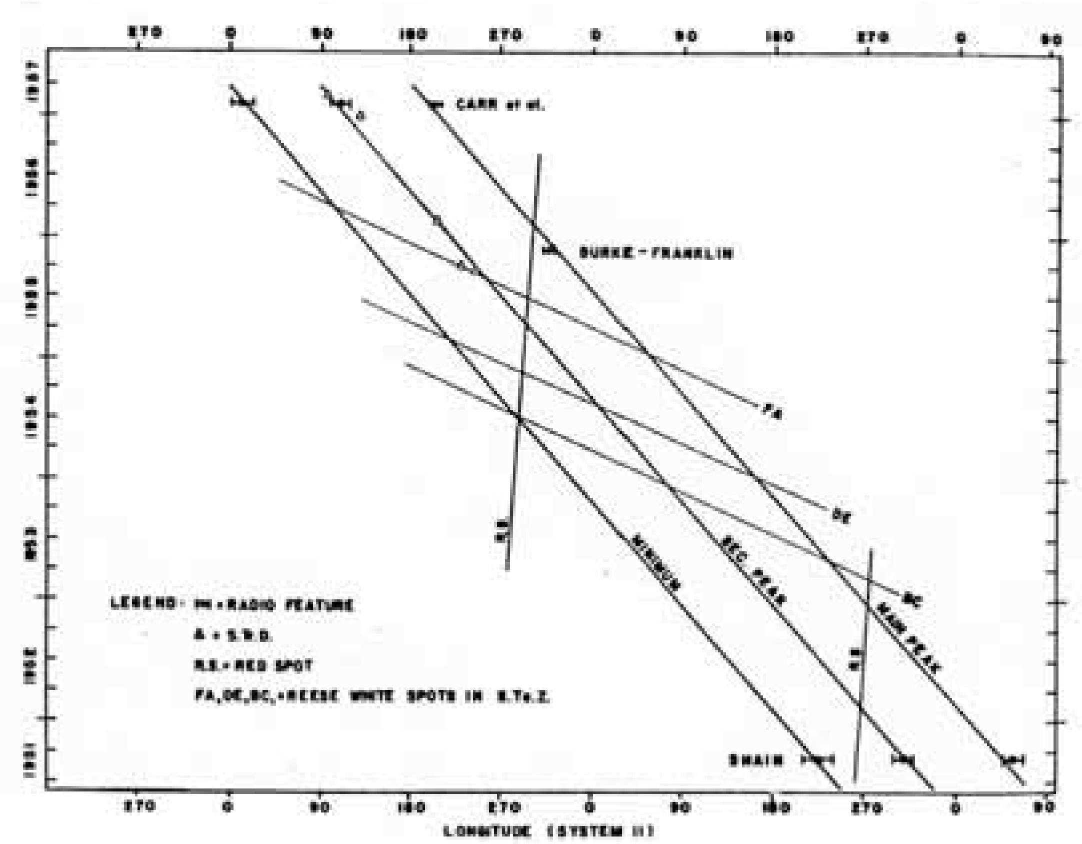


Figure 5: Drift of the radio emission sources in System II CML using the observations of Burke and Franklin [1955], Shain [1956] and Carr et al. [1958]. The well-known optical features (South Tropical Disturbance, Red Spot and the three Reese white spots) are also shown.

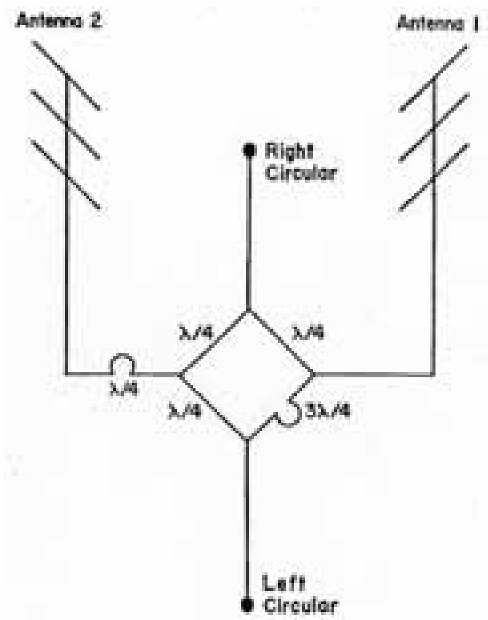


Figure 6: Schematic of the method of measuring polarization sense.

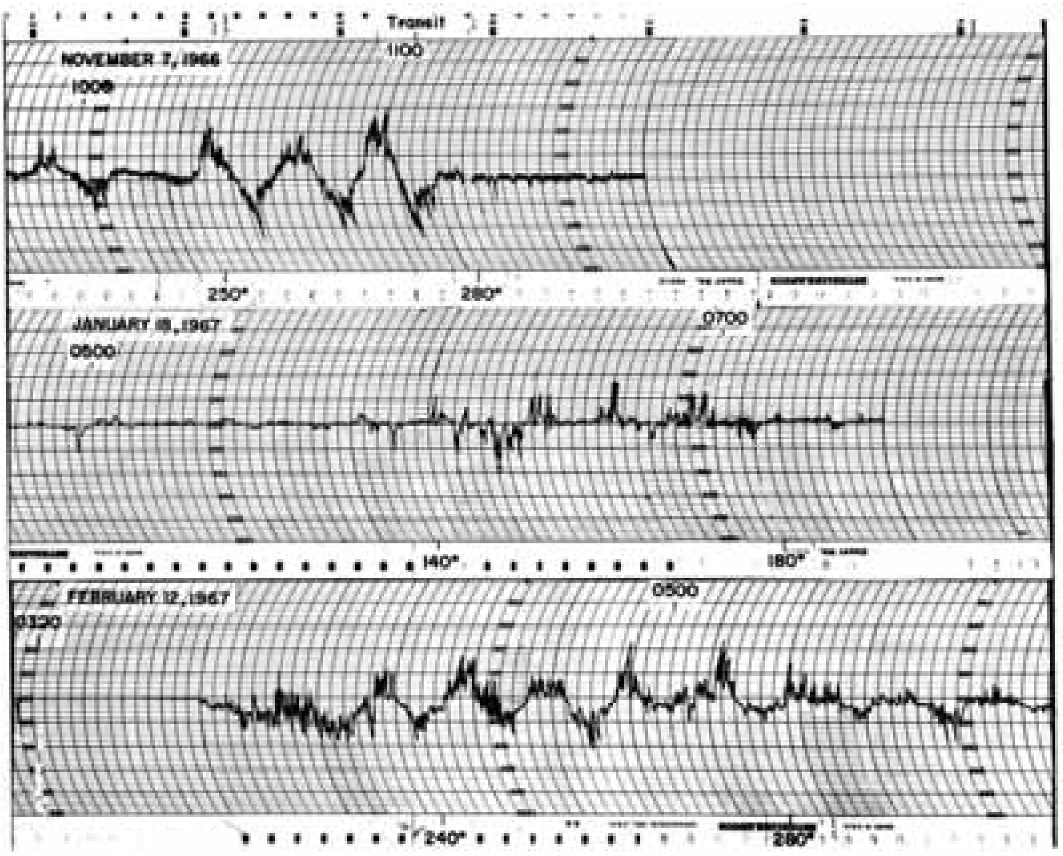


Figure 7: Typical events recorded by the interferometer. The time constant for the top record was 1.0 sec. For the other two records the time constant was 0.5 sec.

5 Concluding remarks

There is no doubt that research was more basic and more fun in the nineteen-fifties. One followed an idea, building and operating the equipment and analysing the data oneself. One acquired a certain feeling for a project that is, perhaps, lacking nowadays in an age of high technology and large teams of investigators. It was very satisfying to look at our antenna and receiving system and to think that the data that we had obtained was the result of our own work and initiative.

In 1956 radio astronomy was a novelty at the University of Florida. As the Vice-President of the University was himself a keen amateur astronomer the project aroused much popular interest and there were numerous visitors to the radio site. Amusingly, it seemed that the first instinct of most visitors would be to walk to the end of the antenna array and to look along the reflecting screen and a line of dipoles; so our careful efforts of alignment were not entirely wasted.

I returned to England in 1958 at the end of my Fulbright Scholarship, returning to Florida in 1960 to set up another radio observatory for studying Jupiter at Florida State University in Tallahasse. Alex and Tom continued to develop the Jupiter observation programme and eventually established the present University of Florida Radio Observatory on an isolated

60-acre site some 50 miles from Gainesville. Alex Smith was Observatory Director until 1985 when Tom Carr became Director, a position he still holds today. This was the beginning of Jupiter radio astronomy in Florida, due to make a profound contribution over the following years.

References

Barrow, C. H., and J. R. Williams, Evidence of continuum emission from Jupiter at 18 Mc/s, *Nature*, **216**, 462-463, 1967.

Burke, B. F., and K. L. Franklin, Observations of a variable radio source associated with planet Jupiter, *J. Geophys. Res.*, **60**, 213-217, 1955.

Carr, T. D., A. G. Smith, R. Pepple, and C. H. Barrow, 18-megacycle observations of Jupiter in 1957, *Astrophys. J.*, **127**, 274-283, 1958.

Gallet, R. N., Results of the observations of Jupiter's radio emission on 18 and 20 Mc/s in 1956 and 1957, *Trans. Inst. Rad. Eng.*, **AP-5**, 327, 1957.

Ryle, M., A new radio interferometer and its application to the observation of weak radio stars, *Proc. Roy. Soc.*, **A211**, 462, 1952.

Shain, C. A., 18 Mc/s radiation from Jupiter, *Aust. J. Phys.*, **9**, 61, 1956.