For the use of R.R.S. Staff only

R.R.S. Newsletter No. 11 — 15th March 1962

RADIO RESEARCH AT DITTON PARK - III

1927 - 1933

Of the considerable changes that came about at Ditton Park in the last month of 1927, one resulted from the need for unification and others were brought about by force of circumstances. On the 1st December the trinity of D/F, Field Strength and Atmospherics research combined to form the unity of the Radio Research Station, with Watson-Watt as superintendent.

This smooth state of affairs lasted about half a day, for by two in the afternoon buildings in N. Park and a 210 foot wooden lattice tower were found to be ablaze. It was later thought that a fault in a stove had started the fire, though nothing definite was known. The chaotic events of this day have been well described by Mr. Naismith in an article in a recent newsletter; the matter has been summed up by Watson-Watt thus:- (I) ... 'arrived in time to do nothing useful, but to watch the local fire brigade do a remarkable amount of quite needless damage'.

Fortunately nobody was hurt, but losses were considerable, about £1600 for inventoried items and a further £1300 for other property, including books etc. and personal possessions of the staff. The R.R.B. report for that year notes that all this caused serious interference with the work of the station, though overall progress remained 'satisfactory'.

Much good eventually came of this destruction, new buildings designed, within certain financial limits, to suit the requirements of Superintendent and staff were built near the pond in one corner of W. Park. These, now known as the 'Old Buildings' are much as they were when first completed. The large corner room with the bay window was the Superintendent's office and remained as such until 1956. These buildings, the first coherent R.R.S., were occupied by about April 1928 and found so useful that the Board's report for that year stated 'the new arrangements .... have resulted in considerable improvement in conditions of work which has led to a marked increase in the output from the station'.

The nature of this work continued much as before, the researches being extended further throughout the radio spectrum. The Cathode Ray Oscillograph was used increasingly as a means of display and circuits and techniques concerning it were being evolved.

An attempt to provide simultaneous observations of atmospherics at a number of observing stations was the introduction of the Fultograph,

This was a simple and quite effective machine for slow scan facsimile transmission and about this time the B.B.C. had instituted a Weather Map Service which could be received by this device. In addition they agreed to transmit a picture of a piece of graph paper; on being received at the various observing stations this would display marks caused by atmospherics. Thus all stations receiving a given disturbance would have marks having identical co-ordinates. The records were analysed at Slough.

The investigations into the spectral distribution of atmospheric disturbances were renewed with fresh apparatus, though subsequent events prevented an early fulfilment of this aim, and it is interesting to note that the present observations of the diurnal variation of noise at various frequencies do not accord with the early findings.

/During

During 1929 Admiral Jackson resigned from the Board because age and increasing ill-health prevented him from continuing his valuable work. The nine years of his Chairmanship had been invaluable in guiding the work of the Station and bringing it to a position of strength. He could look with satisfaction on a vigorous establishment at Ditton Park with such an output of work that it was decided that future reports should no longer be included with those of D.S.I.R. but should appear separately.

The first of these was in press at the time of publication of the last of the older type of report and when it appeared it gave summaries and detailed accounts of the Station's work together with illustrations, one being of the 'New Buildings' and of the station transport, a Morris van which survived until comparatively recent times.

R.R.B. report No.2 published in 1931 had the sad task of announcing the death of Sir Henry Jackson. He survived his resignation for only a short time and died at Hayling on 14th December 1929. During the 1914 war when he held the appointment of First Sea Lord his conduct of the anti U-boat campaign had been the subject of much controversy and criticism, and he was replaced by Jellicoe at the time of the fall of the Asquith government. As a scientist and an early example of a modern scientific leader in what Snow has called the 'corridors of power' he appears to have been an unqualified success.

After a short interval the Lord President of the Council appointed Lt. Col. A.G. Lee to be chairman of the Board and under his leadership a survey of the last ten years work caused them to emphasise the need for certain aspects of fundamental research to be undertaken not only by the universities, but by such bodies as R.R.S. who were in a stronger position to obtain co-operation from observers throughout a large area.

An opportunity for this sort of work was fast approaching. From 1882 - 83 the first International Polar Year had yielded valuable geophysical data about the Polar regions and 50 years later, from 1932-33, the second International Polar Year was planned to take place. This time, however, more powerful methods of investigation had been evolved, including the use of radio methods for studying auroral effects and observing the behaviour of the region that Watson-Watt had christened the 'Ionosphere'.

In the course of observing this region it had been noticed that reflections were obtainable at nearly vertical incidence and it was arranged for the transmitter and receiver to be a short distance apart, one being at Ditton Park and the other at the 'Prince Consort's Workshop' in Windsor Great Park. (Doubtless Albert the Good would have approved of such scientific work). A series of experimental measurements of apparent heights and of critical frequencies was undertaken, which gradually developed into an observational routine.

Meantime in the United States a method of pulse retardation sounding had been developed by Breit, Tuve and Dahl and experiments were made at Slough to compare it with the frequency shift method of Appleton and his co-workers. The first transmitter was based on a squegging valve oscillator, a simple self-quenching device derived from a time base circuit produced at Slough for use with the Cathode Ray Oscillograph.

This device was the ancestor of the present vertical incidence ionosonde. It was eventually operated entirely at Slough, and when, a short time afterwards, an improved pulse transmitter developed by Ratcliffe and White was installed, the Ionospheric Observatory may be said to have been well established.

It was decided that the ionosphere investigations for the Second International Polar Year should be carried out in Norway. Accordingly from 1932-33 a party, which included R. Naismith and W.C. Brown from R.R.S., operated equipment at Tromsø, being helped by such visits from Professor Appleton as his other duties allowed him to make. The records also show that on the advice of the R.R.B. 'a loan of equipment was made to

/ Mr.

Mr. J.A. Ratcliffe of the Cavendish Laboratory' and that 'the Cambridge records will form an important part of the British radio data from the Polar Year'.

By the end of 1933 a preliminary analysis of this data yielded much of interest. General conclusions were that solar Ultra-violet light accounted for the normal ionisation of the two main regions of the ionosphere and for the daily and seasonal variations therein. Abnormalities at lower levels might be due to charged particles entering the atmosphere from without and being acted upon by the Earth's magnetic field. There was quite a high correlation (0.75) between thunderstorm activity and an increase in ionisation in the lower layer.

The same year also saw another administrative change, when R.R.S. and Wireless Division, N.P.L. were amalgamated to become Radio Department, N.P.L. Watson-Watt was appointed Superintendent.

The new organisation had workers with considerable experience in the use of pulse techniques, D/F work and propagation phenomena, also time base circuitry and cathode ray oscillograph display methods. These two matters were of such general interest that a book 'The Application of the Cathode Ray Oscillograph in Radio Research', written by Watson-Watt and his associates, was published by H.M.S.O.

The time was soon to come when this various knowledge was to be integrated to start a major and far-reaching branch of applied science.

G.W. GARDINER

THE PARAMETRIC AMPLIFIER

That oscillations in one part of a mechanical system could be maintained by varying some parameter of the system at some other frequency has long been known; it was discussed, for example, by Lord Rayleigh. A simple example is a child working a swing. Similarly it was known that oscillations could be maintained in an electrical circuit by means of a time-varying reactive element, but it is only fairly recently that it has been possible to produce such an element in a reasonably practical form. Ferrite elements have been used, but the one which is almost universally used now is the so-called "varactor" diode. Here, changes in the depletion-layer capacitance are brought about by means of a local oscillator (usually called the "pump") which produces voltage changes across the diode. If the input signal frequency be f, and the "pump" frequency f_2, then the oscillations caused by the signal can be amplified provided that (a) a circuit is also provided to resonate at the difference or "idler" frequency, $f_2 - f_1$, and (b) the capacity changes in the diode can be made large enough. (If they are too large the circuit will oscillate at the self-resonant frequency f_1).

It should be noted that power is also available at the "idler" frequency, and conversion gain may be obtained (the so-called "up-converter"). At high frequencies, however, the usefulness of this device is limited by the need for a low-noise receiver to follow the converter at the higher frequency.

This brings us to the main reason why such amplifiers, called parametric amplifiers, are now coming into use, in spite of the fact that, as may be surmised from the foregoing, the gain tends to be critically dependent on pump power. They are used because they produce very little noise. Even at room temperatures and at microwave frequencies noise figures of 1 decibel have been obtained. To achieve this however, one needs a very good diode, and a very great deal of research and development has gone into the production of high grade varactor diodes which have (a) low effective series

/ resistance

resistance at the frequencies in use, of the order of 1 ohm, (b) large variable-to-fixed capacity ratio and (c) high "cut-off" frequencies. (The cut-off frequency is that at which the capacitative reactance equals the series resistance, and a high cut-off frequency therefore means both low resistance and low fixed capacity). Cut-off frequencies of 300 Gigacycles per second have been obtained, but the cost, alas, is roughly 10/- per Gigacycle!

The simple form of parametric amplifier outlined above has one other disadvantage besides instability - it tends to have a limited bandwidth. Optimum bandwidth is achieved when the signal and idler circuits have the same frequency response characteristic (or Q), and the gain is then a function of the product of the circuit Q and the ratio of variable-to-fixed diode capacitance. The higher the gain, the narrower the bandwidth. Some advantage is gained by the use of the "degenerate" amplifier. Here the pump frequency is about twice the signal frequency, and the signal and idler are both accommodated in one tuned circuit. If the signal is incoherent, as in radio astronomy, where it is just noise, then it enters at both frequencies and the two powers are simply added at the output. The degenerate amplifier may, therefore, have almost twice the gain-bandwidth product of the single-channel amplifier with a higher idler frequency, but even so, an amplifier at 1000 Mc/s with say 15 dbs gain will have a bandwidth of about 8% only, under optimum conditions.

There are two ways of dealing with this problem. The first was described by Professor Cullen in a recent talk at the Radio Research Station, and is the "travelling wave" parametric amplifier, in which a number of diodes form part of a loaded transmission line circuit. The amplifier can be made almost unidirectional, and each diode produces only a low gain, so that it is fairly stable. However, at 10/- per Gigacycle per diode, the cost of such an amplifier could be very large, and so it is fortunate that there is a second way of achieving a wide bandwidth, first described by Seidel and Hermann and more recently by Matthei. This is the use of correctly designed filter networks in the signal and idler circuits, or one such filter in the common circuit in the case of the degenerate amplifier. Matthei has recently described a degenerate amplifier employing a double tuned circuit, which had 22% bandwidth at 1000 Mc/s, with 15 dbs gain and a noise figure as low as 1 db, even at room temperature.

One other point about the single-diode amplifier is that it is bidirectional and a circulator or similar device is necessary to isolate the output from the input and vice versa.

Some work has been going on at the Radio Research Station in an attempt to produce a reasonably good amplifier at 3000 Mc/s in waveguide, but it was found that bandwidth was restricted by the frequency/velocity dependence of the distributed circuits used. In addition, available waveguide circulators tend to be rather narrow-band, and so a coaxial line version is now under construction and should be working shortly. It is hoped that a gain of 20 db and a bandwidth of 150 Mc/s or so will be achieved, with a noise figure not greater than 2 db. (One or two quite interesting constructional problems have arisen, and it is quite creditable that Mr. Oakman's staff and the writer are still on speaking terms in spite of some very indifferent draughtsmanship!) We have also seen some work going on at both Mullards and G.E.C., but in both cases the noise figures left something to be desired, although Mullards have produced a very effective single tuned amplifier in S-band. We are therefore hoping that with luck we may get there first.

F.V. BALE

STAFF NEWS

Welcome to:	Mr. McGivney, returned from the Falkland Islands, who recommenced work at R.R.S. on 5th March.	
Appointments	Mrs. N.E. Hawkett t/Clerical Assistant	15.2.62
	Mrs. K. Bain t/Scientific Assistant (part time appointment)	22.1.62
Resignations	Dr. D.W. Lahaffey	13.3.62
Visits	Mr. Lane to U.S.A. from October 1961 to February 1962.	
	Dr. Cairns to Paris to attend a Symposium on Theoretical Interpretation of Upper Atmosphere Emissions. 25th - 29th June.	

CORRECTIONS

It is regretted that the Director's projected visits were wrongly given in the last Newsletter.

It is also regretted that our last issue was dated 15th March instead of 15th February! Perhaps readers (if any) will amend their copies.

SPORTS AND SOCIAL CLUB

CAMERA CLUB

Weekly exhibitions of selected colour slides are continuing in the Canteen. Thanks to the kind loan of material from several contributors, including Messrs. Froome, Golton, Legg and Rishbeth, we were recently able to enjoy glimpses of Malaya, India, Morocco, Ireland and take trips from the Mediterranean to the Cape and up the River Thames. Other places on show included France, Switzerland, Austria, Windsor and Ditton Park.

The present series of displays will end shortly, to be resumed perhaps in the autumn when further contributions will be greatly appreciated, even from non-members, (should anybody have failed to join the Club by then).

We hope to continue our monthly print exhibitions in the near future.

W.S. NEWMAN

BRIDGE CLUB

A bridge tournament was held at R.R.S. on the 15th February. It was arranged by Dr. Bramley to give a winning individual player from each of two groups of six. The winning N - S player was Mrs. Bain, (23 pts) and there was a tie between Mr. and Mrs. Gordon-Smith (12 pts each) for the winning E - W player. Scoring was arranged to make the average zero on each side, and the maximum possible score was 40 pts

A match against N.P.L. II was played at Slough on 23rd February. R.R.S. lost by 1510 aggregate pts. The team was: A.J. Legg and V. Owen; K. and W.C. Bain; E.N. Bramley and J. Harwood; C. Nicolson and P. Smith.

AMATEUR RADIO SOCIETY NEWS - March 1962

We have now returned to the Society's Room, No.14, in the Old Building, after some two months of meetings elsewhere, and the Club-room is now bright and fresh after its redecoration. The chill of the British climate has been dispelled with the purchase of an electric fire from our funds, and we hope to make our surroundings attractive enough to provide a port of call for lunch-time strollers.

Morse classes will begin again in the very near future, and theory instruction to cover the requirements of the Radio Amateur Licence Examination can be arranged for any members who request it. Please watch the Notice Board for details.

The Top Band transmitter is now complete, and as soon as we get our receiver serviceable and an aerial erected we hope to be on the air two or three lunch-times a week. In the meantime plans are going forward regarding our High-power transmitter, and we hope to begin construction on the Power Supply and Doubler stages in the coming month. Assistance at lunch time will always be welcomed.

Our Annual General Meeting will be held early in April, and we would like all our members to make a special effort to attend. Our policy for the coming year will be based on the views expressed at this meeting, so this will be your opportunity to make the Society a little more the way you would like it to be. BCNU !

73 de G3LTP

LETTER TO THE OUTSTATIONS

15th March,1962

Dear Colleagues,

John MacGivney is now back at work after returning from Port Stanley. He has taken over Brian Garner's job of making UHF soundings of the troposphere. Brian himself has moved into the plasma physics section.

Two members of the R.A.F. recently made what must have been the quickest-ever trip to Port Stanley, where they will be helping with our work there. They left London on Monday, February 14th and Montevideo on Wednesday, February 16th, thus arriving at Stanley within a week of leaving London.

Another two R.A.F. people are to help the Singapore Station. The Royal Society has arranged this assistance from the Services.

The Slough Station has a new brick building nearing completion. It is situated between B and C spurs and is to house apparatus for the temperature-control of a room in B spur. The temperature-controlled room is for measurements using precision DC and LF standard ammeters and voltmeters, and Wheatstone bridges, and also for low level power and attenuation measurements in the X- and S- bands.

Best wishes from us all,

Yours sincerely,

The Editor

15th March 1962