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AORG Radar Section 1941-5

Introduction

The following notes give an outline of AORG's work A.A, S.L. and F.A. Radar, and on the enemy jamming watch and anti jamming investigations. No attempt is made here to present an analysis of fire control results.

Reference to early, work (date 1940) of Prof. Blackett's original research group has been made in Dr. Bayliss' paper 'History and Origins of Operational Research in A.A. Command.' In April 1941 a radar group was formed to include some of the early radio officers. Dr. Wilkes was in charge of the radio section and he worked under Mr. Ratcliffe's direction. Subsequently, in July 1941, the group was officially recognised as A.D.R.D.E. (ORG) with B.F.J. Schonland (then Lt. Col.) as superintendent, Mr. Ratcliffe handing over his control of the Radar work. When Dr. Wilkes left in July 1943 the radar section was divided between Mr. Humby (Coastal Radar) and Mr. Hey (AA, Field army radar and jamming).

1. Jamming, window, interference.

In Dec. 1941, D. Lack prepared a paper for A.A. Command on the characteristics of various types of interference. At this time jamming investigations were T.R.E's responsibility. The Scharnhorst episode on 12.2.42 revealed the inadequacy of existing J watch facilities for investigating Army radar jamming. An Army J watch was instituted. A mobile laboratory, the Army J van, was prepared and manned by A.O.R.G. for the analysis of jamming signals on Army radar frequency bands. The Army J van was put on the DZ site at Dover. It began (?) by radiating interference and the equipment was given a complete overhaul by S.J Parsons. It was efficiently in action by June 1942. J. S. Hey was in charge of the A.O.R.G. A.J. section which not only manned the J van. but also organised a reporting system so that enemy jamming was reported without delay from sites to the J van – it was linked directly with C.A. Ops, G.O.R. and the R.A.F. J watch – and subsequently written reports were sent from sites via Brigades to A.O.R.G. The J van reports and the site observations were analysed at A.O.R.G. and the findings published in A.O.R.G. Reports. Among A.O.R.G. officers who worked at the van were H. Gaunt, R.E.V. Prince, J. Rimmington, S.J. Parsons and G.S. Stewart.

When the window raids commenced in October 1943 the number of sites sending in reports to A.O.R.G. sometimes exceeded 1000.

The J watch and reporting system enabled the War Office and Army Commands always to have an accurate picture of the enemy's jamming effort, and the effectiveness of the A.J. measures designed by R.R.D.E., or suggested by others, which were given an operational trial by the A.O.R.G. team at Dover. There was always a tendency for jamming scares to develop and A.O.R.G. investigations proved many reports of Airborne jamming to be false alarms. When Airborne jamming did actually occur on the night of 14/15 May 1944 it was not until A.O.R.G's report was made that some quarters were convinced that it really was airborne jamming.

Many A.J. measures were tested out, but one, the simplest and most universally effective, was first recommended by A.O.R.G., namely local oscillator detuning. Not only did A.O.R.G. demonstrate how effective this measure could be in practice but by the J watch analysis they also showed why it was so important - the enemy's jamming radiations were nearly always slightly 'off tune' with respect to our carrier frequencies.

The following is a very small selection to indicate ty.es of reports -

Memo 'Investigations of suspected airborne jamming of S.L.C. in 41 AA Bde on 11/12 and 13/14 August 1942' (A typical false alarm)

Report 1015 'enemy jamming of Amy Radar during May and June 1943' (A typical A.O.R.G. report issued monthly or bi-monthly according to activity)

Report 1022 'enemy jamming and Use of Window during Feb. 1944, and its effect on Army Radar' (As above but including window analysis)

Report 133 'Performance of RRDE prototype improved video amplifiers for AA No. 1 Mk. II (Typical as test of A.J. measure for design establishment)

Report 275 'Solar Radiation in the 4 (?) to 6 metre wavelength band on 27th and 28th Feb 1942' (Noise radiated from the sun on G.L. Frequencies)

Mutual interference was also investigated by A.O.R.G. and the inter-service mutual interference trial 'Feeler' in the winter of 1943 – 44 was of particular operational importance. J.T.C. Milne played a considerable part in the running of the trial. He also took part in the RRDE airborne jamming trials on G.L. II in summer 1942 and on S.L.C. E.R. Briton and G.S. Stewart took part in similar Window trials at Malvern in February 1944.

Mention should also be made of C. Powell's work at Malta in ???? where he devised a 'black out' unit which was effective against the type of jamming used there against GL II.

2. G.C.I.

In May 1941 it was decided to try out a modified RAF/GCI at a site in or near London to see whether this would satisfactorily enable the AADC to keep informed of enemy manoeuvres during attacks. RRDE prepared the equipment which had the height finding gear removed. B.L. Andrew, W.H. Hill, D.B. Pike and G. Varley supervised the test which was carried out in Hyde Park. A method of relaying the P.P.I. picture to the London G.O.R. about two miles away was solved with the help of the B.B.C. No major raid occurred during this development period. On July 28th 1941, about 50 enemy aircraft raided London and the equipment worked satisfactorily. On the basic of this the G.O.C. in C. asked that every major G.D.A. in A.A. Command should be provided with a AA/GCI. In autumn 1941, D.B. Pike was in charge of trials to find a new site with less clutter than the one at Hyde Park. A site at Cobham was chosen. Stations at Liverpool and Glasgow were sited in early 1942 and others followed rapidly A.O.R.G. advising on the siting.

The idea of P.P.I. Transmission to G.O.R. was found unsatisfactory owing to the requirements for darkness. Telling and plotting methods were devised by B.L. Andrew and training courses given for A.A. Command personnel.

A Prototype trainer was designed at A.O.R.G. and proved of value in simulating blitz conditions particularly at newly installed sites. This work was carried out by Andrew and Hill.

A post-mortem recording camera was also built by G.S. Stewart. This converted the display to rectangular range-bearing coordinates. The design of the camera had not much priority at R.R.D.E. and was not finally available in production form until during 1944. This type reproduced the P.P.I. display, taking one frame for each sweep. Re-transmission by cable was installed at Liverpool and Glasgow, and by wireless from Cobham to London, (by Messrs Pye Radio). Only at Liverpool was the retransmission used operationally. Skiatrons were tried out at Liverpool and London, but although promising it could only be regarded as experimental.

3. S.L.C.

As in G.L. II some of the earlier work on Searchlight and S.L.C. problems was in the form of theoretical appreciations by Prof. Mott assisted by F.R.N. Nabarro.

Subsequently most of the field investigations were made by Spalding and E.R. Britton while K.G. Dobson assisted by Morpher and London worked particularly on S.L.C. modifications.

In early 1942, Spalding and Britton toured S.L. areas to study S.L.C. and S.L. tactics. Dobson and Britton worked out method of using Mk. IX sound locator mounting as remote control pillar. Britton and Wingfield (ORS. F.C.) tried out methods of G.C.I. and S.L. co-operation and showed that central control could not be successfully operated. Simple rules for target selection by S/L detachment commander were devised.

In July 1942 a low flying trial at Digby showed that normal SL layout was adequate for targets at 3000 ft.

In Autumn 1942 height finding methods by S.L.C. were introduced so that target heights could be passed via B.O.R. and S.O.R. to the nightfighter pilot.

This necessitated the designing of a new range scale for the S.L.C.

In November - December 1942, Bobson, Allen and Morphet devised modifications for improving S.L.C. accuracy. These included a new type of placing switch using an inductor ring principle in place of moving contacts, additional smoothing in the AGC and display, and a reduction of feeder lengths to obtain optimum split sensitivity.

In March - April 1943, a field trial of 24 equipments incorporating these modifications and satisfactory improvement in accuracy foud. [sic] The modifications were adopted by the War Office.

During this time, Spalding investigated a method of using six searchlights in co-operation with a nightfighter for defending a beach-head. Also Britton found that moving the transmitter aerial forward to the front of the projector considerably improved the polar diagram.

In June 1943, Dobson and Morphet developed a method of using a C.W. oscillator for S.L.C. co-ordination in place of an aircraft.

In July 1943, Mk. II D IFF for use by nightfighters operating with SL was developed by Britton. The use of the dousing signal and improved identification was valuable and the modification was adopted by Fighter Command.

In the latter part of 1943, trials were carried out by London on the accuracy of SLC close to a wooden hut and wire fence and on the reduction resulting [from] lowering the transmitter aerial.

In March 1944, modifications to SLC were devised for reducing its sensitivity to window. These modifications included [blank]

In June 1944 in co-operation with R.A.F. the dousing signal application to Mk. Ill IFF was tried out.

4. G.L. I & II

During 1940-1, Prof. Mott, assisted by F.R.N. Nabarro, made theoretical appreciations on the aerial system of GL/EF and GL II, on feeders, and siting problems including mats and ‘cliff edge’ effects. 'Theory of the Aerial System of G.L. Mk. II and GL/EF Conversion Equipment’ Feb. 1941 by Prof. Mott with J.M.C. Scott (RRDE) was a well known report.

During the summer of 1941, S.J. Parsons carried [out] bearing alignment investigations under Prof. Mott's direction at Highfield; J.S. Hey and J.T.G. Milne took part in the G.L. II trials at Windsor and later at Hampstead, and J. Mort supervised the Bedford Double Bearing Aerial system at Rayners Park. By the autumn of 1941 the following had been achieved:

(a) On G.L. I & II the causes of the major errors in elevation calibrations and bearing alignment were understood, and drafts for the first complete calibration and alignment instructions prepared for the War Office.

(b) In G.L. II 'flutter' caused by the wear of the aerial switch contacts and receiver oscillator design had been investigated and remedies found sudden fluctuations in the bearing bias were found to occur and subsequently remedied by RRDE by improved earthing.

(c) The 0.4 bearing aerial system for G.L. II was found unsatisfactory owing to the unusually large bearing scatter.

(d) For C.L. I, however the 0.4 λ bearing aerial system proved to give better high angle following than the complicated double bearing aerial system.

A solution to the problem of high angle following in bearing became urgent requirement for G.L. II J.S. Hey, J.T.C. Milne and S.J. Parsons found that putting the range and bearing aerials in line at 0.5λ gave the most satisfactory solution.

Work on G.L. II continued throughout the war, and the following list of sample (?) reports illustrates the type of investigations in which A.O.R.G. were involved, the greater part of the work being done by May, Milne and Parsons.

Report 25 Comparison of the 0.4, 0.5 λ Bearing systems for G.L. II (Oct. 1941)

" 57 Investigation of Performance of G.L. II (Feb. 1942)

" 59 Variation of G.L. II bearing discrimination with the length of No. 8 feeder (March 1942)

" 115 The bearing accuracy of A. A. No. I Mk. II with an observer on the external seat (Sept. 1943)

" 131 Quarterly calibration summary, AA No. I Mk. II (Aug. 43)
April - July 1943 (The first of a series)

" 94 The detection range performance of AA No. I Mk. II & IA (Mar. 1943)

" 102 The performance of flexible feeders on AA No. I Mk. II under operational conditions (June 1943)

" 147 The bearing alignment of Radar AA No. Mk. II with Field oscillator Type ERA2. (Nov. 1943)

Memo The effect of camouflage on the accuracy of AA No. I Mk. II (Oct. 1942).

G.L. IIII B.

Work on this equipment commenced with the issue of the first pre-production model in December 1942, although some theoretical considerations had been made earlier by Schonland and D.K. Hill on vulnerability to jamming and to the requirements for early warning equipments.

The pre-production model was deployed on an operational gun-site at Chester and investigations carried out by Parsons and G.S. Stewart on general performance capabilities with special reference to the results obtained with G.L. II as a search equipment. The work involved some study of mobility and the effects of ground clutter, while the L.W. and an A.A./G.C.I. were also used for a target selection, particularly in the later stages of the programme carried out on a Tyne-side gun-site. Many recommendations (mostly of a minor character) were made to A.D.R.D.E. as a result of these trials.

A further short investigation was carried out by Milne and Parsons in March 1943 to determine the effect of shell burst echoes on the operational performance of the equipment, and it was shown that serious effects were very unlikely.

During the summer of 1943 the Monitoring Van was introduced by R.R.D.E. and the War Office, and liaison was maintained in the early stages, at least, with A.O.R.G., suggestions being made to A.D.R.D.E. as a result of the observations.

Little work was necessary on the alignment or calibration procedure with this equipment as A.D.R.D.E. issued complete instructions with the pre-provisional pamphlet, but a simplification of the adjustment drill was evolved by A.O.R.G. and later adopted for field use.

In December 1943, work for 21 A.G. (and No. 2.O.R.S.) began with a self searching trial carried out by Parsons and Humphreys (mostly at York) in early 1944, and this demonstrated the value of a scientifically constructed drill in enabling efficient target engagements to be achieved without a

warning equipment. These methods were adopted by G.H.Q. A.A. Tps. in the drills issued to 21 A.G. A.A. Bdes.

About the time a tour of 21 A.G. A.A. sites (in this country, of course) was undertaken by Parsons to investigate the performance of equipments and give advice on problems arising in the training programmes. Considerable detailed information was collected which was passed on to G.H.Q. A.A. Tps. and No. 2 O.R.S. This work was cut short by the intensification of enemy attacks (using window on a large scale) necessitating investigation of anti-window methods for all equipments and particularly G.L. II. and L.W. As a result of these experiences A.O.R.G. recommended to G.H.Q. A.A. Tps. (through No. 2.O.R.S.) that G.L.II should be taken in the invasion programme on equal footing with L.W. as search equipment for the IIIB sets. This was adopted and the decision well repaid later in the excellent performance of the G.L.II's on the Continent.

A.O.R.G. carried out trials under the direction of G.S. Stewart at the A.A. Command Experimental Site (T.S.21) from Aug. 1943, and in Jan. 1944 an A.A. Command (?) directional I.F.F. array for the equipment was investigated, while in March/April the R.R.D.E. auto-following design of IIIB was covered. Advice was also given when trials of a R.E.M.E. design of auto-following system were made.

With the commencement of flying bomb attacks in June 1944, intensive operational tours were undertaken to study operational problems and the performance of all Radar equipments used in the defence schemes. Parsons and Capt. G.R. Lindsay visited IIIB sites and studied the deployment with light and heavy guns.

Calibration analyses was made on data arriving at A.O.R.G, by Parsons and this resulted in a revision of the pro-forma for returning results although the potentially wider scope for analysis then possible was never fully realised owing to the slow adoption of the newer pro -forma. Further analysis continued to the end of the war and demonstrated the high degree of alignment accuracy possible with this type of equipment.

Following on work by Hey and Parsons in late 1943 on the use of kites for carrying troop marker radar reflectors (see F.A. section), A.O.R.G. pursued in 1944 the use of kite-borne reflectors for alignment purposes.

It was also suggested by Hey and Parsons on the early deployment of IIIB that artificial screens may be useful for clutter reduction, and later such screens were postulated for anti-jamming purposes with other equipments, but it was not until the employment of low flying-bombs that the matter was taken up again. Hey calculated the effects to be expected and decided to carry out experiments on clutter reduction which were developed by Stewart and Jackson. Much of this anti-clutter work (extended by Milne and Prince to SCR 584) were successfully employed in the Continental Defence scheme.

The following is a small selection of Reports and Memoranda relevant to IIIB:-

Memo. 57 : Some Operational Characteristics of A.A. No.3 Mk. II (G.L. Mk. III) Model B7.

Report 89 : The Response of A.A. No. 3 Mk. II to Shells and Shell Bursts,

Memo. 287 : Self Searching with A. A. No. 3 Mk.II.

Memo. 346 : The Performance of an Automatic Following Modification for Radar A.A* No.3 Mk.II.

Memo. 404 : Observation on the operational performance of Radar equipment with 40 mm guns in the Coastal Defence Belt.

Report 240 : Analysis of Calibrations of A.A. No. 3 Mk. II up to 31 Aug. 44.

G.L. IIIC.

Work was carried out mainly by D.K. Hill in co-operation with Canadian Personnel in early 1942 on the proto-type model of this equipment. These trials covered general performance of the equipment but were mostly directed to an analysis of the fire control data obtained, and it was not until the Spring of 1943 that further work was possible on production equipments.

Stewart and Jackson visited operational sites where the first production equipments were deployed, studying general performance problems while their recommendations for a revision of the maintenance instructions were adopted in July 1943. Rose and Jackson made further tours in the Autumn of 1943 (reporting direct to 1st A.A. Group on their observations) and made suggestions for the improvement of some of the defects coming to light in operational service. A general study of the equipment was under way at this time by G.S. Stewart at the A.A. Command Experimental site; and angular accuracy, maximum range, and target engagement problems with ZPI and L.W. were included in his investigations. This was followed up by a trial of the R.E.M.E. auto-following modifications, first in Jan. 1944, and then the improved version in June 1944.

The main concern in early 1944, however, was with the large scale deployment in the London area of IIIC equipments and the operational effects of enemy window. Jackson, Rose, Lindsey and Stewart all visited sites during this period giving direct advice to operational units and to Group H.Q. Britton and Stewart collaborated with R.R.D.E. in controlled window trials of the equipment, and meanwhile Jackson studied the problem of alignment procedure for the equipment. Two methods were evolved, (with the approval of R.R.D.E.) one as an interim measure assuming no test gear and, therefore, horizontality of the elevation axis, and later a complete drill with all relevant checks. The latter was eventually approved almost in entirety by the Canadians (N.R.C.) and issued as an E.M.E.R.

In the Autumn of 1943 a pro-forma for circulation to sites to provide operational performance data was proposed by A.O.R.G. and adopted by A.A. Command, and in early 1944 there were sufficient data from field units to be able to made [sic] an analysis and prepare a memo on (No.319) on field performance figures for both IIIC and IIIB.

Typical of reports issued were:-

Memo 114 A.O.R.G. Observations on the Deployment of A.A. No. 3 Mk.I (G.L.IIIC) in A.A. Command Moy-June 1943.

Report 171 An investigation of the operational performance of A.A. No.3 MkI (G.L.IIIC.AFFF.) and A.A. No.4 Mk.I. (ZPI.)

Memo 260 The Performance of an Automatic Following Modification for Radar A.A. No. 3 Mk.I.

Memo 295 Preliminary Analysis of the effects of 'Window' on H.A.A. Fire Control in 1st A. A. Group 21 Jan. to 2 March 1944.

Z.P.I.

D.S. Pike collaborated with Canadian officers in May 1942 to investigate mutual interference with these equipments, and it was shown that ground effects are more important than distance. Siting trials continued in June, including range performance checks, and it was shown there was difficulty in tuning over the band and that range performance was limited with serious gaps in the vertical coverage.

In the Summer of 1943 it became increasingly apparent that the ZPI must work below 15 Mc/s (preferably at 145 Mc/s) to avoid interference with I.F.F. Mk. III., but it was found that range performance fell off badly below 150 Mc/s. Work by Milne and Rose at A.O.R.G, produced a suggestion for achieving this by aerial modifications, while on similar but somewhat simpler modification was evolved by R.R.D.E. Trials of this were made by Stewart at T.S.21 (Report 171). Further shortenings [sic] of the equipment were manifest in the window raids of early 1944, and investigations were made by Rose and Lindsey of the possibility of anti-clutter measures including improved limiting, short time constant video coupling and swept gain.

L.W. and Pack Set.

The Paok Set (modified A.S.V. equipment) was investigated by E. Humphreys and D.F.B. Pike from May 1942. Humphreys instructed S.A.A.A. in the use of the equipment, and then trials were carried out by Pike on Salisbury Plain in July in collaboration with S.A.A.A. It was shown that the set did not meet the L.A.A, requirements (for which it was adapted) of a mobile equipment except for aircraft flying between 2,500 ft. and 6,000 ft.

Attempts were made by G.S. Stewart and J. Mort to improve performance by means of a single or double Sterba array. The performance of the set was still inadequate, however, and it was stressed in the report that both the Paok Set and the more powerful L.W. now in the pre-production stage were unsuitable for low flying aircraft detection. In the late Summer of 1942 there was an A.O.R.G. Saturday Meeting on the L.W. set which served to ventilate ideas by various operational representatives, Schools etc. on this type of equipment, and for authorative [sic] statements by War Office and design establishment representatives.

In Sep. 1942 a trial of a vehicle L.W, for use by Airborne Forces was carried out by Pike and Swann to investigate the value of plotting out own forces in a landing operation. There were later airborne (glider) tests with a Pack Set. Pike advised the G.O.C. Airborne Forces on the use of the equipment as a result of these trials,

Humphreys and B.L. Andrew carried out mutual interference trials (L.W.) in April/May 1943, showing that with p.r.f. adjustment there was no serious problem. This was followed by operational usage investigations (also with P. Freeman) at Clacton, involving plotting drills for A.A.O.R. purposes and the recommendations were taken up by S.A.A. The L.W. had been included in the early 1943 work with the IIIB.

Visits to a few A.A. Command sites were made by Humphreys in Oct. 1943 to check performance generally, but with the growing concern about I.F.F. Mk.III he went to T.S. 21 to carry out a trial with the standard R.R.D.E. design. This he showed to have serious limitations.

Stewart included work on the L.W. in a G.L. Cabin (for operators' comfort) in his T.S. 21 programme.

A.A. Command had by this time deployed L.W. equipment on the Maunsell forts and there was no doubt about the resulting coverage. P.E.V. Prince therefore carried out coverage trials on a fort and also investigated anti-clutter modifications to improve the serious problem on the Estuary forts. Parsons was also investigating anti-clutter and A.J. modifications for the L.W. because of the now wide-spread use of window by the enemy and the expected approach of ‘D’ Day, and it was shown that some improvement was possible, but it was finally agreed that alternative frequency provision was desirable for invasion purposes. Humphreys continued his tour of sites in the Spring of 1944 but confined attention to 21 A.G. units advising locally on operational problems.

I.F.F.

Work on I.F.F. IIG. was prompted by over-interrogation problems with S.L.C., and K.G. Dobson investigated this in Oct. 1941, although W.H. Morphet had already made some general observations on I.F.F. for locating particular aircraft. Also in Oct. 1941 inter-service trials of Mk.III I.F.F. were carried out at Manorbier: J.S. Hey studying the G.L.II's and Dobson the S.L.C.’s. It was shown that the G.L. I.F.F. worked reasonably well while the S.L.C.’s were unsatisfactory due to over-interrogation, and reduced p.r.f. to avoid this reduced performance excessively since the equipment range display was used. It was also shown that target following was impossible with the interrogator switched on. Field reports on Mk. II G I.F.F. collected by Britton and Dobson in early 1942 showed similar difficulties. Nabarro investigated this mathematically in March 1942 and showed that this was to be expected; he also produced a report on the optimum sensitivity of IIG responders using S.L.C.

The need for directional I.F.F. aerials on the L.W. was shown by Nabarro in a paper published in Sep. 1942, and this was confirmed when equipments came to be fitted with an omni-directional system in the Autumn of 1943. E. Humphreys examined this and reported on the operational efficiency. A.R.D.E. produced a directional I.F.F.III system for L.W. under pressure from A.O.R.G. and A.A. Command, and Stewart showed in trials at T.S. 21 that there was a considerable improvement over the production design. Stewart also investigated an A.A. Command directional system for G.L.IIIB. During 1943 A.O.R.G. afforded facilities for N.R.C. to try out this I.F.F.III system for the IIIC under operational conditions, but this equipment was never in service.

In the Spring of 1944 investigations were made by Hey, Humphreys and Parsons for No.2 O.R.S. 21 A.G. on the limitations of Mk.III I.F.F. for the large-scale air operations expected for 'D' Day. This work culminated in the recommendations for reduced interrogation (the fitting of ‘interrogate’ switches) reduced power, and the banning of non-directional interrogate aerials. J.S. Hey attended the S.H.A.E.F. Conference on these natters in May 1944 at which the proposals were adopted.

L. A.A. Radar.

With the employment of flying bombs by the enemy from June 1944 the need for Radar controlled L.A.A. became urgent, and the IIIB was immediately deployed with Nos. 1 and 3 predictor (or even a No. 10 predictor in one or two cases) at L.A.A. sites.

Crash programmes were also started for producing R.0.3. and 'Cupid' (modified A.I.X.) by R.R.D.E., and the A.G.L.T. at T.R.E. Parsons and Lindsey toured many of the L.A.A. sites studying the performance of the IIIB for this work and later the R.O.3. London followed up the R.O.3. equipments on the move of the defence belt to the East coast. Lindsey and Bullock were attached to T.R.E. during the development of the modified A.G.L.T. advising on predictor and operational problems, but the equipment was never in service owing to reduced activity.

S.C.R.584.

The first A.O.R.G. work on S.C.R.584 was carried out by G.S. Stewart, who supervised the A.A. Command trials at T.S. 21 in May 1944. The mean residual errors were found to be about 0.1 degrees in bearing and elevation and about 20 yards in range? Useful experience was obtained in the test setting up of the tracking units.

In the Summer of 1944 S.C.R.584 proved tbs most suitable equipment for dealing with flying bombs. J.T.G. Milne and P.E.V. Prince continued A.O.R.G's screening investigations by experiments in the Diver Belt, and demonstrated on sites the effectiveness of screens in reducing both land and wave clutter. A further important investigation by Prince and Milne in the Diver Belt was the elimination of the serious effects of mutual interference which could result from close spacing of S.C.R.584s having the same crystal controlled recurrence frequency. This trouble was cured by adjusting the counting down circuits to stagger the recurrence frequencies and also to classify the magnetrons in frequencies so as to avoid adjacent sites having the same R.F. frequency. (A manufacturers' magnetron frequency classification was in fact supplied but it did not prove a reliable guide). Further work on screens was continued by F. Jackson, A.F. Dunn, in the East Coast Diver Belt, and A.G. Loudon in Richmond Park. The elevation bias above a wire netting screen at various angles of sight was determined (this averaged 3 mils. The maximum being 10 mils.), and the coverage at different angles of site was measured, and a search angle of 1 degree above the screen top recommended.

F.A. Radar

During the summer and autumn of 1943 the possibility of the application of radar to Field Army problems was actively considered: a small meeting convened by Brig. Schonland discussing the apparent potentialities. AORG suggested as a result of work by Hey and Parsons means of marking forward troops by the use of coherent dipoles observed with 10 cm. radar gear: this was later taken over by RRDE at the point when means of projecting the dipoles other than by balloon were being devised, but the scheme was not developed. About this time 100 AA, Bde discovered that mortar bombs could be seen in the early part of their trajectory by their III B's, this matter was not seriously pursued until the summer of 1944.

In Feb. 1944 a conference at AORG explored the possibilities of radar for Field Artillery work, but at that time lack of experimental evidence of radar echoes from ground bursts led to a rather luke-

warm reception by the School of Artillery, experts who demanded very high accuracy before it was considered that radar would be of much value. However, RRDE planned experiments with 3 and 10 cm. equipments for observing ground objects and S.J. Parsons undertook the study of developments. It was found during the summer of 1944, that very strong ground burst echoes were observed with the CA No.l Mk.IV from all types of field artillery shell, while vehicles could be detected at long ranges in the right conditions. Accordingly a Radar Wing was set up at the School of Artillery with Parsons as AORG Liaison officer, and trials were undertaken In the autumn of 1944 on Mortar position location and Field artillery ground and air burst detection. At the same time mortar location was investigated under operational conditions by 21 AG No.2 ORS taking a prominent part and the beginnings of an operational location service were made.

Lindsey joined Parsons in the S of A liaison work in late 1944, but AORG was not able to carry out much Independent work until the necessity for ground clutter elimination became apparent in the operations on the continent, and the AORG artificial screen was Introduced for mortar location purposes. The effect of these screens and of natural screens on the vertical polar diagrams with III B was of considerable importance since the point of first pick-up of bombs was empirically decided by approximate rules. Parsons and Lindsey therefore started, In Dec. 1944, an investigation into ground reflection and screening effects at 10 cm. (with GL III B), being joined later by Jackson and Hey who carried out some theoretical work on the same subject.

This work was dealt with in Report No. 275, but many avenues of research were opened and much remains to be done on the subject.

Considerable work had been done by S of A on the static accuracy of CA No.1 Mk.IV, but little on the operational accuracy of observation of ground bursts, so in Feb. 1945 Parsons carried [out] operational accuracy trials with the equipment and showed that extraordinarily high accuracy could be achieved. Many recommendations were made about the methods of observation to bo adopted and also for modifications to the set.

In the summer of 1943 P.E.V. Prince took over the S of A liaison work and commenced trials on air burst detection, 3 cm. VPD measurements, and fragment observations with 10 cm. equipment. In this work many possibilities of ballistic investigations came to light which aroused the interest of the Ordnance Board. The fragment investigations were prompted by reports of anomalous propagation giving rise to the observations of shell bursts, behind crests. J.S. Hey and G. Kaye showed this to be more likely to be due to fragments, and experimental work was undertaken to substantiate this.