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White Lecture Brisbane, 1943: Radar Development and Usage in Europe

(All text: Quote from Evans, History of the Radiophysics Advisory Board, 1970, p 145-153)

Introduction and Conclusion of White's talk in Brisbane in late 1943 after returning from Europe

The introduction set the stage for "Radar Development and Usage in Europe":

> The following was the text of a lecture given by White to personnel at G.H.Q. Brisbane late in 1943 after his return to Australia following an official visit to Europe and America. It is reproduced in toto since it described the background of radar development in the European theatre of war, and so doing contrasted the sharp difference in adaptations of radar techniques between Europe and the war in the Pacific. It also gave perspective on the genesis and evolution of such derivative applications as Air-borne radar, (ASV), Aircraft Interception (AI); Microwave radar; Operational Research; Radio Navigational Aids (H2S, Oboe, Gee, H); Radio Counter Measures, (RCM). White's statement effectively couched the Australian radar programme in the current world scene, and focused it in perspective as a basic facet of Allied war technology.

> **General Review of Radar and Countermeasures: Introduction**

> During this war there have occurred very remarkable and rapid developments in our ability to generate and detect radio waves of very short wavelength. At the beginning of the war, in 1939, the scientific knowledge of the radio wavelengths of less than about 10 metres was in a very rudimentary state, but during the past four years the scientific knowledge which has been accumulated concerning the behaviour and the methods of use of wavelengths down to about 1 centimetre has been very great indeed.

> These developments have been the result of a co-operative effort between the United States of America and the British Commonwealth. These developments have been very widely applied to the prosecution of the war and have given us a very distinct technical lead over the enemy. It is impossible, however, to prevent the enemy from obtaining knowledge of the technical developments used in operational theatres because it is impossible to prevent him from listening to the radiations which are sent out by equipment installed on shore, and in addition he does gain a good deal of information from captured equipment, the loss of which is inevitable.

> Our success against the enemy is, therefore, entirely dependent on our maintaining a more rapid development of the radio equipment we use than he is able to maintain, so

that when any of our equipment is rendered useless by his knowledge of it, we may have new equipment to perform the same function in a different way or in a better way.

The fact that we are involved in a very rapid expansion of our knowledge of this science, and are therefore working on the fringe of technical developments all the time, makes it necessary for us to have rather special arrangements to permit a co-ordination of scientific advances with the operational requirements of the Fighting Services. It is difficult, if not impossible, for those who are actively engaged in operations, and therefore out of touch to some extent with the scientific advances that are being made in the laboratories, to specify their requirements. It has been found in Great Britain that the only way to overcome this difficulty is to establish a very close and intimate relation between the Fighting Services and the senior members of the Experimental Establishments, so that suggestions as to the use of new ideas and new equipment may come from both sides, and so that the Experimental Establishments will have a sufficiently-intimate knowledge of the objectives of the operations to permit them to think sensibly about the application of their scientific works.

Scientific Institutions

It may interest you to know in general terms the arrangements which exist in Great Britain and America for scientific research and development on radio and radar equipment.

In Great Britain probably the most active work at the moment is concerned with the bombing offensive against Germany. This is, as you know, one of the activities of the RAF. The operational activities of the RAF come under the direction of the Air Ministry, while the responsibility for the design and production of equipment for the RAF is the responsibility of the Ministry of Aircraft Production. This Ministry is therefore responsible for organising all aspects of scientific research and of production of equipment for this Service, and in order to carry out part of this function it maintains a large experimental establishment called the Telecommunications Research Establishment.

The same subdivision of responsibility is made in Great Britain between the War Office and the Ministry of Supply. The Ministry of Supply controls the Air Defence Research and Development Establishment, which is responsible for research and development of all Army radar equipment.

This subdivision of responsibility between operations and supply is not made in the case of the British Navy, but the Admiralty maintains a number of research establishments.

In the United States the Army and the Navy each have several Experimental establishments of their own. There is, however, a very large and independent organisation concerned with research and development. This is the Office of Scientific Research and Development, an organisation brought into being by the President of the United States in order to encourage and advance research and development in all phases of physics and chemistry which might have an important bearing on the war effort. This body is sub-divided into two parts, the first of which is concerned with medical research, and the second, the National Defence Research Council, with research in physics and chemistry.

The National Defence Research Council has some sixteen Divisions, each of which is concerned with some separate aspect. For instance, Division 14 [Radiation Laboratory at the Massachusetts Institute of Technology] is devoted entirely to radar development, and Division 15 to radio countermeasures [Harvard]. Although the Office of Scientific Research and Development is in fact entirely independent of the Services, the United States Navy and the United States Army maintain very close liaison with this organisation, since it is the desire and objective of OSRD that its research work shall be directed as closely as possible to the requirements of the Fighting Services.

The Lessons of the European War

Great Britain has now been involved in the war against Germany for four years, and during that time many changes in the organisation of scientific research and the relationship between scientific research and the Fighting Services have taken place. There is, as a result, very much to be learnt from Great Britain as to how this organisation should be arranged, and as to how successful the application of scientifically designed equipment can be against the enemy.

I think the first lesson which is of importance is that, in the radar field at least, a small quantity of the right sort of equipment used in the most effective way can have far reaching consequences in operations. To illustrate this I would like to give some examples.

During the Battle for Britain the British had only about 26 stations in their air warning chain and about two or three stations in Great Britain for the ground control of night-fighter aircraft. The major part of the success in Britain in the use of night-fighter aircraft against the German night bombing raids, was achieved with only something of the order of 50 to 100 sets of MkIV AI equipment. Until very recently, in the Atlantic, very effective work has been done against U-boats by relatively small quantities of ASV equipment. Something of the order of 500 MkII AS V sets made an appreciable difference to that campaign during 1940 - 41, and after the introduction of the shorter wave types of equipment a major contribution was made by 50 sets of the American-

designed ASGG equipment in Coastal Command, together with about 30 sets of the British H2S equipment in aircraft. An important contribution to the bombing of Germany has been made by the employment of Mosquito aircraft controlled accurately by one of the navigational systems designed in Great Britain. For a considerable time this offensive was carried on with something like 20 sets of airborne equipment controlled by two or three ground stations.

An excellent example of the use of a small quantity of equipment for a special purpose is also to be seen on the South Coast of England. During the last year the Germans have, in the nuisance raids over England attempted to avoid detection while approaching the coast by flying at a very low altitude, so low in fact that the aircraft cannot be seen by the older forms of air detection equipment. By converting equipment originally designed for the British Navy, fifteen sets of equipment have been produced for the special purpose of detecting these low-flying aircraft, and these sets are now installed on the South Coast.

I do not wish to imply in giving these examples that large-scale production of radar equipment is undesirable, but it is worth emphasiing that many operational problems are of a transient character and can be handled by devising special equipment. If this is to be done, however, it demands an early understanding of the requirement, and special measures to obtain the necessary apparatus as rapidly as possible.

A second important lesson to be learnt from Britain is the great value which has been obtained from the activities of the operational research groups which are now attached to many of the operational commands.

These operational research groups have a utility to the commander which is most obvious in those fields of operations where technical developments are being used and where technical changes are often imperative through the action of the enemy. Their function is primarily to study all aspects of past operations immediately they are concluded in order to assess the degree of effectiveness of the technical equipment used, to estimate as accurately as possible the counter-measures employed by the enemy and to suggest when it is desirable to alter or improve the technical aspects of the operations. Among the many cases that could be quoted, there are two good examples of the results that can be achieved by a close correlation of the Operational Command with the Operational Research Group of that Command, and the activities of the experimental establishment contributing the technical ideas and equipment.

Early in the anti-submarine campaign in the Atlantic, equipment was introduced into the aircraft of Coastal Command which permitted those aircraft to detect surfaced submarines at night or in thick weather. This equipment was designed by TRE. The results obtained with the equipment in aircraft were closely studied by the Operational Research Section of Coastal Command. This was done by obtaining as accurate reports as possible from the air crew as to the number of submarines sighted with the

equipment, and the time and conditions under which the sightings took place. Through these studies it was concluded that the maximum contribution of the equipment was not actually to increase the number of submarines sunk, but rather to make conditions in the Atlantic such that a surfaced submarine was as likely to be sighted at night as by day.

After this equipment had been in use for some time it was found that the number of occasions on which submarines were sighted was decreasing rapidly. This was ultimately traced by the Operational Research Group to the use of receiving equipment in the U-boats which permitted them to hear [to detect the transmitter carrier at radio frequencies] the aircraft equipment long before the aircraft had any possible chance of sighting the submarine. By listening [at radio frequencies] in this way the submarine was able to dive before being sighted.

While this campaign was going on the experimental establishments were devising a new and better form of aircraft equipment on a very much shorter wavelength. It was fortunate that the development of this equipment had reached a stage where a relatively small number of sets could be introduced into Coastal Command aircraft. This move to a shorter wavelength defeated for the time being the listening practice employed by the U-boats. This phase was, however, itself a transient one, for in the course of time we lost over Germany a number of aircraft fitted with similar equipment. The Germans were thus enabled to find out the more modern practice being employed against them, and for the Atlantic they devised a method of confusing the searching activities employed by Coastal Command with this new equipment. This they did by throwing overboard from the U-boats a number of floating buoys, which, when observed by the aircraft equipment, looked exactly similar to a surfaced U-boat.

The complete story of the anti-submarine campaign in the Atlantic is rather a long one, but it has been a story of continual change in the tactics used by Coastal Command and by the United States Air Force. These tactical changes are being introduced as a result of detailed study of the activities of the enemy.

Another very good example of the influence of technical developments is to be found in the intensive bombing campaign which has now been going on for some time against Germany. The success of this campaign can be attributed in a major degree, firstly to the development of radio navigational systems for aircraft, secondly to the development of a number of such systems so that whenever one system is compromised by the activities of the enemy, the second is available, and thirdly to the development of equipment carried in the aircraft which permits detailed observation of the ground during the night or in thick weather.

Early in this campaign a navigational system known as Gee was brought into operation in England. This permitted aircraft of the Pathfinder Force, equipped with a small receiving gear, to be accurately guided to any point over Germany distant about 400

miles from the coast of Britain. This system was successfully used for many months until the Germans had learnt about it by listening to the signals radiated from Britain and by capturing equipment in lost aircraft. The Germans then introduced methods for jamming the signals sent out by this system. They have not, however, succeeded in rendering the method completely useless, for several alternative ways of using the system have been devised. In addition to the Gee system there are at least two other navigational systems which are at present in use without interference from the enemy.

Modern Developments of Radar

If one reviews the present position regarding the development and use of radar equipment it appears that laboratory experimental development Is reaching a stage which will permit a very wide and varied use of such equipment for operational purposes. I believe that a considerable amount is still to be done in order to make the fullest use of the technical advances which have occurred, and I would like now to review some of the fields in which I think such advances are possible.

Radio Navigational Aids

I have already mentioned the methods which are at present in use in Great Britain for the radio navigation of aircraft. These schemes all depend essentially on the fact that the distance from an aircraft to a ground station may be measured by radio with great accuracy. Most of the methods which are used in Great Britain, however, have been devised essentially for that theatre of war, and although they may have some degree of importance in the Pacific, much greater distances have to be covered in this theatre and this demands a different approach. The three British systems called Gee, H, and Oboe give navigational facilities to a distance of approximately 300 or 400 miles. There is, however, one new system at present being introduced in the Atlantic and in Europe called Loran, which extends the navigational range to something of the order of 1000 miles. A modification of this, called SS Loran is to make use of the fact that much greater distances can be covered by using the radio waves which are reflected from the upper atmosphere. By doing so, the ground stations from which the distance of the aircraft is to be measured can be placed much further apart, and the range of operation of the equipment as a navigational aid extended to 1500 or 2000 miles. In order to prove that this is possible, however, one requires an experimental investigation of the scheme in these latitudes. If it is desirable that we should use such navigational aids in the Pacific, it is very desirable indeed that experimental investigation of their possibilities should be undertaken. These radio methods of navigation have the advantage of:

(a) Accuracy. (An aircraft can be located at a distance of about 500 miles to within one to five miles.)

(b) They can be used at night or in thick weather over the region within which the signals from the ground station can be heard.

(c) They are much simpler to use than any other form of navigation.

Air-borne Equipment

Radar equipment in aircraft was first introduced for the purpose of permitting aircraft to detect surface vessels at sea. There has been a continuous development of such equipment, and the chief uses to which it is put are:

(a) The detection of surface vessels and submarines at sea.

(b) The detection of aircraft for interception purposes.

(c) The presentation to the pilot or navigator of a coastal outline for navigational purposes.

(d) The recognition of towns over such countries as Germany where a town pattern permits such use.

All these schemes are at present used with varying degrees of success. The most important development taking place at the moment is the adaptation of such equipment for blind bombing attack against surface vessels. The airborne equipment is used by Bomber Command as a navigational aid over Germany; but the equipment in this case is simply used to locate the aircraft as accurately as possible over the selected target, and it is a much more difficult and precise operation to use such equipment for bombing a single small target such as a ship. In the United States a number of developments are taking place with this objective in mind. One is at an advanced stage and has actually been used successfully in operations in the Pacific. I think that this equipment which is in the form of an attachment to the normal centimetre ASV equipment in the aircraft, will probably be the most successful, since it has the virtue of simplicity, which many of the other schemes lack.

In Europe of course, the desire is to improve the airborne equipment to a degree which will permit the recognition of individual streets and buildings of a town, so that as a bombing aid the airborne equipment will be of much greater utility.

Although a ground equipment for the detection of attacking aircraft and for the control of night-fighter interception was developed very early in the war in Great Britain, there does not appear to have been a very well correlated development of similar equipment for operations in the Pacific, where the conditions are very different from those obtaining in Great Britain. This has probably been due to the fact that in the

European theatre the original equipment devised in Britain is quite satisfactory, and attention has been diverted from this aspect of radar developments to bombing aids and to other aspects of the problem which have been of increasing importance in that theatre. This has meant, therefore, that the ideas in the experimental establishments both in Great Britain and in America as to the operational requirements for warning equipment and for ground control of interception equipment for the conditions which obtain in the Pacific war are not very closely related to fact. There is a grave necessity, I believe for the experimental establishments to be given considerable guidance in this field.

It is interesting to note that in the early days in Great Britain, when only the early MK IV AI equipment was available, it was essential for good night interception to be able to measure the height of the raiding aircraft to something of the order of 500 feet. With the introduction of the SCR 720 AI equipment this accuracy is probably unnecessary for the SCR 720 equipment permits the night fighter aircraft to observe its target at a distance of 10 to 15 miles and to see aircraft between itself and the ground. It is possible that with this equipment night fighters may employ far more freelance tactics with only general directions from the ground control stations. This may render it unnecessary for us to employ special ground control of interception stations if we have available air warning stations with reasonably good height finding facilities.

It is possible that in the Pacific radio aids to combined operations will be of great importance. In the Sicilian campaign attempts were made to use radar with two important purposes. Firstly, a special station was erected at Malta to control by radio the air offensive against Sicily. This arrangement was tactically possible because Malta happens to be situated at a convenient distance from Sicily to permit this operation. The idea behind this method was to have a station at Malta which could continuously observe the movement of all our own aircraft and which would also observe all enemy aircraft in the air over Sicily. With this information continuously available, the operations room at the station was to attempt to direct the whole air operation.

This type operation is being carried out by a similar station on the South Coast of England with great success. I understand that the arrangements in Malta were interfered with to some degree by the permanent echoes which were received at the station from the mountainous country in Sicily. It is quite obvious that such a tactical set-up is a special one, depending upon the geographical configuration of the theatre of operations.

In these operations another aid was used in the form of centimetre equipment fitted to landing craft, the purpose of which was to permit observation at night of the shore line and beaches. These two examples will show what I have in mind when I suggest that special radar measures can be devised for this type of operation.

Counter-Measures

The success of all such technical weapons as radar is almost entirely dependent upon the technical superiority of our own devices as compared with those of the enemy. It is thus extremely important that we should know as accurately as possible of the technical advances of the enemy, so that not only can we attempt to maintain our superiority in devising new weapons, but also so that we may attempt to destroy the efficacy of his devices.

The activities of a counter-measures group thus naturally subdivide themselves into:

(1) Reconnaissance (2) The devising of special measures to be used against the enemy communications or radar equipment (3) The continuous development of our own facilities with special reference to the counter-measures that the enemy may use against us. The degree of secrecy involved -in counter-measures activities varies very greatly. As is obvious, much of the information which we obtain about the activities of the enemy is already known to him to a far greater extent than we are likely to learn it. On the other hand, the measures which we propose to employ, before they are employed are naturally of the very highest order of secrecy. When they have been employed against the enemy he will, of course know all about them, and will in general set about devising means for overcoming the difficulties with which he is embarrassed.

I can give you some idea of the various stages of the radar and countermeasures activity in Europe by referring to one particular phase of the bombing campaign against Germany. The Germans have devised, as you are probably aware, radar systems somewhat similar to those we ourselves employ, for detecting aircraft approaching Germany across the North Sea and for observing aircraft travelling over Germany at night.

About a year ago the Germans were using the Würzburg equipment for observing bombing raids and for controlling accurately the interception aircraft sent against the raiders. A very desirable counter-measure was to confuse or destroy the ability of these ground stations to observe the bombing raid, and with this in mind the British developed a form of artificial reflector [Project Window, spreading chaff] which, when thrown out of the bombing aircraft, gave a picture to the ground stations which was indistinguishable from a large bombing aircraft. Thus the effect at the ground station was to observe a flight of bombers approaching, and as they passed over Germany they seemed to split up and to multiply until the ground stations appeared to be observing many hundreds of times the original number of bombers observed. They were totally unable, therefore, to decide which were actual bombers and which were artificial reflectors, and this manoeuvre completely threw out of gear the whole of the German

system of night fighter control and brought about a considerable reduction in bomber losses for many months.

The introduction of this counter-measure against the German ground control system has had two important consequences. Firstly, the Germans have completely altered their method of night fighter attack against the bombing raids[1], and secondly the British and United States Air Forces have had to become seriously concerned to see that they themselves have a method of night fighting which cannot be interfered with by the German use of this device. It is thought that this will be achieved by the use of the SCR 720 AI equipment now in production in the United States.

[The conclusion portrayed a level of optimism about the course of WWII as the tide had turned in the Pacific war]:

There is a tendency in the United States and Great Britain for the opinion to be expressed that the Japanese are not likely to be as efficient as the Germans in the devising of special technical devices and counter-measures against our equipment. I think that this is a dangerous opinion. We must, I believe, assume that all the information which the Germans have obtained by now concerning some of our most modern radar devices is available to Japan. It is to the advantage of the Japanese to refrain from using any counter-measures which they may have devised until the opportunity occurs which to them seems to give best promise of a most successful tactical advantage. This opinion may be the result of our having too little information concerning the technical activities of the enemy, and I believe it is very important indeed that we should first of all push forward with the reconnaissance schemes which are already in existence, and that we should give mature consideration to the possible future activities of the Japanese in terms of what they must have learnt from Germany.

[1] By the introduction of a Doppler radar in place of the pulsar radar. The difference in velocities of the aircraft from the chaff (Project Window) echoes provided a differentiation in the return signals.