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CODENAMES APPLIED TO SELECTED EW EQUIPMENT AND ASSOCIATED TACTICS DURING WW II

Device/Tactic	Description
ABC	AIRBORNE CIGAR; airborne transmitter to jam German fighter control frequencies in the VHF (34-38 MHz) band
AI	Airborne Interception; night fighter radar equipment
ABDULLAH	British radar homing device, to enable fighter-bombers to home on the German *Würzburg* gun control radar
ASPIRIN	Ground jammer to counter the German *Knickebein* navigational aid
BENJAMIN	Ground jammer to counter the German *Y-Gerät* bombing aid
Bernhard	German ground-to-air communication system
BOOZER	Radar warning receiver fitted to RAF bombers
BROMIDE	Ground jammer to counter the German *X-Gerät* bombing aid
CARPET	Airborne jammer to counter *Würzburg*
Chain Home	British early warning radar
CORONA	British operation, mounted from a ground station in England, to broadcast spoof orders to German night fighters
DINA	US equivalent of MANDREL (sometimes 'Dinah')
DOMINO	Ground jammer to counter the German *Y-Gerät* bombing aid
Düppel	German code name for metal foil dropped to confuse radar
Erstling	German IFF (FuG 25)
FIGET	British ground jammer to jam German fighter control channels
Flak	(Abbreviation of) *Fliegerabwehrkanonen*, ie anti-aircraft guns
Flensburg	Airborne radar receiver, to enable German night fighters to home on to the emissions from the British MONICA tail warning radar (FuG 227)
Freya	German ground early warning radar
GEE	British hyperbolic navigational aid
GLIMMER	Feint seaborne invasion near Boulogne, in support of the invasion of France
GROCER	British airborne jammer to counter the German *Lichtenstein* night fighter radar
HEADACHE	Generic term for the measures taken to jam the German *Knickebein* navigational aid

Heinrich	German ground jammer to counter the British GEE navigational aid
Himmelbett	German system of close-controlled night fighting
H2S	British airborne radar bombing aid
Jagdschloss	German fighter control radar
JOSTLE	Airborne high powered jammer to jam German night fighter control channels
Kleine Heidelberg	German ground passive system for aircraft detection, using reflected radiation from British ground radars
Knickebein	German beam navigational aid
Korfu	German ground radar receiver which gave bearings on aircraft transmitting with H2S (Fug 351)
Lichtenstein	German night fighter radar (FuG 202/212)
Mammut	German early warning radar
MANDREL	British airborne jammer to counter the German *Freya*, *Mammut* and *Wassermann* early warning radars operating in the 90 to 120 MHz band
Mattscheib	German tactic to silhouette bombers flying above cloud at night, by shining searchlights on the base of the cloud
Meacon	Ground device imitating the transmissions of German radio beacons, thus providing aircraft with false bearings
MOONSHINE	Radar repeating device to produce a false picture on German ground radars
MONICA	British tail warning radar fitted to night bombers
Naxos	Airborne radar receiver, to enable German night fighters to home on emissions from the H2S radar (FuG 350)
Nuremberg	Modification to the *Würzburg* gun-laying radar to minimise effects of WINDOW
OBOE	British airborne radar bombing aid
PERFECTOS	Device to enable British fighters to home on emissions from the identification equipment of their German counterparts
PIPERACK	British airborne jammer to counter the German *SN-2* night fighter radar
Postklystron	German ground jammer to counter the British H2S bombing radar
Seetakt	German naval gun-laying radar, also used to direct the fire of coastal batteries and to provide warning of the approach of enemy ships
SERRATE	Airborne radar receiver, to enable British night fighters to home on emissions from the *Lichtenstein* and *SN-2* radars of their enemy counterparts

SN-2	German night fighter radar (FuG 220)
TAXABLE	Feint seaborne landing on Cap d'Antifer, in support of the invasion of France
TINSEL	Modification of bombers' HF transmitters, to broadcast engine noises on the German fighter control frequencies
TUBA	US high powered ground jammer, to counter the German *Lichtenstein* night fighter radar
Wassermann	German early warning radar
Wilde Sau	'Wild Boar'; German tactic, use of single-engine fighters to engage bombers over the target
WINDOW	British name for metal foil dropped to confuse radar – referred to as 'chaff' in later years
Würzburg	German radar used to direct AA guns, searchlights and, for a short time, night fighters
Würzburg Riese	'Giant *Würzburg*' - German fighter control radar
Würzlaus	Modification to the *Würzburg* gun-laying radar, to minimise effects of WINDOW
X-Gerät	German beam bombing aid
Y-control	German method of controlling night fighters using modified *Y-Gerät* equipment
Y-Gerät	German beam bombing aid
Zahme Sau	'Tame Boar'; German tactics, designed to bring freelance operating night fighters into contact with night bombers en route to and from the target

DESIGNATIONS OF SELECTED POST-WAR EW EQUIPMENT

Up to and including the early Valiant era, equipment of wartime origin continued to be employed, notably ABC, CARPET, MANDREL, DINA and PIPERACK. While far from exhaustive, the following list, which is roughly chronological, includes most of the additional devices used by the RAF between 1945 and the end of the Cold War, roughly the era bracketed by the introduction of the Lincoln and the withdrawal of the Vulcan. Note that:

a. Devices with designations beginning with AN/ were of US origin, much of it supplied under MDAP, although the Westinghouse ALQ-101 pods were purchased.

b. PWR = Passive Warning Receiver

c. Chaff is the modern term for the wartime WINDOW

ARI 5625	MANDREL 2 – spot or barrage comms jammer
ARI 5699	PIPERACK – spot or barrage comms jammer
ARI 5749	POTATO – experimental (1950s) centimetric radar spot jammer
ARI 18006	TORIST – homed on CW jammers (usually in association with AI 21)
ARI 18021	FLANGE – Centimetric radar homer (or ground-based D/F as MGRI 18023)
ARI 18027	APPENDIX – airborne VHF homer associated with TR1934
ARI 18030	CARPET 4 – spot jammer
ARI 18040	APPENDIX – airborne VHF homer associated with TR1935
AN/ALT-4	Noise jammer 7500-11000 MHz
AN/ALT-6A	E/F Band swept frequency noise jammer
AN/ALT-6B	D-I Band tuneable noise jammer
AN/ALT-7	Swept frequency metric (VHF/UHF comms) noise jammer
AN/APA-11	Signal analyser (in conjunction with APR-4 or -9)
AN/APA-17	S-band D/F (in conjunction with APR-4)
AN/APA-64	Signal analyser (in conjunction with APR-4 or -9); superseded APA-11
AN/APA-69	S/C/X-band D/F (in conjunction with APR-4 or -9)
AN/APR-4	Wide (38-1000MHz) band search receiver
AN/APR-9	Wide (1000-10750MHz) band search receiver
AN/APT-5	CARPET 4 – L Band jammer
AN/APT-16	Tuneable centimetric noise jammer, 1000-7700 MHz
AN/ARR-5	Narrow band radar or comms search receiver (27-143 MHz)
-	INDIGO BRACKET – S-Band jammer
-	RED CARPET – projected X-Band barrage jammer
ARI 5800	ORANGE PUTTER - tail warning radar (Canberra)
ARI 18044	GREEN SALAD – airborne VHF homer
ARI 18074	GREEN PALM - VHF comms barrage jammer (Mks 1A & 2 V-Bombers)
ARI 18075	BLUE DIVER - metric barrage jammer* (Mks 1A & 2 V-Bombers)
ARI 18076	RED SHRIMP – S (or E)-band barrage jammer (Mks 1A & 2 V-Bombers)
ARI 18077	Warning device to prompt dispensing of chaff via ARI 18051
ARI 5919	RED STEER Mk 1 - tail warning radar (Mk 2 V-Bombers)
ARI 5952	RED STEER Mk 2 - tail warning radar (Mk 2 V-Bombers)

ARI 18051	WINDOW dispensers (Vulcan - Type 26 (2.8-8 GHz) & Type 28 (7.5-14.25 GHz). Short (350 packet) belt in each wing and long (1150 packets) belt in port wing, plus chaff cartridges for the Very pistol
ARI 18105	BLUE SAGA - PWR (Mk 1A & 2 V-bombers)
ARI 18146	X (or I) Band jammer (Vulcans and Victors) - displaced GREEN PALM
ARI 18205	L Band jammer
-	Infrared Decoys (Vulcan): 92 short belt; 172 long belt
ARI 18228	PWR (square fin cap on Vulcan B.2)
ALQ-101	US pod of 1970s vintage used by Jaguar and Buccaneer
Skyshadow	Current pod for Tornado
BOZ-107	Combined chaff/flare dispenser - Tornado

* Jammed the KNIFE REST and SPOON REST acquisition radars of the SA-2 and SA-3 missile systems.

THE RELATIONSHIP BETWEEN FREQUENCY AND WAVELENGTH

In the course of this seminar it was almost inevitable that there would be instances of 'wiggly-amp-speak'. This note can hardly be comprehensive but it just might shed some light.

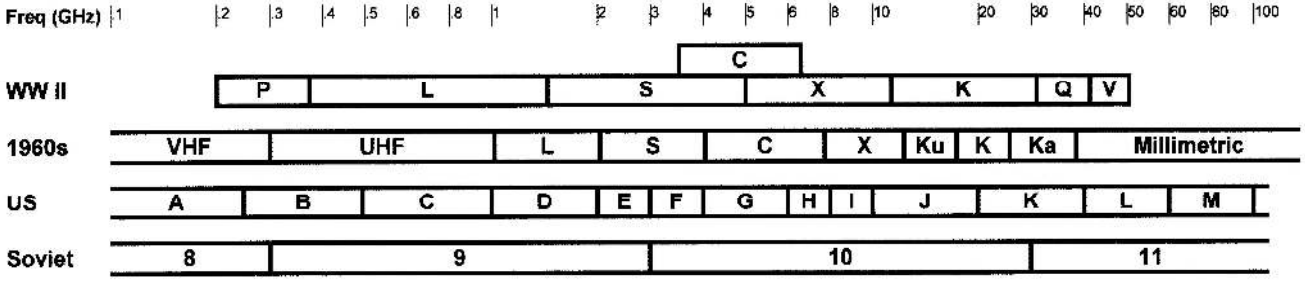
Wavelength and frequency are related by the speed of light 'c' (3×10^8 mtrs/sec) thus: Frequency × Wavelength = c. The easy way to remember this mathematical relationship is via the very familiar BBC Radio 4 which, like the old Home Service, is broadcast on (roughly) 200 Khz or 1500 mtrs. These two parameters are directly related thus:

200,000 × 1,500 = 300,000,000.

To put this another way, the shorter the wavelength, the higher the frequency, and, when dealing with radar, the shorter the wavelength, the better the discrimination. Thus, for example, while the AI sets of 1940 had worked at 1.5 mtrs, this had been reduced to 10 cms by 1942. Similarly, while the original H2S sets operated on a wavelength of 10 cms, these were soon superseded by the Mk III which produced a much better picture because it operated at 3 cms. (It's all in 'the science'.)

FREQUENCY ‘BANDS’

During WW II it was sometimes found convenient to refer to ranges of frequencies as lettered ‘Bands’. Rather confusingly, however, the bands were redistributed and relabelled in the 1960s while the Soviets and Americans later introduced their own systems; the latter is now used more or less universally. The diagram below provides some impression* of the way in which the foundations have shifted. Note, for instance, that reference to an ‘L Band’ device can mean quite different things depending upon who is saying it and when.



* The relationship depicted between ‘Bands’ and frequencies here is only approximate; the presentation of frequencies is intended to represent a logarithmic scale.

ABBREVIATIONS

Most acronyms and abbreviations are jargon and, while they may feature within the RAF patois for a time, few are absorbed into the Service lexicon on a permanent basis. Depending upon when (and whether) one wore a uniform, therefore, oddly associated clumps of letters may be very familiar or quite meaningless. The following is a selection of the abbreviations that crop up within this edition of the Journal and which may, or may not, be familiar. **Ed**

AAA	Anti-Aircraft Artillery
AD	Air Defence
AEO	Air Electronics Officer
AFU	Advanced Flying Unit
AI	Air Interception (radar)
AMD	Activated Metal Decoy
ARM	Anti-Radar Missile
BAA	British Airports Authority
BEA	British European Airways
BOAC	British Overseas Airways Corporation
COMSEC	Communications Security
CRT	Cathode Ray Tube
CSE	Central Signals Establishment
CW	Continuous Wave
ECM	Electronic Countermeasures
ELINT	Electronic Intelligence
EW	Electronic Warfare
EWOSE	Electronic Warfare Operational Support Establishment
IR	Infrared
MANPADS	Man-Portable Air Defence System(s)
NASM	National Air and Space Museum
OR	Operational Requirement
ORB	Operations Record Book
PRF	Pulse Recurrence Frequency
PWR	Passive Warning Receiver (aka RWR)
R&D	Research and Development
RCM	Radio Countermeasures (later ECM)
RWR	Radar Warning Receiver (aka PWR)
SAM	Surface-to-Air Missile
SHAEF	Supreme Headquarters Allied Expeditionary Force
SPJ	Self Protection Jammer

ELECTRONIC WARFARE

RAF MUSEUM, HENDON, 10th APRIL 2002

WELCOME ADDRESS BY THE SOCIETY'S CHAIRMAN

Air Vice-Marshal Nigel Baldwin CB CBE FRAeS

It is a pleasure to see so many of you here today to discuss one of the more esoteric subjects the Society has ever tackled. Much is subsumed within the brief title Electronic Warfare as many of you already know, and as many others of you are about to find out.

Before I introduce our Chairman for the day, let me say my usual thanks to Dr Michael Fopp and his staff here at the Museum for allowing us to use their excellent facilities and helping us so much with the production of the day.

We have had a fascinating time putting together the various threads of this subject and have come up with a programme that broadly splits into World War II this morning, and the Cold War this afternoon.

The Society's Life Vice-President, Air Mshl Sir Freddie Sowrey, will guide us through the day. To relative newcomers to the Society, Sir Freddie is one of our founding fathers. Just over fifteen years ago, with just a few like-minded colleagues, his enthusiasm and drive started us off, and he was, of course, the Society's Chairman for its first decade. With his own RAF flying and staff time honed and shaped during WW II, and then the Cold War, he brings much experience to his task today.

Sir Freddie, over to you.

INTRODUCTION BY SEMINAR CHAIRMAN

Air Marshal Sir Frederick Sowrey KCB CBE AFC

Electronic Warfare has often been the poor relation, frequently misunderstood, often undervalued, perhaps misused or abused, occasionally ignored completely and sometimes the easiest item to cut when budgets are tight in peacetime. By its very nature, electronic warfare is not the most obvious or glamorous facet of air power, and anyone who is looking for a demonstrable offensive capability will be disappointed. On the other hand, the employment of EW may well be the only means of making penetration of enemy airspace possible without sustaining prohibitive losses. It is, therefore, and as we shall hear today, a vital weapon in the air battle, and this will be even more the case in the future. Richard Hallion, the USAF air historian, writing on the Gulf War cited instances in which, without electronic support, fully 50% of the strike aircraft despatched would probably have failed to return.

For the purposes of today's seminar, I offer the following definition of electronic warfare. It is the exploitation of the electromagnetic spectrum and the denial of its use to the enemy. Within the scope of this definition come all aspects of the use of active and passive technologies to produce countermeasures designed to confound the enemy and counter-countermeasures to thwart his attempts to regain his freedom of action.

'Seeing with radio energy', as it was first called, was the subject of a patent awarded to a German scientist, Christian Hülsmeyer, in the spring of 1904. Little practical progress was made over the next thirty years, however, although it is worth pointing out that, no sooner had radio been invented, than efforts were being made to intercept wireless transmissions for intelligence purposes. During WW I, for instance, it had been possible by this means to keep track of the sailings of U-boats and to detect incoming Zeppelin raids.

Things eventually began to move as the Germans and British prepared for war in the 1930s. In February 1935, Robert Watson-Watt, of the National Physical Laboratory, presented a paper to the Air Ministry in which he outlined the principles of 'radio location', or 'radio direction finding', as it was first known. The paper proposed the creation of a screen of radio stations, suggested the sort of

performance that might be expected, summarised the way in which the system's information might be translated to aid our fighter aircraft and, and with considerable foresight, indicated the ways in which this technology could be countered if it were also to be used by the enemy.

A trial was undertaken in which a Heyford target aircraft was detected by the BBC radio station at Daventry, where an experimental receiving device had been installed and linked to the short-wave transmitters. The range of the detection was barely eight miles, a result that could have been achieved by a man who had climbed the mast with a pair of fieldglasses!

Shortly afterwards an Air Ministry Experimental Station was set up at Bawdsey Manor and rapid progress was soon being made in creating the Chain Home stations with their massive girder masts and in developing radio direction finding equipment, such that reliable detection was soon possible at ranges of up to 100 miles.

Coupled with this work, much effort was put into ensuring that the RAF's fighter aircraft were equipped with VHF radio in order to communicate with the controllers on the ground.

The Germans, for their part, were also heavily involved in developing radio detection systems but it was a naval scientist; Rudolph Kühnold, who developed a device for detecting warships and within less than three years he had improved it to the extent that it could detect targets more than 50 miles away. His system, called *Freya,* was ordered by both the navy and the air force and Kühnold went on to develop a naval gunnery radar called *Seetakt*, whilst Telefunken developed *Würzburg*, a longer range gunnery radar.

Running in parallel with technical developments, there was an intelligence battle being fought to determine what the other side was up to, to evaluate their progress and to devise ways and means of negating their efforts. An early success for the British was the examination, at no little risk to his person, by a radar expert, Mr L Bainbridge Bell, of the *Seetakt* aerials on the hulk of the *Graf Spee* as she lay smouldering in the River Plate.

Today we will hear a fascinating story of great courage and ingenuity, on the ground, as well as in the air. A story in which intelligence plays a considerable role and where bluff and counter bluff had their part.

A NEW LOOK AT 'THE WIZARD WAR'

Dr Alfred Price

Alfred Price joined the RAF as an apprentice in 1952. Commissioned as an air electronics officer in 1956, he flew in Hastings and Vulcans and, of particular significance to this seminar, in Canberras of No 360 Sqn. He left the Service in 1974 to become a full time, and prolific, aviation writer; he now has more than forty titles to his credit. It is a measure of his standing that he was commissioned by the American Association of Old Crows to write a three-volume History of US Electronic Warfare. He is a Fellow of the Royal Historical Society, and has a PhD in History.

The purpose of this paper is to cast new light on the action that Winston Churchill termed 'The Wizard War': the jamming of the radio beams intended to guide German bombers to targets in Great Britain during the dark days of 1940 and 1941. As many of you will be aware, this was the first protracted use of the military discipline that we now, after many changes, call 'Electronic Combat'.

The story began in the early 1930s, when the German Lorenz Company pioneered a VHF radio beam system to assist airliners to reach airports in bad weather. The principal of operation was similar to that of the radio range system that saw widespread use. The German beam comprised two fine overlapping beams. Morse dots were radiated in one beam and Morse dashes in the other. Where the beams overlapped, the dots and the dashes interlocked to produce a steady note. In the 1930s, it was believed that VHF waves travelled only in straight lines. That meant they would not follow the curvature of the earth, so a VHF beam system would have only a limited usable range. However, when German engineers conducted tests with the VHF beams they discovered that the usable range of the system was about 30% greater than expected. In fact the beams did bend slightly to follow the curvature of the earth; an aircraft flying at 20,000 feet could pick up the beam signals at a distance of up to 250 miles from the transmitter.

To exploit this discovery, the *Luftwaffe* contracted the Telefunken

Company to design and build a high powered long range beam transmitter code-named *Knickebein*. To produce a steady note lane that was only 0.3^{o} wide, the transmitter fed a huge directional aerial array 315 feet across and 100 feet high. The whole thing was mounted on railway bogies, which ran on a circular track to allow it to be aligned on the target. *Knickebein* radiated 500 watts of power on one of three frequencies - 30, 31.5 or 33.3 MHz.

To guide bombers to their target at night or in poor weather, two such beams were employed. The aircraft flew along the steady note lane from one transmitter, and released their bombs as they passed through the steady note lane from a second transmitter, which crossed the first at the bomb release point. One of the clever things about *Knickebein* was that the bomber needed no special equipment to pick up the beam signals. The airfield beam approach receiver, a standard item of equipment on German multi-engined bombers, could also pick up the *Knickebein* signals. *Knickebein* was easy to use for any bomber pilot practised in the use of the airfield approach radio beam system.

In August 1940, the *Luftwaffe* began its large scale day and night bombing campaign against targets in Great Britain. As well as the *Knickebein* beam transmitters at Kleve and Schleswig Holstein in Germany, the *Luftwaffe* erected others in France, Holland and Norway. Thus, any target in the British Isles could be marked using the *Knickebein* beams.

In June 1940, shortly before the start of the Battle of Britain, a Royal Air Force ELINT aircraft picked up *Knickebein* signals for the first time. The German beam attack system seemed to pose a grave threat to Britain's cities; the RAF could deal harshly with attacking forces coming in by day, but at night the British air defence system was weak to the point of impotence. Briefed by his scientific advisors of the seriousness of the menace, Winston Churchill ordered the formation of a radio-jamming organisation at the very highest priority.

Exactly two months later that jamming organisation, designated No 80 Wing, was ready to begin operations. Commanded by Wg Cdr Edward Addison, the unit rapidly built up to strength of 180 men and women.

Dr Robert Cockburn, at the Telecommunications Research Establishment at Swanage, headed the small team that hand-built the jamming transmitters. Initially, they modified hospital diathermy sets

into jamming transmitters with a power output of about 150 watts. But soon a purpose-built jammer was built to counter *Knickebein*, codenamed ASPIRIN.

ASPIRIN radiated Morse dashes on the German beam frequencies at a power of 500 watts. Those Morse dashes were not synchronised with the German signals; rather they were superimposed on top of them. The idea was that when a German pilot entered the dash zone, he would turn in the required direction. But when he arrived in what should have been the steady note lane, he continued to hear dashes. When he reached the dot zone, he heard simultaneous dots and dashes, which did not resolve into a clear note.

Both during and since the war there have been stories that the Royal Air Force deliberately 'bent' the German beams. These stories are not true. The normal method of jamming *Knickebein* was to radiate unsynchronised Morse dashes on the beam frequencies. It is possible that on occasions the British dashes and German dots came together to produce some sort of bent beam. But there was never any deliberate 'beam aiming'.

The 'official' British line on the jamming of *Knickebein* is that the German system soon fell into disuse, ASPIRIN was so effective in disrupting the beams. Having spoken to several German bomber crewmen who flew over Britain at that time, I would assert that while *Knickebein* did indeed fall into disuse, it was not because ASPIRIN was particularly effective in disrupting the radio beams. In fact, crews have told me that usually it was quite easy to hear the *Knickebein* signals through the jamming.

The modified hospital diathermy sets gave a jamming output of 150 watts, while ASPIRIN gave an output of 500 watts. In each case, the jamming was radiated from an omnidirectional aerial. As many people in this audience will readily appreciate, such levels of power were inadequate to provide effective jamming against *Knickebein* signals radiated at 500 watts and boosted by a high gain directional aerial array.

ASPIRIN was effective, but for a quite different reason. Although the jammer rarely disrupted the beam signals, by its very presence it showed that the defenders were aware of the beams' existence and of their location. German bomber crews feared that the RAF might send night fighters to fly along the beams and pick off them off. In fact that

tactic did not work; the RAF had tried it a few times, but without success. But German bomber crews were so concerned about the possibility of such a thing, that most of them refused to fly along the beams while over enemy territory.

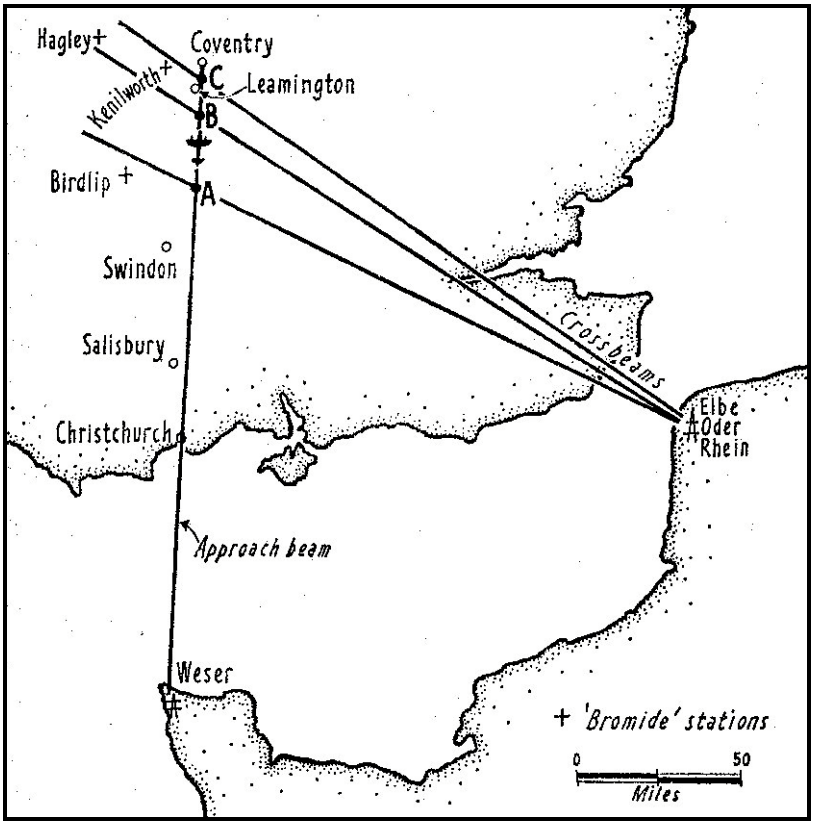
I think there is an important lesson here. Even when electronic jamming is not fully effective in concealing signals, it can cause an enemy to distrust the system being jammed.

In the autumn of 1940, from ULTRA decrypts and other sources, the British intelligence servicea discovered that one German bomber unit was using a new and more precise radio beam bombing system over Britain. This was the so-called *X-Gerät*. *X-Gerät* was essentially similar in operation to *Knickebein*, but it worked further up the frequency spectrum between 66 MHz and 75 MHz and that made it considerably more accurate. The *X-Gerät* transmitters radiated 1 Kw of power into a fan of beams. For simplicity, however, only the four that were necessary for the operation of the system are shown on the accompanying diagram. One beam marked the approach path to the target, and three more crossed the approach beam to provide accurate waypoints short of the target. As the bomber passed between the last two cross beams, a special clock was run to measure the ground speed very accurately. When the aeroplane reached the computed bomb release point, the bombs were released automatically.

X-Gerät was more difficult to use than *Knickebein* and only one German bomber unit, *Kampfgruppe* 100, was trained and equipped to use it. The intention was to make *KGr* 100 the world's first night precision attack unit.

As British Intelligence learned more about the *X-Gerät*, work began on building a jammer. Codenamed BROMIDE, this radiated omnidirectional Morse dashes with a power of about 100 watts. By mid-November 1940, the first few jammers had entered service.

That was the position on the night of November 14/15 1940, when *Kampfgruppe* 100 led the large scale bombing attack on the city of Coventry. Thirteen of the unit's Heinkel bombers lead the attack, dropping canisters of incendiary bombs to start fires to guide in the rest of the German bomber force. A BROMIDE jammer was located on the bombers' run in, but it proved ineffective. When the jammer was designed, insufficient had been known about *X-Gerät*. Although the jammer probably emitted on the correct frequency, the note it



Orientation of X-Gërat over Coventry 14/15 Nov 40.

transmitted was modulated not at the 2,000 Hz used by the new system, but at the 1500 Hz used by *Knickebein*. The filter circuits in the *X-Gerät* receivers were sensitive enough to separate the beam signals from the jamming. In the ensuing attack, Coventry suffered heavy damage. More than 500 people were killed and 400 injured, and large sections of the city were burned to the ground.

Following this catastrophe, RAF intelligence officers examined a captured *X-Gerät* receiver and discovered the deficiency in BROMIDE. At top priority, the jammers were modified to radiate on the correct modulation. During the months that followed, *Kampfgruppe* 100 led several more attacks. But never again did a British city suffer the degree of concentrated devastation inflicted on

Coventry. It was reasonable to conclude (as British Intelligence did conclude at the time) that the modification to BROMIDE had caused the sharp decrease in effectiveness of the German pathfinder unit.

The above account is what I would call the 'conventional wisdom' regarding the jamming of *X-Gerät*. I too believed it, and wrote along those lines, until I attended a reunion of *Kampfgruppe* 100 aircrew in Germany a few years ago. I asked one radio operator how much trouble he had had from the British jamming of *X-Gerät*. He said he did not remember any jamming. I described the Morse-dash jamming put out by BROMIDE, but he said he had never heard any such jamming. He called over some friends and soon I had half a dozen ex-radio operators standing around me and discussing the matter. None of them remembered hearing the British Morse dashes.

Those guys were not stonewalling; I was an honoured guest at their reunion. They were genuinely intrigued at what I had said and they really wanted to help. They racked their brains. They described buzzing noises, musical breakthrough, unscreened engine ignition noises and various other sorts of interference. But none of it sounded anything like the British jamming, and almost certainly all of it had been unintentional.

I was eventually introduced to Hubert Langerfeld, the unit's expert on the *X-Gerät* system and the officer responsible for setting up the beams. I told him about the British attempts to jam *X-Gerät* with BROMIDE. Could he, perhaps, explain what had gone wrong? Langerfeld told me that when the *X-Gerät* was conceived, the possibility of enemy jamming had been anticipated. To counter that threat, the system transmitted spoof beams to give the enemy something to jam. Before an attack on Britain the spoof beams were turned on early and ostentatiously tuned in. The 'real' beams usually came on only a few minutes before the leading bombers reached their target.

Eventually No 80 Wing discovered what was happening, but the jamming of *X-Gerät* was far less effective than had been thought. Later, looking through the official raid reports of *KGr* 100, I found only four occasions when the *X-Gerät* suffered effective jamming; in December 1940, in March 1941 and twice in May 1941.

Langerfeld's disclosure answered one question, but it raised others. If the X-beams were not being seriously jammed, even after the

modulation of BROMIDE had been corrected, why was it that *Kampfgruppe* 100's later attacks were less effective than the one against Coventry? If the BROMIDE jamming was ineffective throughout, one would expect to have seen further instances of concentrated damage inflicted on other British cities.

To find the answer to that question, we need to look at the weather and the state of the moon on the night of 14/15 November 1940, when Coventry was attacked. The attack took place on a very clear night with a full moon. So the main part of the German bomber force was able to find the target relatively easily, even without the assistance of Pathfinder aircraft. Coventry possessed many old timbered buildings, which were vulnerable to fire. Also, its gun defences were weak (by the way, these factors were also present when the German city of Dresden was burned out later in the war).

In fact it was the rare combination of perfect weather, a full moon, a highly combustible target and weak defences that sealed the fate of Coventry, rather than the use of radio beams and Pathfinder marking. Germans who flew with follow-up bomber units that night have expressed doubt that the *Kampfgruppe* 100 marking made much difference; the moon was so bright that they could have found the city anyway.

It should also be pointed out that *KGr* 100's Pathfinder methods were, by later standards, naive. Using a dozen or so aircraft to drop containers of 2-pound stick-shaped incendiary bombs, a weapon with notoriously poor ballistics, was not a good way to mark a target. Moreover, the follow-up aircraft also dropped these weapons, so that, even if the Pathfinder marking was accurate, its effect was quickly diluted.

Compared with the methods used by the RAF's Pathfinder Force later in the war, *Kampfgruppe* 100's efforts were puny. During large scale RAF night attacks, the Pathfinders dropped specially developed target indicators with excellent ballistics, to produce distinctively coloured spot fires at the target. As many as seventy Pathfinder aircraft might be employed in order to renew the target marking at regular intervals throughout the attack. And even then, things sometimes went spectacularly wrong.

Seen against this background, it is clear that the odds were stacked against *Kampfgruppe* 100, which never had more than twenty aircraft

available and usually operated with about half that number. So when *Kampfgruppe* 100 led attacks on nights with poor weather and no moon, against targets that were far less combustible than Coventry, it is not surprising that in general the results were unimpressive. During 1940 and 1941 techniques for delivering accurate night attacks were in their infancy. Even when there was no effective jamming of the *X-Gerät*, the German bomber crews faced severe problems.

Throughout 1941 the steadily improving defences imposed a steady attrition on *KGr* 100, causing severe losses in experienced crews. Then, in June 1941, Hitler invaded the Soviet Union and most of the German bomber force was redeployed to the Eastern Front.

To conclude, let me make four points. My first is that British Intelligence had a greatly exaggerated impression of the effectiveness of both German beam systems. *Knickebein* was somewhat less accurate than had been feared. I suspect this was because the same diffraction that bent the beams to follow the curvature of the earth, also caused some diffraction in azimuth as the beams passed over coastlines.

In the case of *X-Gerät*, the code-breakers at Bletchley Park had decrypted messages conveying the angular settings of the beams to the transmitting stations. The beam co-ordinates were given to 5 seconds of arc, which implied an accuracy of alignment of less than 13 feet at a distance of 100 miles. On that basis, the theoretical accuracy of the system might be about 40 feet for an attack on London. There is, of course, a world of difference between the accuracy of the alignment of the radio beams, on the one hand, and the accuracy of bombing using the system on the other. In fact, the bombing and marking by *KGr* 100 were nothing like as accurate as that.

My second point is that *Kampfgruppe* 100 and No 80 Wing both operated close to the state of the art in their respective spheres. They developed their operational techniques from first principles as the battle progressed. In such circumstances, it is not surprising that in many cases the methods adopted were not the most effective. *Kampfgruppe* 100 never had more than twenty aeroplanes available to mark a target, and it usually operated with about half that number. That was insufficient to provide effective marking for a long drawn out attack.

My third point is that even though the jamming of *Knickebein* did

not conceal the signals, it had the valuable effect of persuading German bomber crews to abandon using their beams for fear of being attacked by night fighters.

Fourthly, and finally, the campaign against the German beam systems shows how easy it is to get a misleading impression of the effectiveness of a particular electronic combat technique or tactic. Electronic combat analysis is a matter of trying to deduce reasons why things did *not* happen. As I have tried to show, an enemy system can fail for any number of reasons. Jamming might be just one of these, and perhaps not even the most important.

100 GROUP - 'CONFOUND AND…'

Air Vice-Marshal Jack Furner

AVM Jack Fumer served in the RAF from 1941 to 1976; he flew as navigator in forty-two different types of aircraft with 243 different pilots. He did two Bomber Command tours, ending his war in India flying transport support for the Army in Burma. He was subsequently engaged in trials work at both Boscombe Down and Dayton, Ohio before becoming the first Vulcan OC Ops Wg at RAF Waddington. There followed appointments as an operational planner at Bomber Command and SHAPE, the inevitable stint at MoD and command of RAF Scampton. In 1969 he became the last AOC of the Central Reconnaissance Establishment; he then joined the staff of the NATO HQ in Brussels, his final RAF appointment being that of Assistant Air Secretary.

I pick up the story in mid-1943 when I was approaching the end of a Stirling tour with No 214 Sqn. The electronic battle ebbed and flowed. GEE, the navigation aid with the hyperbolic grid, was being jammed long before targets were reached. H2S was available to the Pathfinder Force but was only just beginning to spread to the Main Force; its transmissions, of course, encouraged pursuit.

By this time it was usual to plan for a concentrated bomber stream: common tracking and timing were emphasised as paramount; stragglers were vulnerable. I must say that, from the Stirling crews' point of view, there was a distinct feeling of additional discomfort since they were restricted in height to an absolute maximum of 14,000 feet and therefore 5,000 or 6,000 feet below the Halifaxes and Lancasters, through which the latters' loads were being dropped. Additional, that is, to the *Flak*, the searchlights, and the Kammhuber fighter belt through which any sensible pilot corkscrewed.

MANDREL was fitted to some of the Command's aircraft and this provided jamming of *Freya*, the German early warning radar which had a range of 100 miles on frequencies of 120-150 MHz. TINSEL, essentially a microphone mounted in an engine bay, was intended to

disrupt ground-to-air communications on frequencies of 3-6 MHz. In mid-1943, however, we still had no jammer for the mighty *Würzburg* chain, the German radar system used to direct *Flak*, the searchlights and, for a short time, night fighters, on frequencies around 500 MHz.

Loss rates fluctuated, depending on the interplay of initiatives from each side: at this time it was running at about an average of 5%. The figure says it clinically: to put it in a more meaningful way - on a typical operation involving 750 bombers, it meant the loss of 260 aircrew. Something was on the horizon, however, to provide a temporary decrease in that loss-rate figure; something which would confuse the *Würzburg* operators.

It was WINDOW, metallised strips which were about to be used for the first time during an attack on Germany's second city, Hamburg, in July 1943. What we aircrew did not know was that there had been a long period of heart-searching which had clouded the issue for the previous year and delayed a decision to use. Both sides had it but were initially loath to use it. Fighter Command was unhappy until they were provided with evidence that a newly revised AI equipment would be able to discriminate. Even SASO Bomber Command was opposed for a time. Personalities as high up the chain of Government as Lord Cherwell and the Home Secretary, Herbert Morrison, were dubious and had been arguing against its use. Even the invasion of Sicily had had a bearing on the matter and caused further delay. But 'Bomber' Harris was unwavering in wanting it.

Anyway, the final decision was taken to start WINDOW on the devastating series of attacks on Hamburg: the first was on the night of 24/25 July 1943, followed in quick succession on 27/28 and 29/30 July. A fourth raid on 2 August was a failure with a massive thunderstorm over the target. The strips, 30 cms long and 1.5 cms wide, were being dropped at the rate of a bundle a minute. 2,000 of the strips would have appeared to *Würzburg* operators as the echo of a heavy bomber. The effect, particularly on the first night, was dramatic. The entire radar system was disrupted. Searchlights were seen to be waving aimlessly; *Flak* was hesitant and inaccurate and predicted *Flak* fire gave way to barrage fire; fighter pilots were losing their cool in the general mayhem; and the intercepted radio traffic showed the enemy ground controllers to be hopelessly confused. Dr Price has calculated that the combined effect of 700 plus bombers dispensing

WINDOW would have looked like a force of 11,000 aircraft.

The results spoke for themselves. Only twelve aircraft were lost on the first Hamburg raid, a mere 1.5%. Each of the raids involved between 700 and 800 aircraft. Losses did creep up a little on the second and third attacks, to seventeen and twenty-seven, but they were still significantly below the previous levels. From then on, the use of WINDOW became routine on every flight until the end of the war. 1,000 million strips had to be manufactured every month, in varying dimensions to match different frequencies.

Coincidentally, these Hamburg raids provided many Main Force (ie non-Pathfinder) navigators with their first opportunity to use H2S to assist both their navigation and their bombing. Being a coastal city, there were good contrasting echoes on the H2S screen, even with the comparatively crude technology of the time. In addition, the occasion had been chosen to introduce a new GEE frequency which, temporarily at least, reduced the effects of enemy jamming.

Immediately after the Hamburg raids, which had astonished Goering, Speer and others, Hitler signed a production order for the V2.

The low loss rates did not last, of course. The Germans became used to differentiating between real and spurious returns by filtering out the relative speeds, and their fighter procedures developed from rigid close control to a much greater degree of freelancing. Loss rates crept up again: forty aircraft out of 600 were lost over Peenemunde, and later in 1943, losses mounted significantly over Berlin. The Battle of Berlin, as the period November 1943 to March 1944 came to be called, cost Bomber Command about 600 aircraft and 4,000 aircrew in the course of flying some 10,000 sorties. My type of aircraft, the Stirling, was pulled out of Bomber Command's main force due to greater vulnerability: they were being lost at the rate of 13% in the initial stages of the Battle. Not many Stirling crews were surviving a tour.

I must interject some personal comment at this point since it serves to move forward to the next significant phase in the electronic battle. My crew was tour-expired at the end of August 1943 and soon after Hamburg and Peenemunde we all went our separate ways. I was posted to HQ 3 Group with the specific job of analysing logs and charts in order to make recommendations on better tracking and

timing. But by Christmas, I had heard about the formation of a new Group in Norfolk. I was not clear on its purpose but I knew that No 214 Sqn was re-equipping with B-17s within the new Group. I could not resist this and I asked the AOC to release me from staff work to get back to my old unit as its Senior Navigation Officer. So, shortly after New Year's Day 1944, I arrived at Sculthorpe and was soon flying with the Squadron Commander, Wg Cdr McGlinn, and greeting old friends who were still on the squadron. An intensive conversion programme began for all of us with the aid of a small 8th Air Force detachment.

Now, to return to the main story. Losses of Bomber Command aircraft and crews were up again and too high, climaxing with the absolutely ghastly result on Nuremburg on the last night of March 1944. Electronic countermeasures were prominent in the planners' minds. An equipment called ABC, short for AIRBORNE CIGAR, had replaced TINSEL in some Main Force aircraft as a more effective means of jamming VHF fighter control frequencies, although this required a dedicated operator, that is to say, an additional crew member. But to give ECM a more prominent and more focused environment, it had been decided to establish No 100 Group as the unit responsible for the operational application and co-ordination of all ECM efforts, ground and airborne. The two principal aims of the Group in the airborne context were defined in an Establishment Directive as:

> '(1) to employ airborne radio counter-measures equipment to deceive or jam enemy radio navigational aids, enemy radar systems and certain wireless signals'; and
>
> '(2) to give direct support to night bombing or other operations by attacks on enemy night-fighter aircraft in the air or by attacks on ground installations'.

The Group was to be furnished with about 100 aircraft for bomber support plus four squadrons of Mosquito night fighters. My part of this presentation will deal with the first aim. The second is the subject of the next speaker.

No 100 Gp was duly formed on 1 December 1943. Its strength was built up gradually during the first half of 1944 but it existed only until the end of the European war. The Group's motto, which was in Malay, translated as 'Confound and Destroy'. The AOC was AVM Addison.

The Headquarters was at Bylaugh Hall and all its airfields were in Norfolk. The Group's initial designation was SD, Special Duties, but this was later changed to Bomber Support which more accurately described its function. The aircraft involved were Fortresses and Liberators, based at Sculthorpe and later at Oulton, which were intended to act as jamming escorts; and Halifaxes and Stirlings operating from Foulsham and North Creake to provide screens and spoofs. The Mosquitos will be discussed by my colleague.

Let me start with the Fortresses of my own unit, No 214 Sqn. The B-17 had been chosen principally for its height performance, since it would permit us to escort the bomber stream while flying some 5,000 feet above them. There were, however, no aircraft at all at Sculthorpe when I arrived there in January 1944. Aeroplanes eventually began to appear, one or two at a time. Having originally been provided from US stocks, they had been worked on extensively by Scottish Aviation at Prestwick. There they had been repainted in RAF colours, provided with British navigation equipment and, most importantly, fitted with a variety of jamming equipment. Since they were now going to operate mainly at night, mufflers had been riveted to the exhaust pipes to screen the exhaust flames. The noses of the aircraft had been modified to provide a 'chin' mounting for an H2S scanner. Bomb bays had been sealed to house the jamming gear. The ventral turrets had been removed.

At first, each B-17 was fitted with eight MANDREL transmitters, each one tuned to a different frequency, for use against the *Freya* chain, and three ABC transmitters to disrupt VHF communications, the latter requiring the presence of an additional German-speaking crew member who operated his jammers from a dedicated station which had been provided in the centre section of the fuselage. Later on a more powerful jammer, JOSTLE IV, replaced the ABC equipment. JOSTLE blotted out all of the frequencies covered by the individual ABC sets with 2,000 watts of jamming, thus eliminating the need for our German-speaking special operator to tune manually between frequencies. The main component was housed in what looked like a large dustbin, weighing 600 lbs. Of all the 100 Gp aircraft, only the B-17s and the B-24s could carry JOSTLE. With JOSTLE against them, the Germans were forced to abandon the use of VHF communications almost completely. As the year progressed further, PIPERACK was

installed to jam night fighter radars.

Having started off at Sculthorpe, in May 1944, shortly after they had begun full scale operations, No 214 Sqn moved to a neighbouring airfield at Oulton. Some of us, the luckier ones, were billeted in the elegant Blickling Hall just outside Aylsham. At Oulton, another unit was formed, No 223 Sqn. They had the same task as my own squadron for which their Liberators were equipped much the same gear as our B-17s. The B-24s were comparatively old, however, and they needed a disproportionate amount of servicing; just before the European war ended they began to be replaced by more Fortresses.

I still remember vividly the night of 5/6 June 1944, a few hours before the D-Day assault on Normandy. Sometimes the B-17s had their own special patrols rather than escorting the bomber stream. This night was such an occasion. Five of our Fortresses, together with a larger force of Lancasters of No 101 Sqn, were tasked to generate, for the benefit of the German early warning radar system, a ghost bomber stream. This required us to fly back and forth for many hours on end from a point south east of Eastbourne to the Somme, penetrating into France to a depth of about 80 miles. On each outbound journey we were to toss out WINDOW bundles as fast as we could go. Our special operators were to jam all communications using AIRBORNE CIGAR. The effects of this operation, with a total of eighty-two ABCs going full blast, ensured that no signals within the jammers' cover would be heard over northern France. An electronic wall existed that night between the north east of our designated line and the south west where 1,000 Allied transport aircraft were on their way to drop paratroops. Inevitably, of course, our ghost stream attracted fighters. Our tail gunner, Eric Phillips, shot down an Me 410.

As to the other jamming units, No 199 Sqn was operating Stirlings and No 171 Sqn Halifaxes, both equipped with MANDREL. The primary role of these two squadrons was to present the German early warning radars with a continuous concealing screen on a line parallel to and some 80 miles from the frontier or the front line. The aim was to ensure that all movements coming from behind the screen remained obscured from the early warning radars. Another tactic employed by these two squadrons was to create a WINDOW spoof in support of the bombing operations. Each spoof would involve, say, twenty-four aircraft in two lines of twelve abreast, 2¼ miles between each aircraft,

the second line 30 miles behind the first. Each aircraft would be throwing out one bundle of WINDOW every 2 seconds which appeared on *Würzburg* as a formation of about 500 aircraft. Needless to say, high standards of navigation and precise timing were demanded for this ploy to succeed.

The force was continually changing tactics in detail in order to remain convincing. As an example of what was termed 'conditioning', a spoof advance on 17/18 August 1944 gave an impression that Kiel was to be the target. Night fighters went up in strength to meet this supposed threat, which came to nothing. The following night the real Main Force was targeted on Bremen and was routed over much the same area: they were totally ignored in the belief that it was just another spoof.

Thus the pieces of the 100 Gp jigsaw came together. While ghost bomber streams emerged from behind a MANDREL screen, the real attack would come up somewhere else, accompanied by escorting Fortresses and Liberators, flying 5,000 feet above the bombers and shielding them with JOSTLE while the bombers themselves dispensed large quantities of WINDOW.

To summarise, the electronic war was being fought with the following devices:

1. MANDREL against the Early Warning *Freya.*
2. WINDOW and (by US aircraft) a jammer called CARPET to confound the *Würzburg* radars used to direct fighters, *Flak* and searchlights.
3. PIPERACK against night fighter AI.
4. First TINSEL, later AIRBORNE CIGAR and finally JOSTLE to disrupt VHF communications.

There is one other activity that should be mentioned, albeit one that was quite ineffective. In the early days of the V2 rockets, it was thought that they perhaps enjoyed some form of radio control. A number of abortive flights were made by the Fortresses with JOSTLE (a variant named BIG BEN JOSTLE) in the hope that we could jam whatever frequency the V2s were being directed on. The penny eventually dropped when we discovered that there was no control; the V2 was purely ballistic. The jamming sorties had been pointless and, sadly, they had incurred some losses.

No 100 Gp was very busy in the last year of the war. The defences

were more and more over-extended as the Germans were forced to retreat. The work of the Group was commented on by General Galland in January 1945 when he said: 'The enemy's jamming operations are blotting out both ground and airborne search equipments.' He might have added, as the other side of the coin, that German aircrew commenting on operations on the Russian front, were saying 'Night fighting was different from the West; the Russians were so backward in radar technology that they had no transmitters on to which we could home.'

As to the degree of success of 100 Gp in that last year of WW II, Sir Arthur Harris' Despatch says this:

> 'No attempt can be made to state figures of the number of bombers saved. It is, however, indisputable that a very considerable success was achieved. A study of the losses suffered by Bomber Command in night attacks on Germany shows an increasing trend until September 1944, with a succession of setbacks which coincide with the adoption of various countermeasures. The introduction of (*many jamming devices*) all brought about sharp declines in the loss rate. Between these times there was a rise which indicated the enemy's recovery as he in time developed antidotes. In September 1944, the gradual disintegration of the enemy defences following the advance of the armies across France and Belgium coincided with the full development of the ECM offensive and the two combined to deal the enemy defences a blow from which they never recovered.'

It has been Dr Price's estimate that the jamming effort saved 1,000 bomber aircraft and thus about 7,000 aircrew. Fortunately for all of us, and the world, broadly speaking one could say that the UK had always been one step ahead in the electronic war. We have every reason to be extremely grateful for the efforts of TRE – the Telecommunications Research Establishment.

Let our erstwhile enemies have the last word:

> General Kammhuber, when asked which of Bomber Command's operations during the war he had thought most highly of, said, 'Their changing electronics tactics which were always setting the *Luftwaffe* Night Fighter Command new

problems to solve.'

> General Galland, who said, 'The combination of the Pathfinders' operations, the activities of No 100 Gp, the British advantage in radar, jamming and WINDOW techniques combined with intelligent attacking tactics, as well as on the other hand the discipline and bravery of the RAF crews, have been remarkable. We had our severe problems in trying to defend Germany in the air.'

That same General Galland featured in a story from the 1970 Wartime Pilots and Observers Association reunion at Winnipeg. Somebody on the Committee of the Association had telephoned Douglas Bader to tell him that it was their intention to invite General Galland. Bader said, 'Look, it's the most extraordinary thing for a Commonwealth Air Training Scheme reunion to invite a German Fighter ace.' There was a stunned silence at the other end of the line and then, 'Well, if it hadn't been for chaps like him, we wouldn't have had a bloody Commonwealth Air Training Scheme'.

Confound? Yes!

100 GROUP - FIGHTER OPERATIONS

Martin Streetly

Martin Streetly is a full-time defence electronics author and journalist who specialises in the history, technology and use of EW with a particular emphasis on airborne applications. He is the Editor of the Jane's Radar & EW Systems *yearbook, the Editor/Compiler of the* Jane's Electronic Mission Aircraft *handbook, the International Correspondent for the* Microwave Journal *and is the author of several books including* Confound & Destroy: 100 Group and the Bomber Support Campaign, The Aircraft of 100 Group, *and a history of airborne electronic warfare.*

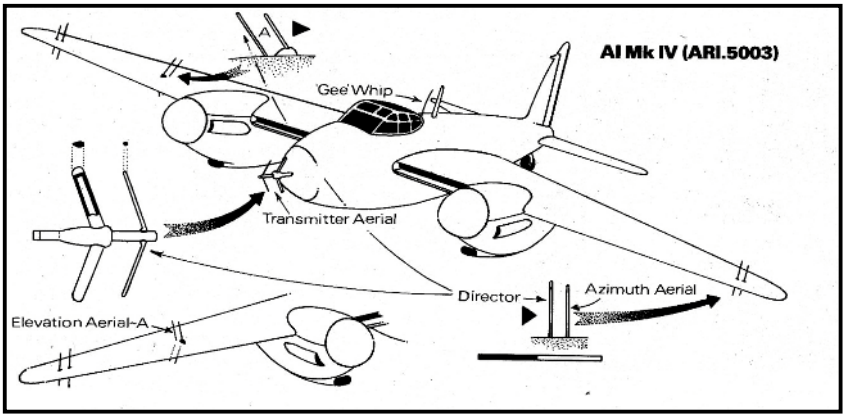
When No 100 Group was formed on 23 November 1943, the idea of supporting Bomber Command's night offensive against Germany with fighters was already well established. The earliest intruder operations against the *Luftwaffe's* night fighter bases involved both Blenheim and Havoc squadrons and in October 1942, Arthur Harris had suggested that it might be 'profitable' to mix some Mosquito fighters with the bomber streams. The first such Mosquito sortie was flown by No 605 Sqn on the night of 11/12 June 1943 and by the time No 100 Gp had formed, Nos 25, 264, 410 and 605 Sqns had all been involved in FLOWER (intruder sorties against night fighter airfields) and/or MAHMOUD (offensive patrols of known *Luftwaffe* night fighter assembly points) bomber support operations.

Useful as these might have been, No 141 Sqn's involvement with SERRATE represents the most significant precursor to No 100 Gp's fighter operations. During the early part of 1943, this squadron had received a number of Beaufighter VIf heavy fighters that were equipped with AI Mk IV radar, the GEE radio navigation aid and the SERRATE homing device. Designed to detect signals from the German FuG 202/212 airborne intercept radar, SERRATE generated a 'fishbone' display that allowed the Beaufighter's navigator to steer his pilot towards a German night fighter that was using his radar to search for bombers. In its Mk II variant, SERRATE had a maximum range of 50 miles when the transmission source was pointing towards the

receiver and up to 10 miles when it was pointing away from it. The first SERRATE sortie was flown on 14/15 June 1943 and by the night of 6/7 September, No 141 Sqn had despatched 233 such sorties, losing three of its own aircraft and reporting a total of 1180 SERRATE contacts. Of these 490 were 'held and pursued', 108 being converted into radar 'holds' and thirty-three into 'visuals'. Twenty resulted in combats, with the squadron claiming thirteen enemy aircraft destroyed, one probably destroyed and four damaged.

This first serial of SERRATE operations was, like the curate's egg, 'good in parts, not in others'. On the one hand, the SERRATE homer had proved itself as an operational system while on the other, AI Mk IV had shown itself to be far from ideal for the bomber support task, as had the Beaufighter in terms of range. It is important to this story to understand why the use of AI Mk IV was problematic. AI Mk IV was a metric radar that operated within the 190-195 MHz frequency range and was designed for use within a Ground Controlled Interception (GCI) system with combat taking place at medium to high altitudes. At its optimum altitude of 18,000 ft, it had maximum and minimum range figures of 3.5 miles and 400 feet respectively. As such, it was prone to ground returns and would almost certainly lose targets in ground clutter at low altitudes. Equally, its relatively small field of view allowed violently manoeuvring targets to escape relatively easily; it could 'squint' if its aerials were knocked, maladjusted or became damp and it was very susceptible to jamming, particularly that generated by WINDOW. With regard to this latter problem, interference over enemy territory became so bad that by the late summer of 1944, the RAF was convinced that the Germans were actively jamming AI Mk IV and re-tuned all of 100 Gp's sets to work on a spot frequency of 188 MHz to overcome this. Sadly, this measure did not help – because the Germans had not actually been jamming.

The solution to the range problem appeared to have been solved when No 141 Sqn became the first fighter squadron to be inducted into No 100 Gp on 3 December 1943. While operations began (on 16/17 December) using its trusty Beaufighters, the squadron began to receive Mosquito NF IIs as replacements almost as soon as it joined Bomber Command. On paper, this superb all-rounder should have been a quantum leap forward in capability but in reality, the change was a step backwards as the airframes received were for the most part



old and, more alarmingly, fitted with worn out engines. This situation was tolerated until February 1944 when No 100 Gp began a major programme to overhaul and re-engine (with Merlin 22s) its entire fleet of Mosquitos.

Four days after No 141 Sqn's induction, No 169 Sqn was drafted in as the Group's second SERRATE/AI Mk IV Mosquito NF II unit. Now stationed at Little Snoring, this unit began bomber support operations on 20/21 January 1944, claiming its first victory ten days later. Another of 13 Gp's night fighter squadrons, No 239 Sqn, became No 100 Gp's third SERRATE unit when it moved into West Raynham on 9 December 1943. This unit received its first operational Mosquito NF II on 11 January, despatched its first operational bomber support sortie on the same night as No 169 Sqn and claimed its first bomber support victory eight nights later.

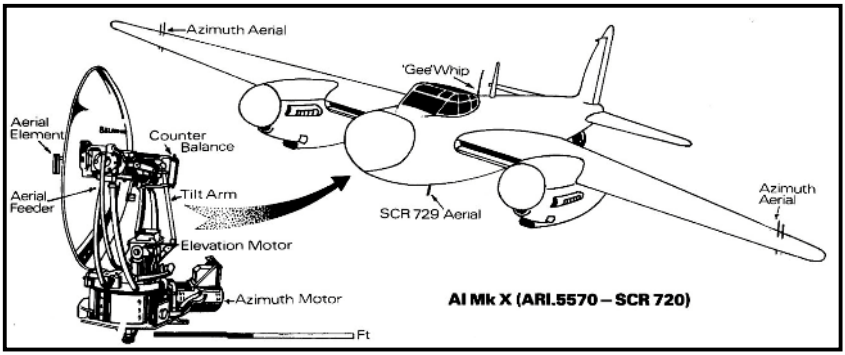
100 Gp's fourth fighter unit, No 515 Sqn, joined the Group on 15 December 1943 as, of all things, a Beaufighter-equipped MANDREL jamming unit! Originally formed in October 1942 to operate MOONSHINE, MANDREL and CARPET jammers, No 515 Sqn had become non-operational in July 1943 and had languished at Hunsdon until its transfer to No 100 Gp and Little Snoring during the following December. Subsequent to a quite prolonged debate, it was decided to re-equip the unit with Mosquito FB VIs for bomber support intruder work. To prepare it for its new role, No 515 Sqn began to receive Mosquito NF IIs for type conversion during February 1944 and flew

its first bomber support sortie (in an aircraft borrowed from No 605 Sqn) on the night of 5 March. Two months later, the unit began to receive its long awaited Mosquito FB VIs.

As might be imagined, No 100 Gp's fighters were not an immediate success. Aside from the already noted airframe/engine problems (which were at least manageable by the end of March 1944), continued use of the metric AI Mk IV radar was a real problem. As previously noted, AI Mk IV was far from ideal for the cut and thrust of bomber support missions over occupied Europe. From an operational standpoint, the already available AI Mk VIII centimetric radar would have made a much better bomber support tool, offering, as it did, longer range (5.5 to 6.5 miles), better performance at lower altitudes (effectively, 5,000 feet), better resistance to jamming and the ability to follow manoeuvring targets (±1.3º in azimuth with the target dead ahead). Despite all of these advantages, it was not until the disaster over Nuremberg on the night of 30/31 March that the powers that be relented and allowed fighters with centimetric airborne intercept radars to be used over enemy territory.

While the foregoing might have seemed quite enough bad news, June-July 1944 saw No 100 Gp's fighter arm receive another major setback when the *Luftwaffe* made the switch from the FuG 202/212 family of airborne intercept radars to the FuG 220 set. FuG 220 operated on a different frequency to the earlier equipment and, as a result, SERRATE contacts all but dried up. Indeed, things were so bad that No 141 Sqn could report only seven such contacts for the whole of July 1944. Once it was realised what was going on, considerable effort was put into developing a FuG 220 SERRATE and it is known that No 100 Gp fielded Mks IV, IVA and VI variants to replace its original SERRATE IIs before the war's end. Of these, SERRATE IV is thought to have been a FuG 220 homer for use aboard the Mosquito FB VI, with the Mk IVA sub-variant being applicable to No 169 Sqn's Mosquito NF XIX aircraft (of which more later). SERRATE VI was introduced during January 1945 and was the first to give an audio, rather than a visual, indication of target direction.

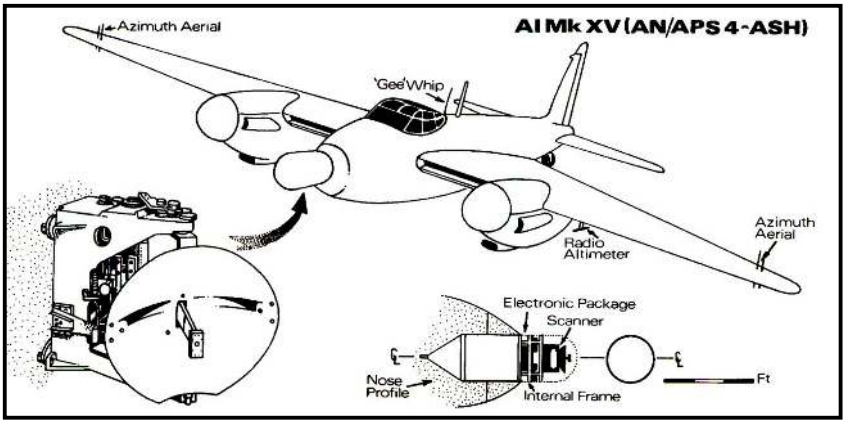
While the spring and summer of 1944 were not a particularly good time for No 100 Gp's fighter arm, all was not doom and gloom. On 1 May, the Group's fighter establishment was reinforced by the arrival of No 85 Sqn, followed six days later by that of No 157 Sqn. Both



units were based at Swannington and both were equipped with Mosquito NF XIXs fitted with the AI Mk X centimetric radar. Seen by many as the ultimate airborne intercept radar of WW II, the American-developed AI Mk X offered a maximum detection range of 6 to 10 miles when operated at heights of above 5,000 feet and 2.5 to 3 miles when being flown at 2500 feet over land. Minimum range was between 300 and 500 feet and the radar could track target movements of ±5º anywhere within its scan pattern.

The two centimetric squadrons were also equipped with the MONICA tail warning radar which, in the bomber support context, was used in the 'Whiting Manoeuvre'. Here, if a bogey was detected astern, it was allowed to approach within 5,000 feet whereupon the pilot would swing his aircraft through 360º in an attempt to get behind the potential target. If successful, use of the 'Whiting Manoeuvre' would reacquire the hostile on radar and allow the navigator to bring his pilot within range for a visual identification. MONICA was widely used throughout No 100 Gp's fighter arm and the Group is thought to have fielded the Mks IIIE (100 produced), IV (specifically for AI Mk X equipped aircraft), VI (96 produced) and VIII (again for AI Mk X aircraft) variants.

Elsewhere in the Group, June 1944 saw the induction of the Mosquito FB VI-equipped No 23 Sqn who began bomber support operations from Little Snoring on 5/6 July. The Group's three Mosquito NF II units (Nos 141, 169 and 239 Sqns) also received a leg up as they too were progressively re-equipped with Mosquito VIs during 1944. No 141 Sqn made the switch in June/July and despatched



its first FB VI sortie on 16/17 August. No 169 Sqn completed its conversion in mid-July, with No 239 Sqn phasing out its last NF IIs during September. All three units initially flew aircraft equipped with SERRATE/AI Mk IV, with three others (Nos 23, 141 and 515 Sqns) switching to an FB VI/centimetric AI Mk XV combination between September and December 1944. Better known as ASH (Air-to-Surface Homing), AI Mk XV started life as a maritime search radar and, as applied to 100 Gp aircraft, it took the form of a five-foot long 'bomb' that was mounted in the aircraft's nose in place of the Mosquito's four forward-firing machine guns. In the hands of a skilled operator, AI Mk XV could detect targets at a maximum range of 3.75 miles and track them down to a minimum range of 600 feet. The set could also produce an 'H2S-like' ground picture that was most useful for navigation.

Of the cited units, No 23 Sqn's aircraft were fitted with ASH, GEE, MONICA and the PERFECTOS IB homer (see below) and despatched its first operational low-level AI Mk XV sortie during December 1944. No 141 Sqn also flew its first ASH sortie during December and continued to use it until the following March when it was stood down to re-equip with the Mosquito NF 30. For its part, No 515 Sqn despatched its first AI Mk XV sortie during January 1945, at which time, it was intended to team its ASH radars with a MONICA tail warner. In the event, this proposal came to nothing.

The Group's remaining Mosquito FB VI unit, No 169 Sqn, began

to supplement its SERRATE equipment with the PERFECTOS homer during November 1944. Designed to trigger the German FuG 25A *Erstling* IFF transponder and give a visual bearing on the signal, PERFECTOS appeared in Mk I, IB and II versions. PERFECTOS I used a modified AI Mk VIII display and in service (with No 169 Sqn) was found to have unsatisfactory direction-finding properties. PERFECTOS IB was designed for use aboard ASH aircraft and in all, No 100 Gp received forty examples of both types of equipment. PERFECTOS II was designed for use with AI Mk X aircraft and the Group is reported as having received forty-eight sets of this type. Operationally, No 169 Sqn flew its first PERFECTOS sortie on 27 November and continued to use the device until 31 December.

Looking again at the Group's original pair of centimetric units, Nos 85 and 157 Sqns had both just begun to get used to their new role when they were pulled off full-time bomber support work to join the anti-Diver (the V1 flying bomb) campaign. No 85 Sqn flew its first anti-Diver sortie on 3/4 July 1944 and continued V1 hunting until its returned to Swannington at the end of August. For its part, No 157 Sqn decamped to West Malling on 29 June and flew anti-Diver patrols until 29 August. During this period, the two squadrons claimed at least sixty-three V1s (thirty going to No 85 Sqn and thirty-three to No 157 Sqn) while at the same time, flying a total of sixty-one (twenty-eight by No 85 Sqn and thirty-three by No 157 Sqn) bomber support sorties. Thereafter, the two squadrons flew both high- and low-level bomber support sorties until their conversion to AI Mk X-equipped Mosquito NF 30s during November. A month earlier, No 157 Sqn had switched exclusively to high level patrols, a move that was followed by No 85 Sqn once it had got into its stride with the Mosquito 30.

While eventually to become a superb fighting machine, 100 Gp's first encounter with the Mosquito 30 had had its problems. No 85 Sqn had, for instance, suffered a series of burnt out exhaust shrouds, unreliable ignition systems and oxygen supplies that iced up at altitude. In terms of equipment, No 157 Sqn's new aircraft were equipped with AI Mk X and the SERRATE IV homer (first used by the unit during January 1945) while No 85 Sqn's Mosquito NF 30s fielded AI Mk X and a variant of PERFECTOS.

November/December 1944 also saw No 100 Gp introduce the 'clock patrol' tactic. This idea came about via the success of AI Mk X

patrols around Main Force targets and consisted of a number of fighters being given a specific ‘beat’ on a ‘clock face’ around the particular target and some six to ten miles from it. Each aircraft then flew a race track pattern towards and away from the target during and after the raid in order to catch the enemy both over the target and on their way to or from it.

As the bomber campaign against Germany reached its climax, No 100 Gp’s fighters began to undertake roles other than the harrying of the *Luftwaffe’s Nachtjagd*. In no particular order, No 141 Sqn began to fly GEE-guided spoof bombing raids to draw off enemy fighters during November 1944 and, once it had re-quipped with the Mosquito 30, became involved in Operation FIREBASH. FIREBASH is supposed to have grown out of a chance Anglo-American train conversation about napalm and its impact on targets such as airfields. After some rather hair-raising experimentation, No 141 Sqn flew its first FIREBASH sortie on 18 April 1945, dropping some 1400 gallons of the incendiary agent on Neubiburg airfield. April also saw No 515 Sqn take on the role of Master Bomber for No 100 Gp’s spoof raids that were being flown exclusively by its fighters and eventually came to involve aircraft from Nos 23, 169 and 239 Sqns as well as those from Nos 141 and 515 Sqns.

With the war against Germany drawing to a close, No 100 Gp’s fighter arm embarked on a final round of re-equipment. No 169 Sqn began swapping its Mosquito VIs for AI Mk X (and in some cases, FuG 220/SERRATE)-equipped Mosquito XIXs on 14 January 1945, while No 239 Sqn had received its first Mosquito 30 during the preceding December.

Throughout the campaign, the operational squadrons had been supported by the Bomber Support Development Unit (BSDU). Formed at Foulsham in April 1944, the BSDU transferred to Swanton Morley during the following December where, as its name suggests, it acted as No 100 Gp’s trials and development unit. For fighter work, it maintained a flight of nine assorted Mosquitos with which to carry out operational evaluation of the various homing devices, radars and other electronics used by, or proposed for, the Group’s aircraft. Additionally, the BSDU acted as the host for visiting test aircraft and provided similar test and development services for the Group’s ‘heavy’ (jamming) squadrons. In the latter context it operated an

esoteric collection of aircraft including Stirling, Halifax and Liberator heavy bombers, a Beaufighter VI and four clipped-wing Spitfire VBs.

It is also worth noting that from late August 1944, No 100 Gp's Mosquitos were supplemented by aircraft from the Air Defence of Great Britain, as RAF Fighter Command had by that time become known. The units involved included Nos 151, 307 and 406 Sqns with Mosquito NF 30s and FB VIs while Mosquito NF XIIs and XIIIs of No 256 Sqn providing similar support in the Italian theatre.

As was the case with 100 Gp's jamming squadrons, its fighter arm did not long survive the cessation of hostilities in Europe. In reverse chronological order, No 23 Sqn was the last to go, disbanding at Little Snoring on 25 September 1945, No 141 Sqn having gone on 7 September. No 157 Sqn disbanded at Swannington on 16 August, No 169 Sqn having closed down at Great Massingham on 10 August. No 239 Sqn had lasted only until 1 July with No 515 Sqn going even earlier on 10 June.

During the eighteen months of No 100 Gp's existence, its fighter units flew nearly 8,000 offensive sorties, lost a total of sixty-nine aircraft and claimed 258 enemy aircraft destroyed in air-to-air combat, with a further eighteen being destroyed on the ground. In terms of effectiveness, there is no doubt that the Group's fighter operations were hampered by a string of problems that included the need to rework and re-engine virtually every Mosquito NF II supplied to it; the unsuitability of AI Mk IV for bomber support work; the loss of the SERRATE advantage when the Luftwaffe switched from FuG 202/212 to the FuG 220 radar and the not insubstantial difficulties encountered during the introduction of the Mosquito 30.

On the plus side there is equally little doubt that the appearance of 100 Gp's Mosquito fighter-bombers combined with increasingly effective electronic jamming and very good intelligence made life extremely difficult for the *Luftwaffe's* night fighter arm. Despite this, the *Luftwaffe's* '*Experten*' continued to be able to shoot down bombers right up to the surrender in May 1945. Sadly for them, what they were unable to do consistently was to inflict the 10% plus loss rate needed to outstrip Bomber Command's ability to replace its manpower losses. In the end, the German night fighter force went into terminal decline, not because of the number of aircraft it lost in combat with No 100 Gp, but because of the fuel famine created by the

mid-1944 Anglo-American oil campaign and its inability to replace lost aircrew with effective replacements. In such a scenario, the contribution of No 100 Gp and its fighters was not so much the winning of the night battle over Germany as preventing the RAF from losing it before a whole range of factors reduced the *Luftwaffe* to a state from which it could not recover.

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D-DAY AND AFTER

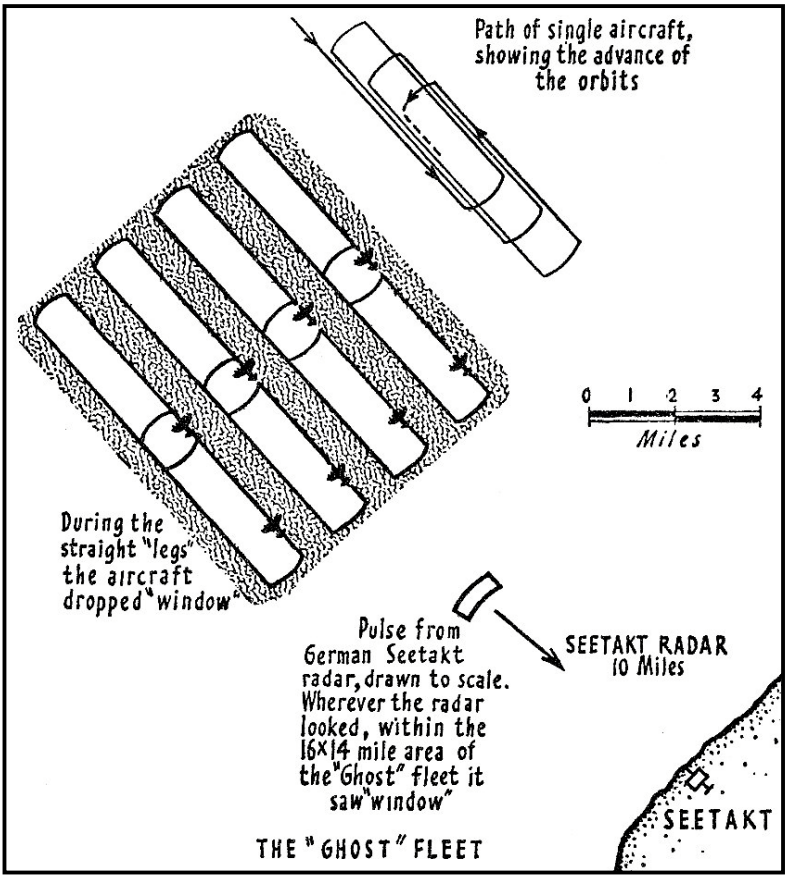
Dr Alfred Price

For biographical note, see page 15.

AVM Furner has already touched on the formation and work of No 100 Gp, and the part his squadron played during the Normandy invasion. My intention now is to concentrate on a couple of operations involving the Group, and use the time available to me to describe these in some detail.

First, I should like to take us back to the Normandy invasion. It was the greatest seaborne invasion in history, and a massive countermeasures operation was set in motion to neutralise the chain of radar stations built into the German Atlantic Wall. Intelligence was the key, and ground direction-finding stations in southern England methodically pinpointed each of the radar stations. Then fighter-bombers flew some 2,000 sorties against these targets. Finally, on the night of the invasion, an enormously powerful barrage of shipborne and airborne jamming was turned on the surviving radars. At the same time twenty-nine aircraft of Bomber Command flew racetracks along the line of the Somme River jamming on the German fighter control frequencies; their aim was to prevent German night fighters to the west of that line receiving instructions from their control stations to the east of it.

While the invading fleets headed for their landing areas on the coast of Normandy, two 'ghost' fleets headed towards France: Operation GLIMMER against Boulogne, and Operation TAXABLE against Le Havre. In fact these 'fleets' comprised no full-sized ships; the illusion was created by aircraft flying carefully planned orbits and releasing large quantities of WINDOW metal foil. The TAXABLE 'ghost' fleet involved eight Lancasters of No 617 Sqn, while GLIMMER involved six Stirlings of No 218 Sqn. The aircraft were divided into two waves, with 2 miles between individual aircraft and 8 miles between each wave. Flying in procedural formation out of sight of each other, the two waves of aircraft flew a series of oblong patterns measuring 8 miles long and 2 miles wide. During the long legs of the orbits, when the aircraft were flying towards or away from the coast, they released one bundle of WINDOW every five seconds; that is to say, one bundle per 400 yards flown. In this way, they laid out a vast field of WINDOW measuring 16



miles by 14 miles, with no gaps larger than the discrimination limits of the German *Seetakt* radar. Each orbit took seven minutes and at the end of each, the formation moved forwards 1 mile. The whole vast field of WINDOW thus appeared to move towards the coast of France at 8½ knots - realistically like an actual invasion fleet.

Beneath the falling WINDOW , nine motor launches cruised towards Le Havre and five towards Boulogne. Each boat towed a float, above which swung a modified barrage balloon. Code-named 'Filberts', these were 29-foot-long naval balloons with a 9-foot-diameter radar reflector built inside its envelope. 'Filbert' produced a radar echo similar to that from a 10,000-ton ship. In addition, four of the motor launches carried

the MOONSHINE equipment, a repeater which picked up pulses from the German *Hohentwiel* ASV radar, amplified them and re-transmitted them.

During the hours that followed, the MOONSHINE boat heading for Boulogne picked up signals from eight separate airborne radars, and returned those signals 'with interest'. A MOONSHINE boat with the TAXABLE ghost fleet returned signals to one enemy airborne radar.

To add further realism to the operation, other aircraft flew near the WINDOW droppers radiating noise jamming. But the positions of these aircraft had been carefully chosen so that German radars watching the area would just be able to see the 'ghost' fleet through chinks in the jamming.

When the two ghost 'fleets' arrived at their stop lines, some ten miles off the coast of France, the boats' crews cast off their 'Filbert' floats. Several of the boats then laid a smoke-screen, at the same time broadcasting over loud-speakers recordings of the squeals, rattles and splashes germane to a number of large ships dropping anchor. Their task of deception complete, the boats then withdrew at maximum speed.

One particular worry that had faced the planners of the 'ghost' fleet operation was this: what would happen if the Germans sent reconnaissance aircraft into the area and their crews saw that there was no invasion fleet? Dr (later Sir) Robert Cockburn, the man behind the 'ghost' fleet idea, told me his reply when asked this question. He said one should try to imagine the scene: a frightened under-trained young conscript radar operator sees the 'ghost' fleet on his screen and reports it to his headquarters as the long-expected enemy invasion force; so do his colleagues at radars on either side. Soon their plot is shown as a nice broad arrow on the situation map at headquarters. The 'ghost' fleet is now a military fact. If aircraft were then to fly into the area and report it clear of ships, would their reports be believed? Probably not. The operation was to take place at night and the crews might not be where they thought they were. Once a broad arrow representing an enemy attack appeared on the situation map at headquarters, Cockburn believed, it would take a lot to remove it.

From German records, we know that Cockburn's prediction was correct. There is clear evidence that the German radar operators observed and reported the approach of the GLIMMER 'fleet', and a full-scale invasion alert was issued for the Calais/Dunkirk area. A telephone

message logged at 1015 hours on the morning of D-Day at the *Luftwaffe* High Command contains a clear reference to Operation GLIMMER. After describing the landings in Normandy in some detail, the report stated:

> 'According to reports from reconnaissance aircraft, ships were assembling during the morning off Dieppe and Le Tréport. The reports of ships assembling off Calais and Dunkirk at 0400 hours have not, so far, been confirmed.'

The German commander in the area dispatched reconnaissance aircraft and patrol boats to scour the seas off the coast between Dunkirk and Boulogne for the suspected invasion force. But it took a disconcertingly long time to prove conclusively that the enemy was not in the area where he was thought to be.

The level of confusion on the night of the invasion was so great that only one German radar passed plots on the real invading ships, and those went unheeded. The first evidence of a seaborne invasion to be believed, came not from radar but from observers on the eastern side of the Cherbourg Peninsula where the rumble of the ships' engines could clearly be heard. No conceivable countermeasures effort could have achieved more. It is a vivid indication of what can be achieved if massive countermeasures resources are brought to bear for a single, decisive operation.

Without the successful anti-radar attacks, and those spoofing and jamming efforts, the fight to secure the beach head in Normandy in June 1944 would almost certainly have been far bloodier than was the case.

* * *

AVM Furner has already described the types of operation flown by No 100 Gp's specialised jamming aircraft. My intention now is to cover a typical Bomber Command raid of the late-war period, to show how No 100 Gp's effort dovetailed with those of the rest of the force.

On the night of 20/21 March 1945, Bomber Command's targets were the oil refineries at Böhlen near Leipzig and at Hemmingstedt near Hamburg. The first action by Bomber Command that night was a large-scale nuisance raid on Berlin by thirty-five Mosquitos, beginning soon after 21.00 hours. Flying fast and high, the Mosquitos required no support from No 100 Gp's jamming force.

Next, night fighter Mosquitos of Nos 23 and 515 Sqns, both of No 100 Gp, fanned out over Germany making for the night fighter bases

thought likely to become active against the raiders. When the intruders reached their objectives they orbited, waiting to pounce on any aircraft seen taking off or landing.

Soon after 01.00 hours the Böhlen raiding force crossed the French coast and headed south east towards southern Germany. Also heading across France, on a track almost parallel to that of the Böhlen attack force but a little further south, was a feint attack by sixty-four Lancasters and Halifaxes. These aircraft came from operational conversion units, and were flown by crews in the final stages of their training.

No 100 Gp's electronic trickery began at 02.05 hours on the morning of the 21st. Established in a line 80 miles long over France and just inside Allied-held territory, seven pairs of Halifaxes of Nos 171 and 199 Sqns began transmitting with MANDREL to jam the German early warning radars and conceal the approach of the Böhlen attack force.

Running across France outside the cover of the MANDREL screen, the feint attack flown by trainee crews continued heading east in full view of the German radars. Defending night fighters moved into position to block the threatened incursion but, just short of the German border, the bombers turned around and went home.

A few minutes later the two Böhlen attack forces burst through the MANDREL jamming screen and crossed the Rhine into German-held territory. Twenty miles ahead of the bombers flew four Halifaxes of No 171 Sqn and seven Liberators of No 223 Sqn, dropping WINDOW to conceal the strength of the attacking forces. Flying ahead and on the flanks of each of the bomber streams, thirty-three Mosquito night fighters of No 100 Gp played a deadly game of hide and seek with their German counterparts.

Shortly before 03.00 hours, a Mosquito of No 85 Sqn picked up IFF identification signals on its PERFECTOS homing equipment. After a 10-minute chase the crew made visual contact with a Messerschmitt 110 night fighter and shot it down.

That night No 100 Gp's spoof tactics were successful. The German fighter controller seriously underestimated the strength of the two raiding forces heading for Böhlen. He had assessed them at about thirty aircraft each, and thought that they might even be WINDOW feints. Only after the raiders had crossed the Rhine and reports began

to come in from ground observers did it become clear that the southerly force was far larger than had been thought: no amount of electronic jamming could conceal the roar of 800 aircraft engines.

By now eighty-nine German night fighters were airborne and orbiting over holding beacons, waiting for their controller to clarify the air situation and direct them against the bombers.

The intention of the spoof operation that night was to create the impression that the raiders' objective was Kassel. The main raiding force headed towards that city, and the German controller ordered almost all of his night fighters to head for the radio beacons around Kassel. He ordered the rest of his force, a single *Gruppe* of Ju 88s, to cover Frankfurt. Soon afterwards he received reports that Kassel was under imminent threat of attack, as Pathfinder flares blossomed overhead and a few bombs detonated.

German night fighters moved on the city. But this was no full-scale onslaught, merely a feint by Mosquito bombers backed by No 100 Gp Liberators and Halifaxes dropping WINDOW. During the course of this spoof, a German night fighter shot down a Liberator of No 233 Sqn.

Meanwhile, some 25 miles south of Kassel, the main raiding force had turned away from that city and was heading for Böhlen. The Liberator crew's sacrifice was not in vain, however, for the feint against Kassel kept most of the German night fighters orbiting uselessly in that area for nearly half an hour. Not until 03.00 hours did the German fighter controller realise that he had been tricked. He ordered his force to head east in pursuit of the raiders, and six minutes later gave the probable target as Leipzig, the city nearest Böhlen. By then, the vanguard of the raiding force was within 30 miles of the target.

Still No 100 Gp had not exhausted its repertoire of tricks. Just short of Böhlen six Fortresses and Halifaxes broke away from the main raiding force and ran a WINDOW trail to the important oil refinery complex at Leuna, about 20 miles to the north-west. Twelve Lancaster bombers accompanied the jamming aircraft to give substance to the spoof. When the feint attackers arrived over the complex, they dropped target markers and bombs. Leuna lay directly in the path of the German night fighters heading for Leipzig, and the spoof attack delayed their arrival at the real target still further. One Lancaster crew

paid the supreme price for those precious minutes of additional delay.

The 211 Lancasters assigned to the Böhlen attack reached their objective and carried out a concentrated eleven-minute attack. The five Fortresses and the Liberator that had provided jamming support along the route to the target now orbited over the refinery throughout the period of the attack. Not until 04.10 hours, as the last raiders were leaving Böhlen, did the first German night fighters arrive in the area. Their radar operators encountered severe jamming and they had great difficulty in picking out their prey amongst the WINDOW returns.

To add to the defenders' confusion, as the Böhlen attack force withdrew to the west, the No 100 Gp Halifaxes that had operated the MANDREL screen had a further part to play. They now ran a further WINDOW spoof 'attack' on Frankfurt, and dropped target markers to simulate the opening of a large-scale attack on that city.

As the Böhlen attack force crossed the Rhine to safety, Bomber Command's operations for the night were only half-complete. While the defenders' attention had been concentrated over central Germany, the raiding force of 166 Lancasters bound for Hemmingstedt ran in at low altitude maintaining radio silence. Shortly before reaching their target the bombers rose above the radar horizon and began climbing to their attack altitude of 15,000 feet. Each aircraft released large amounts of WINDOW , to give the impression on radar that this was yet another feint attack.

At 04.23 hours the attack on the refinery began, supported by jamming from a Fortress and a Liberator of No 100 Gp. Because of low altitude approach and the clever use of WINDOW , the German raid-tracking organisation failed to appreciate the strength of this force. The bombers were on their way home before the first radar plots on 'weak formations' were reported in the target area. Night fighters were scrambled to engage the force but there were few interceptions and only one bomber was shot down.

That night the oil refineries at Böhlen and Hemmingstedt were both hit hard, and neither resumed production before the war ended. The night's action cost Bomber Command thirteen aircraft, including a Liberator and a Fortress of No 100 Gp. Eight of the losses were attributed to attacks from night fighters and one to *Flak*. Two bombers were lost in a mid-air collision, and the cause of the remaining two losses could not be established.

No 100 Gp Mosquitos had several skirmishes with German night fighters, but they claimed only two of the latter shot down. The bombers' gunners claimed the destruction of two more enemy night fighters. German records indicate that the *Luftwaffe* actually lost seven night fighters that night. The fates of the other three aircraft will probably never be known but it is not difficult to speculate: a tired pilot, trying to land quickly on a dimly-lit airfield patrolled by Mosquitos, might misjudge his approach and crash; a crew flying at low altitude to avoid being intercepted by a Mosquito might run into a hillside; a night fighter crew would switch off the IFF equipment to avoid betraying their position on PERFECTOS, and be shot down by 'friendly' anti-aircraft guns. Such losses, which were frequent, were the result of No 100 Gp's efforts as surely as were those aircraft shot down by its night fighters. By this stage of the war the Group's Mosquitos had became the bane of the German night fighter crews' existence.

The value of the jamming support given to the RAF's strategic bomber force is impossible to assess accurately; because it is impossible to prove a negative; one cannot say for certain which bombers would have been shot down and which would have survived if there had been no jamming. But there is reason to believe that, during the course of the war, the jamming and other forms of electronic protection saved the Royal Air Force about a thousand heavy bombers and their crews.

MORNING DISCUSSION PERIOD

Wg Cdr Colin Cummings. It has been said that, at times, the special operators carried by No 101 Sqn used to speak to the German night fighters in order to confuse them. Does anyone know whether there is any truth in those stories?

Dr Price. I do not believe that there is any truth in this. The equipment did not lend itself to broadcasting messages; it was just a noise jammer. Some spoofing was done from ground stations in the UK but it was (and still is) very difficult to do this successfully. The problem is that you have to concoct an order that sounds authentic, so that enemy aircrews will comply without having their suspicions aroused, while being at the same time sufficiently misleading to confer some tactical advantage on your own crews. This was a very difficult trick to pull off convincingly, even from a ground station, and even when it was done the benefits did not last for very long. I am quite certain that it was never done from the air.

Wg Cdr Dick Turpin. Much later on, No 360 Sqn's Canberra crews used to indulge in the odd bit of comms spoofing but this was really mainly only for their own entertainment. Apart from introducing some confusing chatter on the frequency it had little, if any, training value, and, as Dr Price has indicated, if you take into account such factors as language, codewords, specific procedures and the like it would be virtually impossible to do it convincingly in combat. You would be much better off just blatting away with a powerful noise jammer.

Walter Blanchard. Dr Price, in your first talk you mentioned the inadvisability of relying on the notional accuracy of beam laying as an indication of its final accuracy over the target. There is a factor here that is often overlooked - the geodetic problem which is, to put it crudely, the misalignment of British- and German-based latitude and longitude. Long after the war, in connection with North Sea oil exploration in the 1970s, I was involved in measuring this sort of discrepancy. There were differences of as much as 500 metres between British, Danish and Norwegian latitude and longitude and about 150 metres between British and French. During the war years it was suspected that errors of this nature existed, but there was, of course, no way of measuring them at the time and the precision that

was eventually achieved depended upon the use of satellites.

So, I harbour considerable reservations when I hear claims for a beam being projected across this country from Germany having a theoretical accuracy of a few feet. Similarly, the accuracy of some of our own navaids, GEE and OBOE for instance, was said to be accurate to within 10 or 20 metres over Germany. I doubt that this was actually the case, although I believe that, in the case of OBOE, we did go to the trouble of putting markers down and then getting spies to go out to see where they had actually fallen in order to make corrections, but I do not think that the Germans ever did that.

Peter Hearne. I was struck by a comparison between a point raised in Mr Streetly's paper and a chapter in R V Jones' book, *Most Secret War,* regarding the vulnerability of Bomber Command's aircraft to German night fighters homing on their transmissions. This would possibly have involved IFF and the problem was certainly present in the context of H2S and MONICA. Jones recalls that he had a conversation with a German scientist who said that they were very surprised at how lax Bomber Command's discipline was, or perhaps how unguarded they were; either way, it seems that the Germans were certainly planning to exploit this weakness.

I wondered whether there was any sort of read-across between our own night fighter's use of SERRATE and PERFECTOS and our related efforts to protect Bomber Command's aircraft. In that connection someone has written, (it may have been Dr Price) that the one person who correctly predicted that D-Day was about to happen, was a German radio operator on the listening watch in Holland who detected an enormous amount of tuning pulses from RAF aircraft on the night of 5 June and deduced that the invasion might take place on the following day. Happily, his message was disregarded.

Martin Streetly. I would certainly say that by 1945 the German tracking organisation was relying as much on passive detection as it was on active radar. They were certainly capable of picking up test transmissions of H2S from Norfolk and I would also endorse what Dr Price has said about the forecasting of D-Day. Interestingly, there was another instance of vital information being similarly discarded. In 1942 the *Luftwaffe* was using a captured British ASV Mk 2 radar fitted in a Heinkel 111 to look for British ships and they discovered

the convoy that was about to mount the invasion of North West Africa. The crew duly reported their discovery but, in the end, the German High Command decided that it was just another convoy bound for Malta. That aside, I think that there can be little doubt that the Germans were very successful in tracking British radar emissions, just as we were. The moral of the story, of course, is that COMSEC – communications security – and that means the control of *all* emissions, is a vital component of electronic warfare. This was, perhaps, not as well understood during WW II as it is today, but even so, the American forces experienced major problems with it as late as DESERT STORM.

Dr Alfred Price. I would entirely agree that the Germans did become quite expert at homing on our aircraft. They specifically developed their *Naxos* device to home onto H2S signals and they certainly got a lot of mileage out of that. From the German point of view, of course, the first aircraft to be equipped with H2S were the Pathfinders and the Germans always regarded these aircraft as prime targets, the point being that the Pathfinders would be leading the stream so, if you could find them, you could find the lot. *Naxos* was initially introduced as a ground tracking station but the Germans later developed a very handy airborne version.

The other main source of tracking signals was the British MONICA tail warning radar for which the Germans developed a specific homer called *Flensburg*. The discovery of this device came as a considerable shock to the British. An intact example fell into the RAF's hands when the Holland-based crew of a *Flensburg*-equipped Ju 88 night fighter flew a reciprocal compass course; instead of going home on leave to Germany, they ended up at Woodbridge in Suffolk! Once it had worked out what *Flensburg* was for, of course, the RAF promptly withdrew MONICA from its bomber force. That was how serious it was. In other words, MONICA's unforeseen function as a homing beacon had more than offset any advantage that it may have been conferring as a tail-warning device, which is, I think, quite remarkable.

Tony Richardson. In the context of the withdrawal of the MONICA tail-warner, this did not leave us entirely blind, as the H2S radar had an operating mode known as FISHPOOL which enabled the operator

to see other aircraft approaching from below. Its maximum range was restricted to the height at which the bomber was flying, about 3 miles, but this still provided time to focus the attention of the gunners in the appropriate direction.

Streetly. I think it worth adding that, once we had realised just how lethal MONICA had been to the bombers and had withdrawn it, it continued to fulfil a worthwhile function in 100 Gp's fighters, primarily in connection with the Whiting Manoeuvre.

Richard Bateson. Mr Streetly referred to the use of a captured ASH set in the Mediterranean. At the end of July 1944, we were aware, through ULTRA, that a Ju 188 of KG200 had been flown experimentally over a convoy at night using captured IFF. We also knew that the German experimental signals establishment at Köthen was collecting IFF equipment from shot down aircraft and that by then they had acquired twenty-five sets. General Pelz[1] sent some of these sets to 7. *Staffel* of KG26, a unit which specialised in night attacks on convoys. I wonder whether anyone has heard of the *Luftwaffe's* making use of any other captured allied equipment.

Streetly. Yes, there was the unit to which I have already referred that was established to use British ASV radar; if I remember rightly, it was *Aufkl.Gr* 123, the reconnaissance unit based in Italy. Slightly off the point, but it is perhaps worth noting that, with a view to avoiding interception, they carried a fourth man in their Ju 188s to operate a receiver which eavesdropped on Allied GCI transmissions. I have also heard an account of the Germans on the Italian Front attempting to use British IFF to deceive. I believe that this was on a very limited basis, however, because the first aircraft that tried it was shot down. Which does rather raise questions over the way that *we* operated *vis à vis* IFF!

Another interesting observation that I might pass on is that the Germans were often surprised at the sheer size, the bulk, of British radar sets. They always felt that they could build a better piece of kit and if you study their equipment it really was first class. Indeed, we would not have modern radio-astronomy without aerials derived from *Würzburg* dishes. They were beautifully built, very stable, sensitive

[1] *Generalmajor* Dietrich Pelz, who directed the *Luftwaffe* bomber attacks on Britain in 1943 and 1944.

receivers. Furthermore, the Germans were never content; they were always trying to improve the breed. We British tended to cobble together lash-ups. They were not really built to last. They were often designed hurriedly to deal with a specific tactical problem and then rushed into production still in what amounted to little more than an experimental state. Nevertheless, while British kit may not have been perfect, it worked – and that was the point, after all.

By contrast, the Germans were always striving for perfection, attempting, for instance, to develop their excellent centimeric radar technology to produce blind-firing devices, and generally trying to make their sets smaller and more compact. As a result, they failed to field their equipment in adequate numbers. But, to return to the question, yes, the Germans did use captured equipment, as did the British. I do not know the details but I do know that No 192 Sqn used a captured German device of some sort.

Gerhard Heilig. I was an ABC Operator on Nos 214 and 101 Sqns and can offer a comment which may be of interest. Working in conjunction with the Dutch aviation writer, Theo Boiten, I have had access to a lot of German night fighter combat reports which I have translated into English. Two observations cropped up repeatedly in these documents from the late summer of 1944 onwards. The first were remarks to the effect that the Germans often did not bother to switch on their radar on the grounds that they would not be able to see anything anyway, which suggests a certain lack of confidence in their kit. Secondly, it is clear that the *Luftwaffe's* night fighter pilots feared the Mosquito night fighters.

In the latter case, I do not think that it was a question of the numbers of aircraft that the British intruders actually shot down, so much as the effect that the *possibility* of their presence had on morale and, perhaps, the damage they caused by inducing accidents. Some of the reports contain descriptions of the frankly dangerous manoeuvres used by pilots in order to avoid the RAF's Mosquitos which tended to patrol at medium altitudes in the vicinity of night fighter airfields hoping to catch German aircraft leaving or returning. For instance, one pilot reported that he would make a straight in landing from a dive approach commenced at about 10,000 feet – the proverbial 'dirty dive'. Since he survived, it obviously worked in his case but it seems

that the average German night fighter pilot may have spent as much time looking over his shoulder as he did for potential victims.

Streetly. Just to amplify that, there is evidence to suggest that German night fighters actually felt safer when they were flying within the bomber stream. While they were outside it, they presented discrete targets which made them far more vulnerable. I would certainly endorse Mr Heilig's comment; I am quite sure that the psychological impact of intruder operations was infinitely greater than the material results might suggest.

Sir Frederick Sowrey. Could I take up a point raised by Dr Price and Jack Furner; the reluctance to use a facility because of the fear that one's opponents may be equally able to use it against you. I am thinking, for instance, of clearance to use centimetric AI over enemy territory and, more specifically, of the introduction of WINDOW which the air staff had originally persuaded the Chiefs of Staff to authorise in April 1942. Lord Cherwell, however, pointed out what the effect on our own defences might be if the Germans retaliated in kind and, at a meeting with Sinclair and Harris, in May it was agreed to defer the use of WINDOW, this decision being endorsed, as we have heard, by Sholto Douglas at Fighter Command.

At an Air Ministry meeting in November, SASO Bomber Command, Saundby, did not press for the use of WINDOW and it was not until a meeting chaired by Portal as late as April 1943, that Harris finally came out firmly in favour of authorising its use. There were further delays while production got underway and it required Churchill himself, at a meeting which he chaired on 15 July, to overrule Herbert Morrison's objections. As the Minister responsible for Home Security, Morrison had been concerned about the impact of air attacks on the UK if its defences were to be impaired by German retaliatory use of WINDOW. Ten days later, as we have heard, the attack on Hamburg took place.

I have condensed this from Henry Probert's recent book on Harris and I wonder whether he would care to offer any comment on Harris' part in the delay in the introduction of WINDOW.

Air Cdre Henry Probert. I think that the primary reference in support of Harris' commitment to WINDOW is his own book in which he makes it quite plain that he was always pressing firmly for

its use. On the other hand, I was puzzled to observe that Dudley Saward, who wrote the first biography of Harris, and whom, in view of his background, one would have expected to have commented on this specific subject, totally ignored it. There is no mention anywhere in the Saward book of the controversy over the introduction of WINDOW and I can offer no explanation for this omission, other than to speculate that it lies somewhere within the circumstances under which it was written, which was some thirty years after the event. On the other hand, Max Hastings, whom I do not regard as being one of the best sources on all matters, did come out with a firm statement to the effect that Harris failed to press the case for WINDOW in the early stages.

A much better source, which I also looked at, was Webster and Frankland, The Official History. They had researched all of these matters in great depth and are, I believe, pretty reliable. They certainly had access to all of the surviving official documents. For my part, I also had access to Harris' own DO (Demi-Official) files, which were a prime source in the writing of my book. I found no reference to Harris having firmly supported the introduction of WINDOW before April 1943. Until then he had, I think, been holding off, partly because of pressure from Fighter Command and partly because of the influence of Herbert Morrison. Harris and Morrison, who was a great supporter of Bomber Command incidentally, saw quite a lot of each other in 1942-43 and it is more than likely that they would have discussed this question. Finally, I would suggest that it was about April 1943 when Harris judged that Bomber Command was really ready to undertake its main task. Once the Battle of the Ruhr had begun, the risks entailed in introducing WINDOW were going to be more than offset by the advantages to be gained in prosecuting the campaign.

EW IN THE EARLY POST-WAR YEARS – LINCOLNS TO VALIANTS

Wing Commander 'Jeff' Jefford

'Jeff' joined the RAF in 1959 as a pilot but (was) soon remustered as a navigator. His flying experience included tours with Nos 45, 83 and 50 Sqns and instructing at No 6 FTS. Administrative and staff appointments involved sundry jobs at Manby, Gatow, Brampton and a total of eight years at HQ Strike Command. He took early retirement in 1991 to read history at London University. He has three books to his credit and has been a member of the Society's Executive Committee since 1998; he is currently editor of its Journal.

I wasn't quite sure how to start this post-war segment until I came across a letter from AVM Tait, the Director General of Signals. He was writing to Vice-Chief, DCAS, ACAS(Ops) and sundry other luminaries in July 1945, just two months after the end of the European war. He says:

> 'You will, no doubt, remember that at the end of January the Chiefs of Staff approved a list of "new weapons or articles of equipment which are of such importance that the possibility of accelerating their introduction should be investigated." This list included all bomber support RCM and should dispel any doubt as to the importance of making adequate provision to perpetuate RCM.
>
> Disbandment of 100 Group squadrons is to start immediately……..'

Enough said, I think. Within a matter of weeks all six squadrons of Halifaxes, Fortresses and Liberators and seven of Mosquitos had either disappeared or been reassigned to more mundane tasks. What remained of the RAF's expertise in electronic warfare was concentrated at Watton within what became in 1946 the Central Signals Establishment (CSE). The CSE's internal arrangements involved its flying elements being organised as an (un-numbered) Development Squadron and a Calibration Squadron.

Writing in 1953, eight years later, Gp Capt Eveleigh, the Command Signals Officer at High Wycombe, is on record to the effect that until then EW had been 'dormant'. That was probably a bit hard but it was certainly true that the equipment that could be deployed operationally was little different from that which had been available in 1945 and that, until recently, practically all of what equipment there was had been in the hands of the CSE, rather than the squadrons. Nevertheless, despite its limited scope, there had always been a modicum of EW being conducted. The major air exercise of 1948, for instance, DAGGER, had involved night attacks on the UK. The largest of these had been mounted by forty Lancasters and Lincolns, all of them dispensing WINDOW and transmitting noise on two VHF comms channels (that is to say, TINSELLING). Dedicated RCM support was provided by CSE which fielded two Lancasters and a Lincoln each fitted with two DINA and three MANDREL 2 jammers. It was not a lot, but it was something.

In the immediate post-war years EW policy was directed by a tri-Service RCM Board. This was more concerned with R&D work than with operations, however, which led the RAF to set up its own RCM (later ECM) Policy Committee in January 1949. Chaired at one-star level by the Director of Signals, this committee oversaw all air aspects of EW and, when appropriate (or asked), offered advice to the Air Council. This slightly amorphous approach was not to everyone's taste, however, and in 1962 Bomber Command pressed for a specific Air Ministry desk to be identified as the one where the EW buck stopped. Nevertheless, despite the lack of focus inherent in a committee, after reviewing the situation the Air Council declared itself content with the existing arrangements and this mechanism continued to handle RAF ECM policy until well into the 1960s and maybe later.

The RCM Committee came into its own quite early on because the Korean War broke out in 1950. It promptly asked each of the commands to state its present and future requirements. This was still the Lincoln/Washington era so 'the future' for Bomber Command meant the V-Force, which was not too far off because the first Valiant was to fly in less than a year. The most obvious and urgent need was to fill the gap represented by the lack of a centimetric jammer to counter AI, something that the RCM Board had been pursuing since 1947. Responding on behalf of Bomber Command, CSE had laid

1. Centimetric radar jammer (OR 3518)
2. Communications jammer (OR 3520)
3. Metric radar jammer (OR 3521)
4. Proximity fuse jammer (OR 354)3
5. Warning receiver for dispensing WINDOW (ARI 18077)
6. Automatic window dispensers (ARI 18051)

Fig 1. V-Force EW Requirements circa 1954.

down the specifications for practically all of its future needs before the end of 1950. The requirement continued to evolve, of course, and Figure 1 shows how it stood in 1954. Of these six devices, only two actually existed, the others still being represented by Operational Requirements. Three of these ORs would eventually become RED SHRIMP, GREEN PALM and BLUE DIVER (of which more anon) but, so far as I am aware, the gadget intended to cause pre-detonation of proximity fuses never materialised, certainly not as operational hardware. But this is 1960.s kit and I need to go back to the propeller-driven early 1950s.

It was symptomatic of the reawakened interest in EW that had been sparked by the Korean War, that CSE's Development Squadron was allocated numberplates in 1951. The element which dealt with ELINT became No 192 Sqn while that working with active jammers became No 199 Sqn. Since CSE was in 90 Gp, however, No 199 Sqn was now 'wired up' wrongly so in 1952 it moved to Hemswell where its three Lincolns and three Mosquitos were reassigned to Bomber Command. Having regained a notional organic EW capability, High Wycombe began to get a grip and by 1953 it had defined standard EW fits for its various aeroplanes. No 199 Sqn's aircraft were to be equipped as shown in Figure 2. The squadron soon dispensed with the Mosquitos, its notional strength eventually settling at nine Lincolns each of which required a six-man crew comprising pilot, navigator, air engineer, air signaller and two dedicated special operators, the latter also being air signallers by trade.

In war the squadron would have been employed to support the main force. There was a problem here, however, because the Lincoln's power supplies were such that it could operate either its jammers or its nav kit, but not both. In fact the only significant nav kit left was GEE and REBECCA because the H2S had been permanently removed, as

Lincolns

3 × MANDREL 2
2 × DINA plus an associated receiver
4 × AIRBORNE CIGAR (ABC) plus an associated receiver
1 × CARPET 4
2 × POTATO plus associated receiver
2 × WINDOW chutes with Type A1 dispensers

Mosquitos

2 × MANDREL 2
2 × DINA
1 × AIRBORNE CIGAR

Fig 2. No 199 Sqn EW Fit as at 1953.

Lincolns of No 199 Sqn at North Front (probably in 1953 – see page 116). The spinners were striped blue and white.

MANDREL 2 or CARPET 4
DINA or PIPERACK (similar kit, different freq coverage)
TINSEL - Broadcast via T1154 (HF) or TR1143 (VHF)
Type A1 automatic WINDOW dispenser

Fig 3. Main Force Lincoln EW Fit as specified in 1951.

had the mid upper turret and the Automatic Gun-Laying Gear from the rear turret. As AVM Furner has pointed out, accurate navigation and timing was crucial in, for instance, establishing a MANDREL screen so it is clear that, apart from its aeroplanes being virtually defenceless, while No 199 Sqn could fulfil its training task, its operational capability was probably more apparent than real.

In reality No 199 Sqn's *primary* role was peacetime training, rather than operational bomber support. Furthermore, its efforts were not exclusively confined to satisfying the demands of the RAF and its training commitments also embraced the needs of the Army's Anti-Aircraft Command and of the RN. The accompanying photograph shows a four-aircraft detachment of Lincolns which will have been deployed to Gibraltar to annoy the Mediterranean Fleet (and to pick up some 'Duty Frees'). Note, incidentally, that these aeroplanes lack the H2S scanner.

To offset No 199 Sqn's limitations to some degree, a modification programme had been instigated with a view to restoring some sort of EW capability within the main force. Seven Lincolns had been fitted to the standard at Figure 3 by September 1951 and a year later this total would have risen to forty-one. Some Washingtons were fitted with chaff dispensers but there was no corresponding scheme to provide them with jammers because the aircraft were on short-term loan. There was no plan to fit Canberras with active jammers either, partly because they were (for the moment) relatively invulnerable but also because most of the available equipment was too bulky. That having been said, in 1954 HQ Bomber Command stated that all Canberras were to be capable of carrying four automatic chaff dispensers in lieu of bombs. So far as I am aware, nothing much ever came of that specific requirement but before the end of that year at least twenty-four main force Canberras had been fitted with a Type 27 Modulator, permitting them to transmit noise on VHF comms channels, that is to say, to function as TINSEL jammers.

A Canberra B.2 of No 199 Sqn. (MAP)

By this time No 199 Sqn had got its hands on a Canberra of its own which it had fitted with DINA, ABC and an APR-4 search receiver. This, however, was at the expense of the F.24 camera, the bomb-beam and release gear, GEE H, ORANGE PUTTER and IFF; as with the Lincoln, the limited power supplies made it an either/or situation.

Before shifting up a gear to consider the V-Force, we should pay a little attention to the other commands. As shown in Figure 4, Fighter Command planned to equip practically all of its aeroplanes with some form of D/F device which would permit them to home on the transmissions of incoming aircraft operating navigation or bombing aids or those attempting to jam the UK's Control and Reporting System. 2nd TAF's fighters were to have similar homing capabilities to those in the UK.

Aircraft Type	EW Equipment
Meteor F.8	33% to have ARI 18040 (APPENDIX)
Swift	100% ARI 18044 (GREEN SALAD)
Hunter	100% ARI 18044 (GREEN SALAD)
Meteor NF	Two squadrons to have APPENDIX pending universal installation of ARI 18006 (TORIST)
Javelin	100% ARI 18006 (TORIST)
Venom NF	100% ARI 18006 (TORIST)
Four aircraft on each Meteor, Hunter, Swift and Venom squadron were also to be fitted with a Type 27 Modulator for TINSEL.	

Fig 4. Projected Fighter Command/2nd TAF EW Fits circa 1954.

Fighter Command also sponsored an extensive, partially mobile, Ground Defensive Warfare Organisation which employed convoys of vehicles to provide a monitoring, direction-finding and jamming system. By 1954 it was intended that six (of the seven) Sectors were to be established to operate:

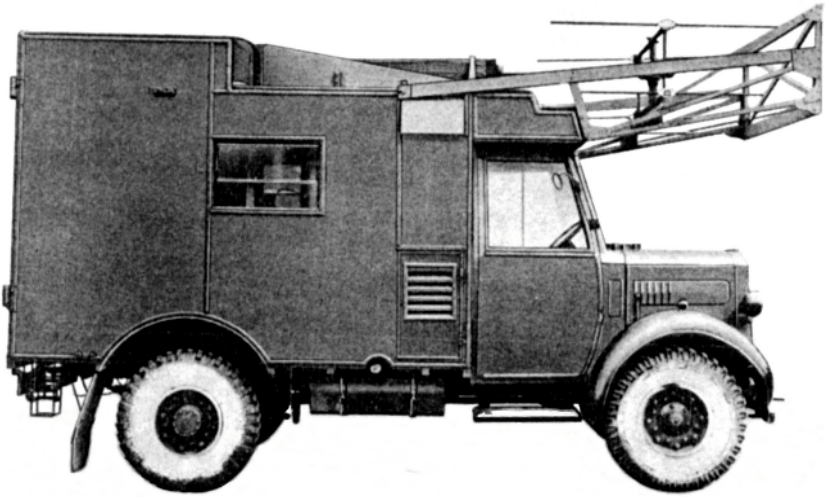
a. One jamming unit comprising one static and two mobile (twelve-vehicle) elements able to jam on HF, VHF and UHF frequencies.

b. One monitor unit comprising one static and two mobile (six-vehicle) elements able to monitor MF/HF/VHF/UHF frequencies.

c. Three mobile (single-vehicle) centimetric D/F units.

This was in addition to No 80 Wg which could field an eighteen-vehicle mobile jamming unit and a seventeen-vehicle mobile meaconing unit. Finally, there was the static D/F fixer organisation able to triangulate on aircraft jamming on VHF frequencies. This involved fourteen permanently active stations plus three at 'readiness'. This was in 1954, of course, I doubt that we have seventeen stations all told today, let alone seventeen in a single command! As with its fighters, 2nd TAF mirrored these arrangements and it too had an extensive network of ground-based, and often mobile, Signals Units.

The mobile facilities were mounted in Radio Vehicles of various



RVT 105D Mk 1 – single-channel VHF D/F equipment mounted on a Commer Q2 chassis.

Aircraft Type	Equipment
Shackleton	100% centimetric search receiver (OR 3555) 50% AN/APR-4 50% AN/APA-17 50% AN/APA-11 6 aircraft to have ARI 18021
Sunderland	100% centimetric search receiver (OR 3555) 50% AN/APR-4 50% AN/APA-11 50% AN/APA-17
Neptune	100% AN/APR-9 100% AN/APA-69 100% AN/APA-64B

Fig 5. Projected Coastal Command EW Fits circa 1954

Types (RVTs). Some of these vehicles sported aerial arrays of varying degrees of complexity but others appeared to be relatively innocuous, the majority comprising a three-tonner chassis with a pretty anonymous-looking enclosed cabin of some kind on the back. By 1956 the global establishment for RVTs for use in the UK, Malta, MEAF, FEAF and Europe (where some were to be operated by the Belgians and Dutch) called for no fewer than 296 vehicles of all kinds, of which 168 were actually on charge in October.

Coastal Command had little requirement for jammers but it did need to be able to detect and home on metric and centimetric radar transmissions from submarines and/or surface vessels. A British centimetric receiver was being developed under OR3555 but, in the meantime, half-a-dozen Shackletons had been fitted with ARI 18021 as an interim solution. Generally speaking, however, most of the equipment in Shackletons, Sunderlands and Neptunes was of US origin supplied under MDAP. Figure 5 reflects the specified fits circa 1954.

While extensive use had to be made of American equipment during the 1950s the seeds of a domestic R&D programme had been planted in the late 1940s and these would eventually bear fruit in the 1960s. There was, however, a steady stream of interim devices during the intervening years, most of which have now faded into obscurity. The

overriding need for a centimetric jammer, for instance, resulted in POTATO which was succeeded by INDIGO BRACKET in the later 1950s. Another experimental jammer was the RRE's RED CARPET which operated in X-band. The demand for a centimetric jammer sparked a corresponding requirement for a suitable detection system. The first of these was YELLOW BARLEY, a project that was terminated in 1955 to be succeeded by FLANGE which eventually saw limited service, both as an airborne homer and as a vehicle-mounted D/F facility.

Meanwhile, the imminent arrival of the V-bombers had brought a growing appreciation of the implications of the fact that these were going to be electric aeroplanes; furthermore, it was planned to provide them with a sophisticated suite of EW equipment. Handling both of these aspects would require a specialist in wiggly amps which meant the air signals fraternity, which, for essentially historical reasons, consisted largely of NCOs. Unfortunately, policy preferred that officers should be employed where nuclear weapons were involved and experience suggested that it would not be possible to obtain the substantial numbers of officers that would be required solely by the traditional ploy of commissioning from the ranks. It was concluded that the complexity of the new equipment and the responsibilities implicit within the deterrent role would require people of the calibre previously associated exclusively with pilots and navigators. After some debate the Air Council decided to introduce the entirely new aircrew category of the Air Electronics Officer, the AEO, some of whom were to be directly recruited while others would be obtained by retraining and commissioning air signallers. The first AEOs emerged from training in 1957, just in time to be bathed in the light of the new dawn represented by Duncan Sandys' White Paper on Defence. There were those who believed that the AEO was destined to inherit the missile-based air force of the future in which intellect would clearly become a more highly prized commodity than mere manual dexterity. It was a nice idea while it lasted, but, as it turned out, the Minister had only been joking.

In the meantime the Medium Bomber Force had been growing apace and until sufficient AEOs could be trained it was necessary to use NCO air signallers. At this early stage, however, the aeroplanes had little in the way of EW equipment but there was a growing need to

1 × AN/APR-4	Wide (38-1000MHz) band receiver
1 × AN/APR-9	Wide (1000-10750MHz) band receiver
6 × AN/APT-16	Centimetric radar jammers
3 × AN/ALT-7	UHF comms jammers
6 × AIRBORNE CIGAR	VHF comms jammers
1 × CARPET 4	Spot jammer (400-1400 MHz)
WINDOW	

Fig 6. Typical EW Fit in No 18 Sqn's Valiants.

provide No 199 Sqn's traditional customers with experience of the sort of jamming that might be produced by a modern bomber. This requirement began to be addressed when the squadron established a Valiant-equipped C Flight at Honington in 1957. The Valiant element subsequently acquired sole title to the squadron numberplate before moving to Finningley in 1958 where it was promptly renumbered as No 18 Sqn.

Figure 6 shows a typical selection of the equipment fitted to No 18 Sqn's Valiants. As you can see, they were a combination of US imports and British devices of wartime origin. But, as you can also see, having finally acquired an aeroplane with adequate generating power, it was now possible to operate, for instance, as many as six AIRBORNE CIGARS at once.

While the use of wartime kit might suggest that little technical progress had been made over the previous fifteen years, this was not entirely the case. There had, for instance, clearly been a great deal of work done on suppressed aerials. As the accompanying picture of one

Valiant B.1, WP213 of No 199 Sqn's Honington-based C Flt which moved to Finningley to become No 18 Sqn in 1958. (MAP)

of the special Valiants shows, they were almost indistinguishable from the standard bomber version, which was in marked contrast to the lumps, bumps, wires and masts sported by the RCM aeroplanes of WW II. In fact the only significant external differences between a standard Valiant bomber and No 18 Sqn's jamming aeroplanes is that the latter had the windows of the visual bomb aiming station blanked off and they rarely seem to have carried the underwing tanks which were more or less standard on bombers.

No 18 Sqn's notional strength fluctuated between eight and nine five-man Valiant crews (it also got its hands on the odd Canberra). The constitution of a standard V-bomber rear crew was two navs and an AEO but on No 18 Sqn it was one nav, one AEO and a special operator, usually an NCO air signaller.

Apart from exercising the UK Air Defence System, particularly its Bloodhound Mk 1s, the squadron ranged far and wide, detachments taking it to Malta, Cyprus and Singapore. Its services were much appreciated, especially overseas, where these expeditions often provided the home team with its first opportunity to work in a jammed environment. Customers ranged from the operators of the radars at such exotic locations as Madelena, Mount Olympus, Butterworth and Bukit Gombak down to the back-seaters of Meteors and Javelins trying to pick out targets on their AI Mks 10, 17 and/or 21.

Did it work? Yes. The only problem was the limited size of the force which meant that, whether in a training or an operational context, it could be effective on only a relatively localised basis. Nevertheless, where its effort could be focused, No 18 Sqn's impact could be devastating. To quote from the unit's ORB describing an exercise carried out in 1959, 'the Type 80 radar at Patrington had been rendered virtually unusable for target allotment and North Coates' Type 82 search radar was quite unusable'.

The Valiant could, and did, do this sort of thing equally well to the radars associated with the Army's Thunderbird missiles and to those on HM Ships but there could be no denying that its dated equipment limited its ability to duplicate the increasing sophistication of the potential threat. Furthermore, each of the Vulcans and Victors had acquired a pretty comprehensive EW capability of its own by the early 1960s which more or less obviated the need for a dedicated jamming unit. Even more persuasively, however, Skybolt would be entering

service in 1964 and from then on the bombers would not have to penetrate defended airspace at all. It was another false dawn, of course, and to sustain the credibility of the deterrent, the Medium Bomber Force had to adopt low-level tactics in 1963, although these too significantly reduced the need to indulge in electronic warfare which meant there were few grounds for sustaining No 18 Sqn for operational purposes. There was still a need for EW *training*, of course, but the use of Valiants was a pretty uneconomic way of providing that, especially as most of their jammers would have to be replaced with newer devices in any case. It was decided to re-establish the EW training force with Canberras and No 18 Sqn was disbanded in 1963.

One final thought. Whenever the purse strings are tightened – and, in peacetime, that is most of the time – one of the first casualties is EW because it is essentially intangible and that tends to make it relatively difficult to justify the expenditure. Although this problem is not confined to the UK, British EW has certainly tended to advance in fits and starts. Nevertheless, while progress may be intermittent, the staffs do know what they want – and they do ask for it. As early as 1967, for instance, Naval Air Staff Target (NAST) 853 was calling for an active search/lock jamming capability in X and J-Bands plus infrared flares *plus* chaff *plus* two towed decoys, both of which were to have repeater jammers to duplicate the emissions of the mother aeroplane; all of this kit was to be stowed within a pod weighing not more than 1,000 lbs. That may have been asking a bit much in 1967 but perhaps not; either way, it never materialised.

I will stop here as I am beginning to poach on the territories of my colleagues.

EW DURING THE V-FORCE ERA

Wing Commander Rod Powell

Wg Cdr Rod Powell joined the RAF in 1963 as a direct entrant AEO and as such he flew in Vulcans with Nos 83, 9 and 50 Sqns. He is a graduate of the GD Aerosystems Course and has occupied a number of posts associated with EW, including work with the Central Trials and Tactics Organisation (CTTO), OC Ops Wg at the Electronic Warfare Operational Support Establishment (EWOSE) and as OR 53 at MOD. He left the Service in 1994 and, after working as an aerospace systems consultant for seven years, took up his current appointment as Marketing Manager with FR Aviation.

Perhaps I could start by endorsing a couple of points that have just been made. First, the lack of investment in EW, which seems to have been a recurrent theme during the post-war years, which has meant that we have sometimes had to spend in a hurry. Secondly, when that has happened, as it did in the Gulf War, the staffs have always been able to provide some sort of solution. I doubt, however, that it will happen like that again in the future because the aircraft that we deal with today are so different. They are integrated weapon systems and we will not be able simply to tack things on at the last moment as we have done in the past.

I can offer an anecdote which perhaps underlines the point about lack of investment, in the context of aircrew training, or perhaps 'education' would be a better term. When I was OC Ops Wg at EWOSE in 1990 we had to train some VC10 crews who were being deployed to the Gulf which had involved fitting their aircraft with ARI 18228, a Radar Warning Receiver (RWR). Their initial lack of awareness of EW was such that one of them actually asked me why they were required to learn about 'Early Warning'. Symptomatic, I suggest, of a lack of investment in training.

But, to return to my brief, which was to talk about the V-Force, I joined it at Scampton in 1966. At that time we had three squadrons of B.2s there, three more at Cottesmore and three of B.1As at Waddington. There were two squadrons of Mk 2 Victor bombers at

Wittering, a reconnaissance squadron at Wyton and three squadrons of Mk 1 tankers at Marham. The Valiants had recently been withdrawn from service as a result of a fatigue problem.

I make no claim to presenting a deeply researched historical document. For the purposes of this paper, I shall, in the main, confine myself to my personal recollections of operating in the BLUE STEEL-armed Vulcan B.2s of No 83 Sqn. I shall address our equipment, tactics, training and the calibration of the EW systems.

The point of having BLUE STEEL was that it meant that the launch aircraft did not have to penetrate target defences. The missiles could be launched some 25 miles from the target from a height of 250 ft, which was a considerable bonus to the crews, given the heavy defences around many Soviet cities. The B.2, as you will know, was a highly manoeuvrable aircraft, capable of flying well above 50,000 ft at Mach .84. At low level our speed was restricted to about 350 kts; not very fast, so you can see that we might well have needed a little help to survive.

On paper the Vulcan had an impressive defensive suite comprising powerful jammers, a radar warning receiver, a tail warning radar, infrared flares and oodles and oodles of chaff. This kit provided a reasonable degree of situational awareness, even by today's standards, and the crew could therefore take the necessary action to avoid or evade the ground or air defences. Or could it? We will never know what the survivability rate of the V-Force would have been, but my guess is that many of the aircraft would have been shot down before they reached their missile release point or, in the case of the free-fallers, the target, because, to be honest, the EW suite that we had at the time was just not good enough. Let us take a look at the EW systems that we had and how we were taught to use them.

Figure 1 shows the locations of the Vulcan's main jammers. In the early days there was a VHF communications jammer, ARI 18074, known as GREEN PALM; it is not actually shown in the diagram but its antenna was at the top of the fin. ARI 18075, BLUE DIVER, had notched aerials at the wing tips, and the ARI 18076, RED SHRIMP, antennas were normally located on the flat plates between Nos 3 and 4 engines, although most of the BLUE STEEL aircraft had them between Nos 1 and 2 engines as well. The jammer power units and the transmitters were housed in the large cans within the tail bulge. All of

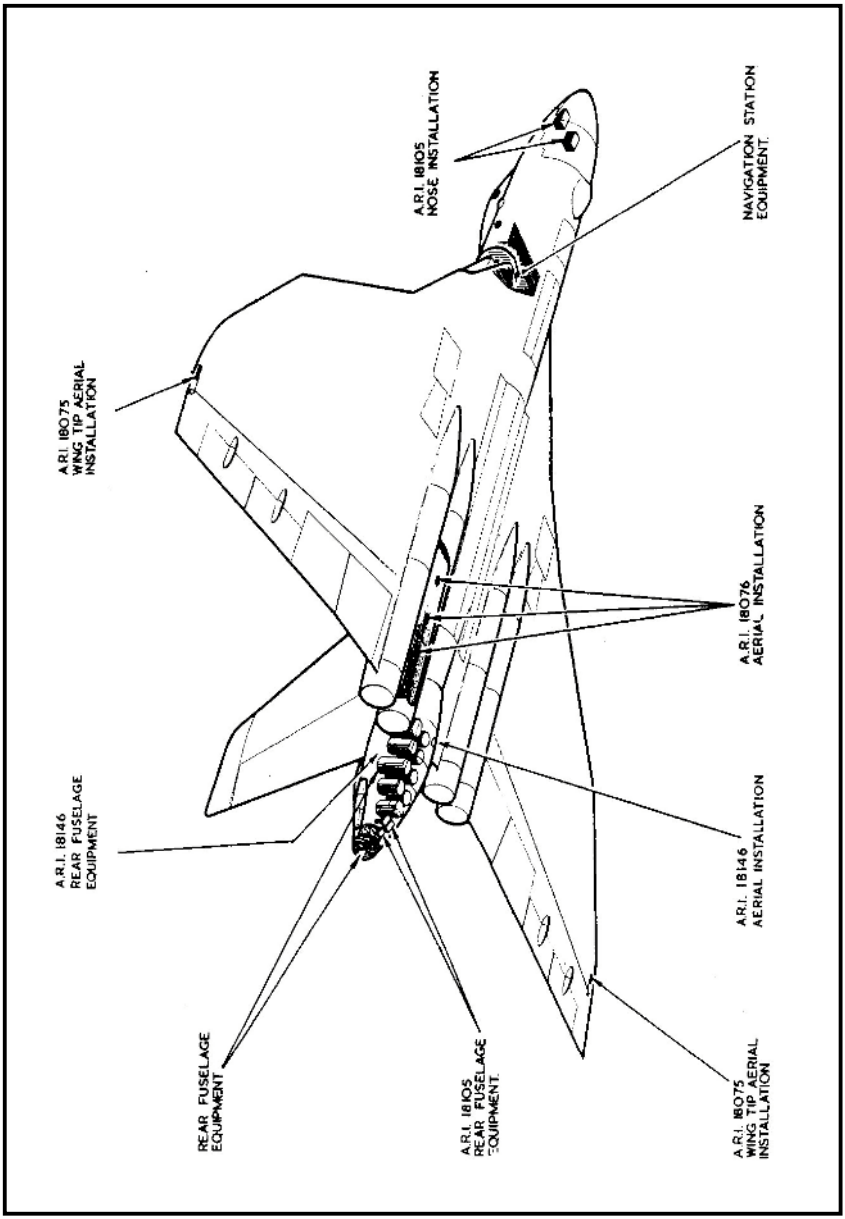


Fig 1. Typical Vulcan B.2 EW installation.

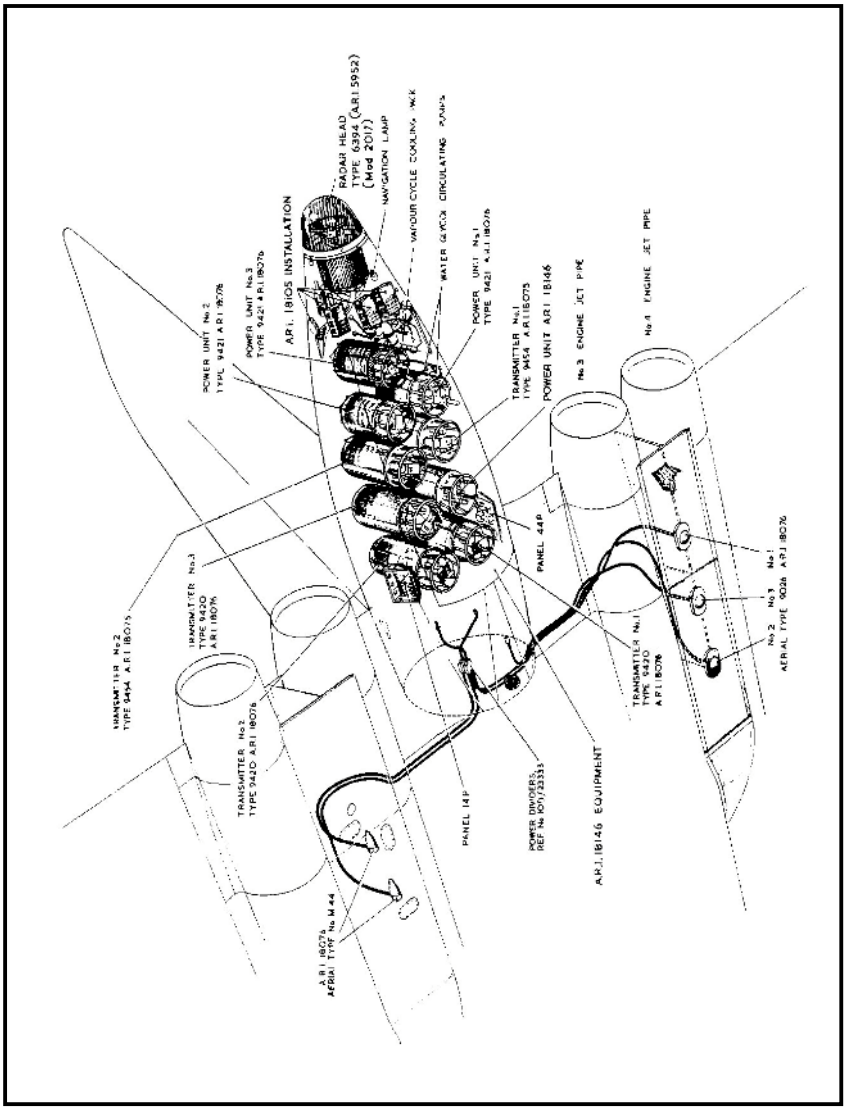


Fig 2. Typical content of the bulged fuselage tail of a Vulcan B.2

this kit had been specifically designed to counter the Soviet high level threats of the 1950s but they were of rather less value once the force had adopted low level tactics.

Figure 2 is a closer view of the tail showing the massive size of the power units and the transmitter cans of the DIVERS and SHRIMPS. I do not recall ever actually knowing what their total weight was, but it must have been several thousand pounds. In fact it was 1978 before I came to appreciate just how big those cans really were. We had lost an aircraft just outside of Chicago and I was involved in the Board of Inquiry. Apart from the engines and the undercarriage units, the most substantial pieces of wreckage were the cans and I was responsible for making sure that they were returned safely to the UK. They each stood about 3½ feet high and had a diameter of about 2 feet – about the size of a domestic dustbin. They drew a *lot* of electrical power in their transmit mode, the total load on the aircraft being about 40 KW, which went some way to explaining why the Vulcan B.2 was blessed with four engine-driven 40 KvA alternators. The biggest single consumer of power in the Vulcan, however, was the Vapour Cycle Cooling Pack, the VCCP. Located towards the rear of the tail compartment, it circulated a water-glycol mixture around the ECM cans. The VCCP drew about 8-10 KW in normal running, but a massive 40 KW on start-up. You will recall that reference has previously been made to the constraints imposed on the employment of EW equipment by the limited power supplies of earlier aeroplanes. Power was no longer a problem with the V-bombers, but heat dissipation was – hence the VCCP.

In Figure 2 you can also see the cables which channelled the transmitter power to the RED SHRIMP antennas between the jet pipes. I am sure that those cables and connections must all have been very ‘lossy’, as we say, because they had to take the jamming output power around the engines, around the jet pipe, to what must have been, if you think about it, one of the most electrically inhospitable locations on the entire airframe. We actually had three RED SHRIMPS each of which could operate in two modulation modes in the, then S-, now E-Band, between 2.5 and 3 GHz. They were intended to jam the gun-laying radars controlling 57mm and 76mm AAA and the acquisition element of the SA-3 missile system, the LOW BLOW radar. On some aircraft there was also a lower

frequency, L-Band, version, which had its own aerial, a blade antenna on the mounting plate between the jet pipes of Nos 3 and 4 engines.

The two BLUE DIVERS operated in the metric frequency range, B-Band in today's parlance, and were intended to jam early warning radars. The wing tip antennas were more than 50 feet from the transmitters so, once again, there may well have been a loss here too, but it would seem that there was plenty of power left to radiate. It was said that there was an occasion during an air defence exercise in about 1960 when, just as the nation was settling down to watch the soap opera of the day, a bunch of Vulcans switched on their BLUE DIVERS and wiped out all the television signals! That was before my time, so I cannot vouch for the truth of the tale, but whether it happened or not, the story probably does reflect the scale of the jamming that could be achieved.

I should perhaps point out that, apart from looking after the jammers, the AEO controlled the aircraft's electrical system and handled a great deal of communications, particularly long range HF radio traffic. In the photograph of the AEO's 'office' at Figure 3 the EW controls are in font of him on the bulkhead with a schematic of the electrical system and its various controls to his right, on the port side wall of the cabin.

As I have suggested, the rather impressive jamming capability of the Mk 2 V-bombers had been designed to cater for the high-level case in the late 1950s and early '60s. One can envisage a co-ordinated attack over a relatively broad front with close to a hundred aeroplanes jamming on full power to provide mutual protection, the DIVERS denying the Soviets early warning, the SHRIMPS negating their anti-aircraft missiles and guns and GREEN PALM disrupting the, still VHF-based, Russian air defence network. To some extent, this was an extension of WW II practice. It was barrage jamming, although at much greater intensities than had been possible in 1945. There was little sophistication involved, however; the V-Force's kit did not respond with specific reactions to counter individual threats in the way that modern systems do. The V-bombers relied on brute force, and lots of it; the jammers were simply switched on at a particular point on the outbound track and left to radiate on a pre-set range of frequencies, regardless of whether or not there was an actual threat to be countered.

The change to low-level operations in 1963 should have been

Fig 3. The AEO's station in a Vulcan B.2. The circular CRT on the bulkhead is RED STEER Mk 1.

accompanied by a change in EW tactics and a reappraisal of the system's capabilities. This simply did not happen, at least, not in any meaningful way. With hindsight, I think that we, the AEOs who were responsible for operating the EW system, should have known a lot more about our EW capabilities than we did and we should have been far more assertive in seeking improvements and changes to enhance our survivability. The fact is that we simply did not do that. Why? I think that it was because of the way we had been trained. We spent an inordinate amount of time learning about the aircraft in minute detail and tracing how each electrical circuit in the aircraft operated. Our knowledge of the sequencing of 'A' breakers and 'S' breakers within the electrical generating system was, it seems, considered to be far more important than learning about EW. If that was what 'the system' wanted, who were we to argue? As a result, very little time was spent studying the EW system or questioning the tactics that we employed.

So what should we have been thinking about? Well, the implications of the operating parameters of our equipment for one thing; and the implications of this in the context of low-level operations for another. As I have explained, BLUE DIVER and RED SHRIMP were barrage jammers. In effect, they transmitted white noise on a wide swathe of frequencies with the intention of swamping the scope of any radar operating within that bandwidth. The problem with this brute force approach was that the power output was spread across the entire transmitted spectrum. That meant that the power density, and thus the jamming effectiveness, on any specific frequency was relatively low. This limitation was offset to some extent in the high-level case by the fact that each aeroplane's jamming reinforced that of the others so the overall effect would still probably have been pretty devastating. At low-level, however, each aeroplane operated in isolation so the mutual support factor simply did not apply.

Another factor that we should have thought more about was the radiation patterns of our antennae which had been optimised for the high level case. Not surprisingly, therefore, they radiated downwards. The RED SHRIMPS, for example, radiated in roughly a 45° semi-angle cone beneath the aircraft such that the footprint of the jamming on the ground was a circle whose diameter was determined by the aircraft's height. At low level the aircraft had barely any 'height' so the jamming footprint was probably about the size of the aeroplane!

Furthermore, apart from pointing downwards, the aerials had no other directionality, so our jamming was radiated throughout the entire 360°.

The upshot of all this was that, while our jammers did have lots of power in theory, the combination of the 'lossy' transmission cables, barrage jamming and the generous antenna radiation pattern severely reduced the impact on a threat radar. We could have done something about this, but we never did. When we adopted low level tactics we did not change our ECM procedures nor did we adjust our antennae. Our route plans still required us simply to switch on all of our jammers as we entered enemy airspace. In fact I seem to recall that there was a red line drawn on the maps annotated 'ECM Switch On Line'. The brief was to leave the jammers on in enemy territory and switch them off when exiting - if we ever did.

As I look back on this now I simply cannot imagine why no one seems to have commented on such a blinkered approach and, if anyone ever did, why nothing was done about it. To be fair, despite what I perceive to have been a general lack of application, some effort was made to provide some aircraft with a more effective jamming capability. About thirty late-production Vulcans were fitted with an X-Band jammer; that would be I-Band today. This had a selectable fore and aft directionality to its jamming pattern, its antenna being located on the centre line just forward of the ECM bulge on the lower rear fuselage. It also had a modulated jamming output against specific threats, a 26 Hz modulated signal against the SA-3's LOW BLOW tracking radar from the forward antenna and a conical scan from the aft antenna to counter fighter AI radars.

Turning to a different aspect, the V-bombers were provided with a radar warning receiver. The first was ARI 18105, more generally known as BLUE SAGA. It was very much a first generation passive warning receiver with four sets of small stub antennas mounted 'quadrangularly' on the upper surface of the nose and the lower tail. It received signals in the S-, C- and X-Bands, roughly 2.5 to 12 GHz. Its display comprised two orange lights, one for S-Band and one for C/X-Bands, which illuminated when a signal reached a pre-determined threshold of PRF or pulse width. At the same time the AEO would monitor the PRF audio tone in his headset and switch between the four sets of antennae to determine the quadrant from which the signal was

being received. This was a pretty ‘manudraulic’ device and it was slow by today’s standards but, with practice, the AEOs became quite adept at detecting, identifying and taking action on incoming threat signals.

The situation improved in early 1970s when the Vulcan was fitted with what was then a state-of-the-art radar warning receiver, the ubiquitous ARI 18228, which is still in worldwide service today, albeit in slightly modified versions. Manufactured by Marconi, the ‘228 does not appear to have been allocated one of those curious coloured codenames but it certainly provided a quantum jump in performance compared to the old BLUE SAGA. It covered 2.5 to 18 GHz, thereby accommodating new J-Band threats as well as all the old threat systems and it was also able to handle CW signals, which was another innovation. The ARI 18228 has an easy-to-interpret polar display on a CRT of about 4 inches diameter. This presents an incoming signal as a strobe, indicating its relative bearing. The frequency band is indicated by the strobe’s being dashed, dotted or unbroken and its length is proportional to the strength of the received signal, which may be interpreted to provide a crude assessment of range. In short, this piece of kit provided a level of situational awareness which is still quite respectable today.

Apart from visual cues provided by the ‘228, one could also ‘hear’ the PRF in one’s headphones. Put crudely, a high-pitched PRF implied a high threat so, depending upon the circumstances, we could direct the pilot to turn away from or towards the threat. One drawback was that the receiver was located on top of the fin; hence the square tipped fin that was characteristic of latter-day Vulcans. This was probably the ideal place for it in the low-level environment but at high-level the vast area of the Vulcan’s wing must have caused a considerable degree of blanking. Perhaps we should have had switchable upper *and* lower aerials.

Moving on, the Vulcan could dispense large quantities of chaff. It was stored within the wing, just aft of the main undercarriage legs, in what were inevitably known as ‘window boxes’, two per side. In all we had four thousand packets of chaff, each packet being about a nine inches long by three inches wide and half-an-inch thick. It was pre-cut to various lengths giving us wideband frequency coverage. It was dispensed through apertures in the underside of the wing which looked

rather like letter-boxes. If we dropped chaff on a training flight, on leaving the area we were supposed to lower the undercarriage to create turbulence across these apertures in order to suck out any chaff that had got stuck inside. This was because our Auxiliary Power Unit (APU) was in the starboard wing just behind the main undercarriage leg; if we fired it up before clearing the stray chaff it could be ingested by our little Rover gas turbine which would do it no good at all. In practice we often left this precaution until we were approaching the circuit when we had to lower the undercarriage and start the APU anyway. Some of the residents of the Gainsborough area may have got a bit fed up with having chaff dropped on them from time to time, but they never seemed to complain. There were some people who did, however. We were allowed to drop chaff quite happily on the range at Spadeadam and the farmers would often phone in to blame us for their sheep dying because they had allegedly been eating aluminium-clad fibreglass filaments. The boffins eventually decided that the stuff wasn't actually toxic, not, at least to sheep, and that the farmers were simply trying it on in the hope of persuading MOD to pay out in compensation.

In addition to chaff we were also well provided with flares, 192 of them in all. They were made of a compound called MTV - Magnesium Teflon Viton - which allegedly had sufficient of an IR signature to seduce a missile away from our jet pipes. Incidentally, the same material, MTV, is still used by today's Tornados and Jaguars. A minor inconvenience with our flares was that a substantial metal pin about two inches long was ejected whenever you fired them. This sort of projectile could do substantial damage when it hit the ground; hardly a problem over enemy territory, but in peacetime we could dispense flares only over the sea and only then after carrying out a clear range procedure to ensure that we were not going to sink any ships. That did tie our hands somewhat for training purposes but I did manage to fire a couple at night, and, my word, did they light up the sky?! I can assure you that it was quite spectacular!

The final element of our EW suite was the tail warning radar. The first version, RED STEER Mk 1, is said to have been derived from an early AI radar. Mounted in the tail cone, it had a conical scan, again, I think, about a 45° semi-angle. The scope was mounted right in front of the AEO but its presentation was a nightmare to interpret. The

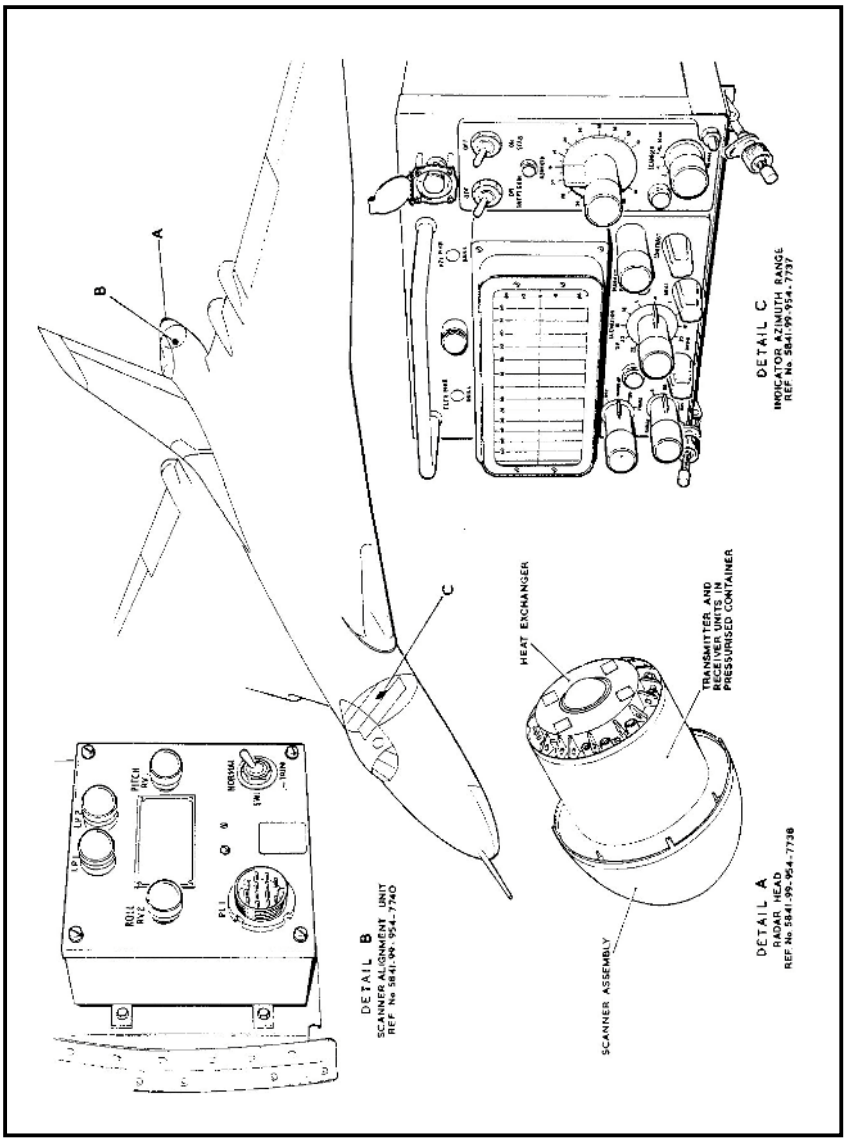


Fig 4. The RED STEER Mk 2 installation (ARI 5952) in the Vulcan B.2. Note the square scope, compared to the circular one in the photograph at Fig 3.

maximum range of the system was about 10 to 12 miles; on the scope, maximum range was in the centre and minimum range around the periphery. A target directly behind presented as a full circle; if it was offset it would be only an arc. Bearing in mind that one was facing backwards, in order to determine where the fighter actually was one had to turn one's mind around laterally and upside down and almost inside out, but, with practice, it could be made to work. Salvation eventually came in the shape of RED STEER Mk 2 – see Figure 4. This was a much better radar, employing an 8-bar raster scan sweeping through ±70° in azimuth and ±25° in elevation; it had a range of 25 nautical miles, the presentation being on a conventional B Scope and you had the option of locking on to a response. Combining this visual information with the tone in your headset, one had a pretty good idea when the fighter was about to loose off a missile so you could hit the action button to dump a load of chaff and/or flares at just about the right time.

So, having outlined the various components of the EW suite, how did we know whether it was working? This was done by carrying out an ECM monitor run which involved flying the aircraft through a calibration facility operated by No 81 SU at Stornoway. It was a fairly straightforward procedure; starting about 90 miles north of the site, we flew towards it at a little under 40,000ft switching specific pieces of kit on and off at predetermined ranges. The clever stuff was being done on the ground where they were able to assess the power output, the effectiveness of each mode, the amplitude of modulation and so on. The results were signalled back to base, any remedial action, from box changes to tweaking, being implemented on our return.

I think that I am right in saying that each aeroplane was supposed to be run through Stornoway every 90 days. When I did a tour in Cyprus that turned out to be very convenient as it meant that we could come back to the UK every three months or so to stock up on coffee and other goodies that were relatively expensive at Akrotiri. I imagine that the main reason for locating No 81 SU in a spot as remote as Stornoway was that it permitted us to operate our jammers with impunity. The problem was that the Soviets used to station a picket ship up there so that they could monitor our transmissions as well. As a result, the range was often inoperative but I suspect that the Russians probably still knew as much about the operating parameters and

efficiency of our kit as we did ourselves. I am sure that, had we put our minds to it, we could have come up with a way of calibrating our equipment without having to broadcast to the opposition. There were other factors which contributed to sustaining the system, however, not least an ECM Trophy which was among the pots awarded as a spin off from the Annual Bombing and Navigation Competition; the winner was decided largely on the basis of the results of monitor runs.

Finally – training. While monitor runs were really rather boring, training could be quite good fun and as this increased in sophistication, once we began to develop a more tactical approach to flying, so too did we begin to develop some awareness of where our deficiencies lay. High on the 'good fun' scale were detachments to the USA where we were permitted to fly at low-level over the Mid-West using routes sponsored by SAC. This was all valuable experience, of course, but I am not sure that it was all that representative of an operational mission and it certainly provided no scope for using EW. Far less exotic, but of far more real benefit was the exploitation of the redundant BLUE STREAK test site in Cumbria to create a dedicated electronic warfare training facility in the 1970s. This was No 71 SU at Spadeadam, and it is still there today.

Operating at Spadeadam at low-level we were able to manoeuvre and to use our jammers and chaff in an attempt to counter systems replicating Soviet equipment, including, for instance, the FAN SONG, LOW BLOW and GUN DISH radars associated with the SA-2 and SA-3 missiles and the ZSU-23 AAA system. It was in the light of this experience that we slowly began to grasp the practical limitations implicit in trying to employ our essentially 1950s-technology high-level kit at low-level in the 1970s. The Vietnam War had seen considerable advances in EW techniques and we had simply failed to keep up. It is true that some effort was made to acquire jamming pods from America for, at least some of, our fast-jets but the lack of investment in the Vulcan's EW capabilities during the 1970s contrasted sharply with the USAF's constant upgrading of its B-52s. The B-52, incidentally, is currently expected to remain in the inventory for at least another thirty years and when it is finally withdrawn, it will probably have a 2030 state-of-the-art ECM fit.

Nevertheless, while Spadeadam may have shown that we had more weaknesses than strengths, this was in itself vital information.

Furthermore, apart from its specific benefit to AEOs, using the range had helped the whole crew to break out of the procedural straightjacket that had cramped the style of V-bomber flying for many years. The key to traditional V-Force operations had been to stay precisely on time and on track at all costs because to stray from the path during a tightly scheduled and co-ordinated nuclear offensive (and that was really all we were about until the end of the 1960s) invited being blown up by someone else's atom bomb – or worse, your blowing up one of your colleagues. After fifteen years of that sort of rigidly disciplined approach, it took time to adapt to a more relaxed regime and to adopt a more tactical approach to operations.

Harking back to a comment I made earlier, regarding our failure, and by 'our' I mean in particular AEOs, to grasp the nettle represented by the limitations of our EW kit, I think that this can also be explained, at least in part, by the discipline which was key to V-Force operations during the years when we constituted the UK's deterrent. The QRA concept was predicated upon adherence to plans and procedures and instant obedience. This sort of culture did not encourage questions, especially not from junior members of aircrews – and a lot of AEOs were pretty junior. If the plan said 'switch on the jammers here', we rather took it for granted that someone who knew what he was about (one of the experts who lurked at 'Group') had thought about this and that it was the right thing to do. That is, I think, probably why it took us so long to begin to ask questions and by the time that we began to devise answers, the Vulcan was rather too long in the tooth to attract much in the way of development funds.

Returning to Spadeadam, we learned that the best answer to enemy systems was to avoid them, rather than to attempt to deal with them. Instead of sticking slavishly to track, our pilots began to weave and dodge and to take advantage of the terrain to hide from threat radars. As crews we became more and more interested in survivability and to do this we needed to fly in increasingly hostile EW environments. The most sophisticated facilities of this kind were in the USA and some of us were fortunate enough to be detached to Nellis AFB in Nevada to participate in RED and GREEN FLAG exercises.

By 1982, with the Tornado becoming established in service and the four remaining Vulcan squadrons on the verge of disbandment, the UK went to war with Argentina. Since it was the only RAF aeroplane

with a significant range capability and an ability to carry a worthwhile load, the Vulcan was briefly reprieved. It stands as mute testimony to the lack of investment in the aeroplane that it was necessary to provide it with some sort of realistic ECM capability by borrowing ALQ-101-10 pods from the Buccaneer force. Somewhat surprisingly, the Vulcan was eventually pressed into service in the SEAD (Suppression of Enemy Air Defences) role, something that can hardly have been envisaged by Roy Chadwick back in the 1940s. Having flirted briefly with MARTEL, the Vulcan was eventually armed with AGM-45 Shrikes acquired from the Americans and these were used successfully to disrupt the operation of a TPS-43 surveillance radar and to neutralise a Skyguard fire-control radar at Port Stanley. During the recovery from the second missile-launching sortie, the aeroplane had a refuelling problem and finished up diverting into Rio – but that, as they say, is another story.

RAF EW TRAINING 1945-1966

Martin Streetly

Following the victory over Japan in August 1945, the RAF's wartime offensive countermeasures organisation, No 100 Gp, rapidly became an expendable asset in the austere post-war environment and it was formally disbanded on 17 December. As we have heard, in an attempt to keep some of its hard won electronic warfare skills alive, the Service had salvaged some elements of the previous organisation to set up the Radio Warfare Establishment (RWE) at Watton during September. The RWE, which operated within No 60 Gp of Fighter Command, received its first aircraft on 6 October, its strength eventually running to twenty-four Halifaxes, eight B-17s, twelve Mosquitos, three Ansons, an Oxford and a Proctor. On 24 September 1946, the RWE was redesignated to become the Central Signals Establishment (CSE), control of the new organisation being vested in No 90 (Signals) Group. Still based at Watton, the CSE included within its remit countermeasures development and training. At this stage, electronic warfare was hardly a priority within the RAF, however, and, even with the onset of the Cold War in the late 1940s, the technology continued to remain dormant. This was due in large part to the view that if hostilities did break out with the Soviet Union, the countermeasures developed during 1944-45 would suffice to get the bombers through to their targets due to the primitive nature of the Russian air defence system.

This rather complacent world view changed dramatically following the outbreak of the Korean War, food for thought being provided by the emergence of aircraft such as the MiG-15 and a Russian-supplied North Korean air defence network that was both radar directed and effective. Accordingly, No 100 Gp's old MANDREL jamming unit, No 199 Sqn was reformed within CSE on 15 July 1951. Soon reassigned to Bomber Command, the squadron was responsible for supporting any offensive operations and for training the UK's air defence system. I will not dwell on the activities of No 199, later No 18, Sqn, as it has already been dealt with, but there was another aspect of CSE which does warrant a mention. Having had its original flying units redesignated as numbered squadrons, a new Development Squadron was established at Watton. As its title implies, this was

This Lincoln flew with the CSE's Development Squadron between 1958 and 1962 when the unit was redesignated to become No 151 Sqn. RA685 was withdrawn from use in April 1963. (MAP)

primarily concerned with trials of electronic countermeasures equipment and the evaluation of tactics but it had a secondary training role which involved providing radar sites with experience of operating in a jammed environment, sometimes via participation in formal exercises. The Development Squadron's veteran Lincolns soldiered on until as late as 1963 by which time the unit had become No 151 Sqn.

To understand the next stage in the evolution of the RAF's post-war countermeasures training effort, we need to recognise the Fleet Air Arm's contribution to the work of the CSE which had begun as early as March 1947 when the Royal Navy had established No 751 Sqn at Watton for radar jamming trials work. This unit lasted for only four months, however, naval interests subsequently being represented by a small permanent detachment. Presumably as another response to the Korean War, No 751 Sqn was re-established in December 1951 (again at Watton) to undertake 'radio' trials on behalf of the Fleet Air Arm and to provide the RN with countermeasures training. In 1957, the unit moved to Culdrose where, in May 1958, it was redesignated as No 831 Sqn. Five years later, by which time it was flying Sea Venoms and Gannets the squadron relocated to Watton to permit closer liaison with the CSE and the RAF, although the latter had just disbanded its dedicated jamming unit, No 18 Sqn. Rationalisation was in the air and in 1965 the CSE itself was disbanded followed by the pooling of the two Services' training resources to create the jointly-manned No 360 Sqn in 1966. And at this point I will hand over to my colleague.

RAF EW TRAINING 1966-94

Wing Commander Dick Turpin

Richard 'Dick' Turpin joined the RAF in 1953, trained as an air signaller in 1963 and flew in Beverleys. Commissioned as an AEO in 1967, he subsequently flew with four Vulcan squadrons; ground appointments included tours at Lyneham, Rheindahlen, Wyton and High Wycombe. After a stint with No 51 Sqn he served at MOD before leaving the Service in 1994. His subsequent involvement in local politics, culminated with six years as Leader of Huntingdonshire District Council.

Since I was an instructor at the Vulcan OCU, I should perhaps confess that I was probably one of those AEOs who caused Rod Powell to concentrate on the wrong aspects of his job. As he rightly said, we were far more interested in the aeroplane's electrical circuits than in electronic warfare. If I knew then what I know now things might have been different. But I didn't, of course. Having got that off my chest, what of the later stages of EW training?

In September 1966, following the demise of No 18 Sqn and the CSE, No 360 Sqn was set up at Watton, absorbing much of the resources of No 831 NAS in the process. To be pedantic, it had originally been intended to establish two joint units and No 361 Sqn was actually formed in January 1967. The second unit was pencilled in for deployment to FEAF but this plan stalled and it disbanded after only six months of rather insubstantial existence at Watton.

No 360 Sqn was to be equipped with Canberras. The Canberra had first become associated with the EW community as early as 1953 when Watton's No 192 Sqn had been provided with a couple of B.2s. Interestingly, these aeroplanes, which were intended for ELINT duties, were the first Canberras to be fitted with a Doppler radar – GREEN SATIN. They were succeeded by quite extensively modified B.6s from 1954 onwards, these aircraft operating around the Baltic and elsewhere monitoring and recording electronic emissions. There was a marginal training aspect associated with this activity, as it was possible to make duplicate tapes from which aircrew could be taught to recognise the audio signatures of specific equipments and thus to

Seen here after its final update to T.17A standard, WD955 kept going until well into the 1990s. Since it had first flown as a B.2 in 1951, it must have been one of the longest lived of RAF Canberras. (MAP)

evaluate the level of threat that they represented. It has to be said, however, that I do not think that there was very much of this sort of applied training going on in the late 1950s. Meanwhile, Canberras began to be issued to other units within No 90 Gp. Most of these were concerned with the calibration of early warning, GCI and missile fire control radars, IFF and so on but in the early 1960s No 97 Sqn acquired a limited jamming capability which permitted it to offer a degree of practical EW training.

So, having established the Canberra's pedigree in the signals world, what of 360 Sqn? Beginning in 1964 twenty-four surplus Canberra B.2s began to be fed through Samlesbury where they were turned into T Mk 17s. The conversion involved the installation of a range of equipment in the bomb bay and the provision of sundry aerials, resulting in the distinctive bulbous and 'warty' nose that was so characteristic of the breed. Twelve of these aircraft were assigned to No 360 Sqn, to provide a realistic ECM training capability for both the RAF and the RN. The squadron moved to Cottesmore in 1969 and in 1975 to Wyton where it remained for the next twenty years.

The T.17 had a comms noise jammer, covering the VHF/UHF bands, and two E/F-Band or, alternatively, one D-Band and one E/F-Band jammers, and an I-Band jammer; the latter could transmit from either front or rear aerials but not both. There was also an I-Band CW Pulse Doppler repeater jammer. It could sometimes be difficult to be certain that the jammers were tuned to the appropriate frequencies because the operator was obliged to work with an APR-9 of some

considerable vintage, this having a ‘window’ covering only 20 MHz.

The annual task set by the MOD amounted to some 3600 sorties per year, allocated variously to NATO and UK forces. The squadron’s success in achieving this task varied over the years. It was probably always too demanding and I doubt that it was ever met in full, even in the early days, and many sorties were being lost towards the end due to equipment problems and aircraft serviceability. This highlights a problem with integral EW equipment in that it complicates the serviceability equation. With built-in kit, both it and the airframe have to be in working order if the sortie is to succeed; with a defective EW pod you may be able to solve the problem by dropping one and fitting another. Either way, serviceability became something of an issue in later years, mostly due to the age of the aircraft.

The squadron flew a variety of sortie profiles according to a weekly programme which was prepared by the Electronic Warfare Training Cell (EWTC), a part of Wyton’s Ops Wg and where I first became personally involved in this business in 1980-82. The squadron’s principle bread and butter missions ranged from so-called COFFEE DELTAs, which exercised the radars of the UK’s Air Defence Ground Environment, PROFITs, against either singletons or pairs of fighters, and Flag Officer Sea Training’s (FOST) weekly ‘war’ off the south coast. Larger scale exercises often entailed multi-aircraft detachments to Scotland for Joint Maritime Courses (JMC), or to a variety of airfields in Germany, Belgium, Holland, Italy, Norway, Portugal and France to participate in NATO or bi-national events. Another range of major tasks involved Mediterranean Fleet exercises flown from Gibraltar and naval exercises sponsored by NATO. Although, as part of the EWTC’s staff, I was not actually filling a flying appointment, I did manage to participate in one of these naval affairs which involved a trip to Landivisiau in north west France.

Over the years I am sure that No 360 Sqn accomplished a great deal in providing RN and RAF personnel with an insight into the problems that ECM could cause them in their operational roles, whether on land, at sea or in the air. By the mid-1980s, however, in order to reflect changes in the Warsaw Pact’s electronic ORBAT, it was becoming increasingly necessary to update the Canberra’s EW fit and there was a corresponding need to modernise the original navaids. In 1985, therefore, WD955, was flown back to Samlesbury to act as a

trials aircraft for a new electronics suite. This time we could afford to update only half-a-dozen aeroplanes to the new T Mk 17A standard but, with their much enhanced capability, they served the squadron well for the rest of its life.

The T.17A had a wide-band spectrum analyser, its 20 GHz window, permitting the operators to cope with the frequency agile radars which used to be able to 'hop' outside the mere 20 MHz covered by the old APR-9s. The new active equipment included a 1 Kw communications jammer, a 3 Kw frequency-controlled I-Band jammer (which actually went just into J-Band) and an enhanced noise/repeater jammer. The installation involved the replacement of all of the original wave guides and the provision of new aerials. The new E/F antenna in the nose, for instance, produced a more sharply focussed 17.5^{o} beam giving a much higher Effective Radiated Power (ERP) while a new omni-directional D-Band aerial beneath the aircraft gave a respectable 15db gain.

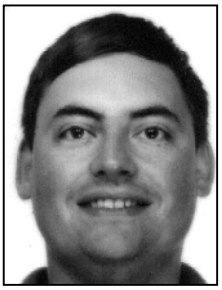
Despite its limitations, the T.17's kit permitted us to play some relatively sophisticated tricks. I recall, for instance, visiting UK radar sites to show the operators that, even with their ECCM features operating, they could be deceived into believing that they were not actually being jammed. Probably one of the more valuable lessons that we were able to teach the AD operators was not just that it was possible to work through jamming, but that, unless they were vigilant, it was possible to persuade them that they did not have a problem and that there simply were no targets out there.

It was, perhaps, a pity that No 360 Sqn never had a formal war role. I am sure that it could have made a useful contribution to an offensive and, had it been seen in that light, the funding of updates might have been easier. Had the chips really gone down I suppose that they might well have been pressed into service, even if only as command and control relay aircraft, and the squadron certainly became involved in some urgent trials work in connection with attempting to counter the Exocet threat during Operation CORPORATE. As it was, the squadron did not long survive the end of the Cold War and it was disbanded in 1994. Like so many other military functions, the EW training role has now been put out to civilian contract. Sad, but true.

Those who did not attend this seminar will be unaware that one of our scheduled speakers withdrew at short notice. The resultant gap in the programme was filled, at even shorter notice, by Flt Lt Williams. As those who were present will recall, his presentation was computer-based, including animated segments and spliced video inserts, amplified by an unscripted commentary. As such, it was an essentially visual experience and, since there was no 'paper' in the conventional sense, it did not lend itself easily to reproduction in our journal. Fortunately, however, the presentation was recorded and what follows represents an attempt to condense and adapt what was actually said to reflect the core of Flt Lt Williams' presentation. It appears here with his endorsement. Due to one of those 'exigencies', to which the Service is so prone, Flt Lt Williams' contribution also had to be inserted out of sequence; here it has been presented at the end, to conform to the chronological pattern of the rest of the day. **Ed**.

SOME THOUGHTS ON PLATFORM PROTECTION SINCE THE GULF WAR

by Flight Lieutenant Larry Williams



Flt Lt Larry Williams joined the RAF as a navigator in 1987 and has logged more than 1500 hours on strike/attack Tornados, including ten operational detachments from DESERT STORM onwards. He is a graduate of the GD Aerosystems Course and is currently the Operational EW Specialist on the staff of the Cranwell-based element of the RAF Air Warfare Centre which has its HQ at Waddington.

Sadly, the Air Warfare Team's stock in trade is current practice and future developments. We do not dwell on history in any depth so what follows may be a little different from what you are used to because it is bound to fall outside your normal timeframe. What I shall try to do is to provide you with some impression of how electronic warfare is conducted today and of the increasing sophistication and complexity that is involved. The period is roughly the 1990s – the Gulf War and its immediate aftermath.

The first point that I should make is that a lot of the technologies

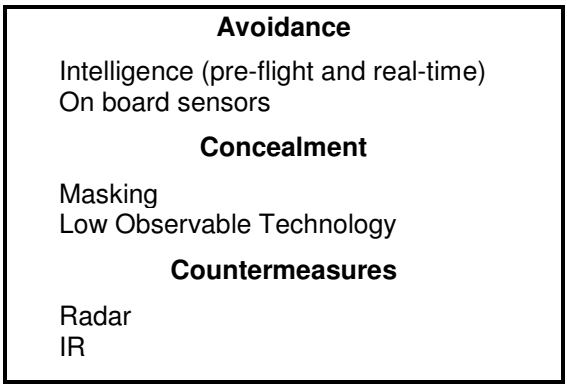


Fig 1. Defensive Measures

and devices employed during the Gulf War were being used for the first time. As a result, a lot of lessons were learned. Needless to say, we were not fully prepared and a lot of the kit did not work quite as expected. That is not to say that they failed to function so much as that they did not necessarily do exactly what we had expected them to do – the difference between theoretical concepts and field practice.

There is a tendency to associate electronic warfare with offensive operations, with the attack role, but it is equally applicable to helicopters, unmanned drones or heavy transports, indeed any aeroplane that is likely to find itself operating within reach of the enemy's weapon systems. Hence the title to this presentation; in the current defence *patois* we speak of 'platform protection'. Nevertheless, because I have a Tornado background, my comments will tend to concentrate on the attack role.

So how do we go about 'protecting our platform'? The ground rules are laid out in Figure 1. As the three headings imply, the idea is not to get into a fight at all. Rule One, therefore, is to avoid the enemy altogether. To do that you need accurate, current and reliable intelligence. Anything less and you are at risk. We have a wide range of intelligence-gathering resources at our disposal today, ranging from satellites, through dedicated manned and unmanned reconnaissance aircraft to ground monitoring stations. While this capability permits us to obtain information, however, we still have a problem with disseminating it. Leaving aside the traditional reluctance to reveal

sources, it is a fact that once you begin to transmit information down the command chain you risk its being compromised, even if it is encrypted, and once the enemy knows what you know he has regained the advantage.

The answer, of course, is to use secure transmissions but this is easier said than done if you want to be able to relay real-time information right down to a crew in its cockpit. At present only the Americans have any sort of realistic capability in this field but it is slowly becoming more widely available and secure radios are just beginning to appear in the RAF's inventory. The ultimate answer lies in secure datalinks because they can be even more heavily encrypted and they can relay information at much higher rates. This sort of technology does not come cheap of course and, for the moment, for the RAF, it is not widely implemented, although we shall no doubt acquire the capability for all our offensive platforms in due course.

Having obtained your high-grade intelligence, how do you use it to avoid the enemy? Basically by designing a route that will minimise the risk of exposure to enemy installations and by flying at low level to 'hide' in the terrain. Once in flight, on board sensors can continue to provide the attacker with an edge because, with luck, the rules of physics will ensure that you will detect the enemy searching for you before he receives a reflected signal strong enough to let him know that you are there.

We have effectively moved on to our second heading, Concealment, so let us, with my fast-jet bias, consider the Tornado in this context. The Tornado was designed to operate at low-level. and, although the first few missions of the Gulf War were flown in that environment, we were employed largely at medium level. By medium level I mean about the 20,000-foot. mark because an aircraft like a Tornado cannot get much higher than that with a worthwhile load on board. As it turned out, this made surprisingly little difference in terms of 'masking'. The aeroplanes had already been repainted in 'sand' and we found that this actually worked rather better at medium level than it had done down on the deck where the aeroplanes had tended to show up surprisingly well. The whole question of camouflage is currently being re-examined. Quite clearly, it is not an easy problem to solve because one needs to consider differing terrain, seasonal variations and so one, not to mention the fundamental question of

whether one is trying to hide an aeroplane against the sky from an observer on the ground or vice versa..

There is more to 'masking' than simply giving an aeroplane a coat of paint of an appropriate colour. Other measures that we can take include suppressing its infrared emissions, maintaining electronic silence and applying a coating of radar-absorbent material. The idea behind 'stealth' is, of course, to reduce the response produced on the enemy's radar. To do this properly, however, one needs to start at the drawing board stage and this can produce some bizarre shapes, like the F-117 and the B-2. Unfortunately, the Tornado was drawn some thirty years ago, before low observable technology had become fashionable. Consequently, despite the undoubted sophistication of its aerodynamic design, in terms of the electromagnetic spectrum it could be described as a breeze block with a couple of engines on the back. In short, the Tornado tends to paint well on radar scopes and it produces a large infrared plume.

These characteristics are less critical at low level because there one tends to be exposed to a threat only fleetingly but our move to medium level meant that we were now vulnerable to many more systems, of many different types and for far longer. It also meant that the enemy's radars were now free of ground clutter. There are ways to suppress returns from static objects, of course, but these are added complications and if the opposition no longer has to worry about this aspect, it is one up to him. Perhaps surprisingly, one of the more significant risks to which we were exposed by operating at higher levels was that of conventional AAA. Nevertheless, one still has to consider more sophisticated systems like the SA-10 and its associated FLAP LID radar.

Another factor which concentrated our minds during the Gulf War was the proliferation of man-portable air defence systems (MANPADS). Generally speaking, these run out of steam at about 10,000 feet, so they did not represent a significant threat while we were operating at about twice that height. Unfortunately, one could be obliged to come down to deliver weapons or to lose height in the course of evasive manoeuvres. Even more frightening, however, was the prospect of an insurgent hiding in the scrub or in a derelict building several miles out on the extended centre line of your home runway with a tube-launched, IR-homing rocket tucked under his arm.

When you are deployed abroad to operate from bases provided by a friendly government which may not actually reflect the bulk of public opinion, this becomes a very real possibility. This was hardly the case when we were operating over Kosovo from airfields in Italy but even there it would not have been too difficult for special forces to have been inserted and had they succeeded in knocking down just one of our aeroplanes it could well have had a significant effect on operations.

Moving on, let us consider the components of what we might regard as an ideal defensive electronic system.

Long-Range Jammers. Epitomised by the USAF's EC-130H COMPASS CALL, such a system carries devices which are capable of interfering with communications and datalinks, the aim being to stand-off at a relatively safe distance and disrupt the enemy's command and control network, including links to missile systems.

Dedicated Tactical Jamming Aircraft. The best example of a dedicated jammer is the US Navy's EA-6B Prowler, a four-seater which accompanies a strike force providing protection en route to, and in the vicinity of, the target by jamming local enemy transmissions, including disrupting his fire control radars.

Self Protection Jammers (SPJ). An SPJ is usually mounted in a pod and carried externally. They are not very big so they tend not to have very much inside, the idea being to create as much havoc as possible on a small budget. As such they are effective, since they do provide each attacking aeroplane with some ability to interfere with a selection of the enemy's electronic systems. It should be appreciated, however, that no podded system has the capacity to cover the entire electromagnetic spectrum, so there will always be an element of vulnerability. Under this heading one might also include chaff dispensers and IR decoys.

Anti-Radar Missiles (ARM). ARMs, which have been in widespread service since the 1970s, come with varying degrees of sophistication – and expense. They may be carried by aircraft dedicated to the suppression of enemy defences, like the F-16CJ, or as a self-protection device by an aircraft such as the Prowler.

Needless to say, only the Americans can afford to deploy electronic warfare systems on a scale as comprehensive is this. So far as the RAF is concerned, dedicated jamming aeroplanes are simply

beyond our budget. On the other hand, we have been using SPJs since the 1970s, initially the Westinghouse ALQ-101 pod and, specifically for the Tornado, the Skyshadow pod. We also have chaff/flare dispensers, again, mostly pod-mounted, like the Tornado's BOZ-107 and the Jaguar's Phimat. The RAF has also deployed ARMs, MARTEL to begin with, but currently ALARM which was rushed into service just in time to be blooded in the Gulf War.

Taking the Tornado as an example, it carries what has become the more or less standard fit for a small attack aeroplane. It has a Radar Warning Receiver (RWR) which, as its name implies, lets the crew know that their aeroplane is being 'painted' by an enemy radar and provides some indication of what type of radar it is and where it is. Put simply, the crew's options are then: to remain silent and/or take evasive action; if appropriate, to dispense chaff and/or activate their Skyshadow SPJ; or, *in extremis*, to request an ARM firing from escorting aircraft. While the individual systems may have been upgraded over the intervening years, this arrangement has changed little since the Tornado first entered service. As I have already noted, however, the aeroplane had always been intended to operate at low level. We now operate increasingly at medium levels and this has created problems.

When the RAF first began to install RWRs in the late-1960s, it was totally wedded to low level tactics. The receiver aerials were therefore installed as high up as possible in order to give them the widest possible field of view, as on the Phantom, Jaguar, Vulcan and eventually, the Tornado. Unfortunately, while the tip of the fin may have been the optimum location at 500 feet it could not have been worse at 20,000 feet because the receiver now needs to look down and its field of view is largely obscured by the airframe. Furthermore, even when signals are detected, they tend to have been distorted by reflections from the airframe so that the directional information derived may often be corrupt. This problem has been under investigation for some time; practical experimentation has even involved taking a Tornado to the USA to have it suspended within an anechoic chamber for trials.

This RWR business, and indeed jamming, is clearly a lot more complex than we thought in the early days and deeper analysis has shown that there are other previously unsuspected weaknesses,

Podded System (eg Skyshadow/ALQ-101)	**Integrated System** (eg Zeus)
Relatively inexpensive	Expensive
Fewer units required	Each aircraft requires a full fit
Simple connectivity	Complex connectivity
Poor integration with aircraft	Good integration with aircraft
Takes up a weapon station	Leaves all weapon stations free

Fig 2. Podded v Integrated Systems.

polarisation, for instance. There is not time to launch into lengthy technical explanations beyond saying that, like light, all electromagnetic radiation is polarised. If the aerials of your RWR (or your jamming pod) are polarised in one direction and the opposition's system is polarised differently you may not be able to detect it and/or interfere with it. During the Gulf War this problem cropped up with the Roland missile, of which the Iraqis had substantial numbers.

Thus far I have tended to talk about podded systems, as fitted to the Tornado and Jaguar. But there is an alternative in that self protection can be integrated within the airframe, as with the Zeus system fitted to later marks of Harrier. Figure 2 summarises the pros and cons. There are obviously pluses and minuses associated with each approach but the one that carries the greatest weight with me is that if anything goes wrong with a podded system you can drop the pod and fit another one; if your integrated system blows a fuse you have to change aeroplanes, which presupposes that a spare will be available. There is also the cost factor, of course, which tends to drive us towards the cheaper option.

Reverting, for a moment, to the RWR problems that were created by the move from low to medium level ops, something similar happened with our jammers. The relatively low power output of our pods was partially compensated for by the use of highly directional transmitter arrays and this arrangement was adequate for the short range engagements associated with the low level case. At 20,000 feet, however, you might be engaged by a system 20 or 30 miles away and well outside the fore and aft polar diagram of your pod's aerial. What to do? You could forget the pod and run for it or turn to confront the threat by pointing the aircraft at the transmitter so that it will receive the full benefit of your jamming. The latter approach was positively recommended by tacticians at one time but it requires something of an

act of faith to believe that an electronic box out on the wing is going to deliver you from evil, rather than simply running away.

Thus far I have dealt largely with radar; I am now going to move on to consider something slightly different – infrared. While infrared radiation is as much a part of the electromagnetic spectrum as radio, we perceive it rather differently because it is so close to light that we can (almost) see it and this does mean that it has distinctive characteristics. We have been using flares since the 1960s and these relatively crude 'fireworks' sufficed until the 1990s. They worked on the simple concept of providing the incoming heat-seeking missile with a more attractive (bigger, brighter, better) target and seducing it away from your jet pipe.

By the 1980s designers were beginning to devise flare rejection systems that could discriminate between an aeroplane and a decoy and by the 1990s these were becoming available in missiles like the French Magic, Israel's Python 3, the American AIM-9M Sidewinder and the British ASRAAM. Since then the game has become increasingly complex. It is no longer considered sufficient merely to deflect a missile; we need to do it without its knowing that its happening. That way the opposition will be led to believe that its equipment is at fault because, so far as they are aware, you are not actually dispensing flares. The keys to this sort of technology are intensity, kinematics, spectral ratios and spatial/point source rejection.

Intensity. Intensity is not a new problem; we had encountered it over Iraq where we learned (a trifle late) of a long-standing weakness. In 1990 there were two sorts of flares, those being marketed by the West, and those available to the Warsaw Pact. They were fundamentally different in that the Western ones all had a fast rise time – they reached full intensity very rapidly. The Russians knew this and they had taught their missiles to ignore any sudden new emission in the vicinity of the target. The Iraqis, had Soviet missiles The answer, of course, was to convert to flares that had a slower rise time or to use a sequential dispenser. The aim was eventually to flood the missile's viewfinder with very high intensity radiation but at a constant level, so that it did not perceive a rise

Kinematics. Kinematics is to do with the missile's ability to distinguish between the relative speeds of the aircraft and the flares which it ejects. In its simplest form, since a conventional flare will fall

behind the aircraft, the missile is simply programmed to home on the fastest source, the one at the front of the string of flares, which is bound to be the dispensing aeroplane. There are a number of ways to overcome this, most of them being variations on the theme of directional dispensing. Put crudely, if you fire a flare ahead of the aircraft the high speed decoy will be at the front of the queue. Extending that idea, if you have a self-propelled flare it could fly in formation with you, so that there would be two (or more) 'fronts' to the queue. The most popular approach is probably the towed decoy which has no relative motion compared to the mother aircraft but which could be arranged to duplicate its emissions but at a higher intensity thus presenting a juicier target. .

Spectral Ratio Discrimination. Spectral Ratio Discrimination works on the principle that the emissions from a conventional flare are not *exactly* the same as those of the aeroplane it is supposed to represent. On that basis, it is possible to introduce frequency filters that can discriminate between the two sources permitting the missile to identify and reject the flare. The answer to this one, of course, is spectrally matched flares, ie cleverer flares which mirror more precisely the radiation of the aeroplane they are trying to duplicate. This will not be cheap.

But there is some light at the end of this particular tunnel. The solution may lie in the Activated Metal Decoy (AMD). In essence, an AMD is metal foil which has been given a pyrophoric coating. That is to say, a coating which, when exposed to the atmosphere, heats up spontaneously and radiates in the IR spectrum. Exactly how it is done is a process that is still known only to the manufacturers but it is possible to arrange for the emissions from an AMD to coincide closely with those of the dispensing aircraft. This system has four major advantages. First, it is relatively cheap. Secondly, because the foil is *very* thin, you can carry *very* large quantities of it, indeed so much that it can be dispensed continuously, rather than in response to a specific threat warning, which is a major plus. Thirdly, it is reasonably environmentally friendly. Host nations tend to dislike people dispensing flares over built up areas immediately after take off, which aircrews, conscious of the possibility of a missile-toting insurgent up a tree, are inclined to do. While AMD's do emit, they do not actually glow, nor do they burn, so there is no fire risk. Finally, and going back

to a point that I made earlier, because AMDs can accurately duplicate the target but do not actually glow, the missile cannot tell that is 'seeing' them so it does not even attempt to discriminate. It is simply seduced into failing to hit its target without ever knowing why, thus undermining the opposition's confidence in the entire system. Alternatively, the missile may not actually manage to lock on with sufficient confidence to warrant its being launched at all.

Spatial/Point Source Rejection. In its simplest form, point source rejection relies on the fact that the seeker head in the missile rotates, aiming to achieve an equal distribution of received energy around the entire 360^{o}, thus ensuring that it is bore-sighted on the target. When a flare is discharged it will cause a bloom of energy in one sector, thus distorting the centroid. The dispensing crew is hoping that the missile will attempt to equalise the received radiation by steering off. The missile designer will have incorporated circuitry which will permit the missile to tell, perhaps because of its relative rate of movement or the comparative intensity of the two emissions, that this is a decoy and to ignore the transient signal. An extension of the point source rejection technique involves creating an identifiable image in the missile's 'brain'. The emissions from the vicinity of an aircraft's jet pipe are not uniform. In much the same way as the eye can differentiate between the photons reflected by an object to perceive its shape visually, so it is possible to do this in the infrared spectrum to create a similar likeness. For the purposes of discrimination, it is not necessary to take this process to extremes but a missile can be equipped with a simple system capable of determining that it is looking at a complex and constant shape. When the bright, moving point source represented by a flare appears, it can be rapidly rejected as not forming part of the original 'picture'. The counter to this sort of thing, there always is one, may lie in 'amorphous flares'. Not dissimilar to AMDs, the idea would be to generate a large diffused area of IR radiation, rather than a point source; one that blanks out a relatively large area enveloping, and thus obscuring, the target.

Much of this IR technology is still in the development stage so I will come back to reality with Chaff. Modern-speak for the wartime WINDOW, it has been with us for half-a-century and it has not really changed a great deal. Having said that, we do use it rather more sparingly today. In WW II it was plainly impossible to hide several

hundred bombers so there was much to be said for confusing the issue as much as possible by filling the sky with aluminium. That simply would not work with modern radars which would quickly distinguish between the relatively static chaff and the moving aeroplanes so the option of wrapping yourself in a foil blanket is no longer viable. Indeed, by discharging large quantities of chaff you would actually be advertising your presence.

Today, chaff is generally employed to escape the grip of a radar that has already locked on to you, using techniques that were originally devised during the Vietnam War and have been refined and revised ever since. When the RAF first deployed to the Gulf in 1990 its Tornados and Jaguars were able to dispense chaff from their BOZ-107 and Phimat pods respectively. This was not the case with our Tornado F.3s, however, and these too had to be provided with Phimat pods – and space had also to be found to 'scab on' Tracor AN/ALE-40 flare dispensers under the rear fuselage.

Had it not been for the fact that the Iraqi defences had been pretty well disrupted during the first few days, the tactical situation was not really all that good during the Gulf War. As I have previously explained, at medium level the effectiveness of our RWR was significantly degraded by airframe blanking and our height meant that we were now detectable at much longer ranges. We could, therefore, be tracked by an IR system, or even visually, neither of which would be apparent to us but then engaged by a *radar*-guided missile. It was in this scenario that using chaff to break-lock came into its own. There were variations on the theme, but in essence, the idea was to execute a rapid manoeuvre, ideally one involving a change of both height and direction, eg rolling on one's back and pulling through, while ejecting a burst of chaff, thus exiting the area as quickly as possible and leaving a cloud of foil to occupy the attention of the missile. A moderately smart missile could be expected eventually to conclude that it was no longer looking at a proper target but, with luck, you would no longer be within its field of view.

Unfortunately, while they are broadly similar, there is no generic break-lock manoeuvre; nor is there an ideal type of chaff. For maximum effect, each radar calls for a specific reaction with the right amount of chaff of a particular specification being dispensed at the right moment. There is no way to store this information other than in

one's memory and your retrieval system needs to be well-oiled because an engagement can occur at very short notice and one needs to be able to identify the threat and then react instantly.

To wind up, I will look briefly at Eurofighter. It will have wingtip pods containing the RWR aerials and self-protection jammers. Chaff and flares will be dispensed from the undersurfaces of the wing. Nothing really new there, although it remains to be seen just how sophisticated the flares will be. A laser warning system with sensors on the fin and the forward fuselage flanks will be an innovation; no one has yet fielded a laser-guided anti-aircraft missile but it can only be a matter of time. Complementing that will be a missile approach warner with all-round sensors plus a towed radar decoy optimised to deal with specific radar threats. Finally, and harking back to one of my opening remarks, platform protection is not confined to tactical aeroplanes. The Nimrod Mk 4, for instance, is to have an RWR, a missile approach system, a towed radar decoy and the ability to dispense chaff and flares.

The Eurofighter will have its own counter measures capability but, like any small tactical aeroplane, it will rely on other dedicated supporting systems to provide comprehensive 'platform protection'.

AFTERNOON DISCUSSION PERIOD

Mike Meech. When reference was made to MANPADS, I gained the impression that the RAF only became interested in them at the time of the Gulf War and later. I should point out that in Northern Ireland we were very conscious of this threat way back in the 1970s when there were a number of crises involving the potential use of SA-7 against support helicopters. Furthermore, during the Soviet involvement in Afghanistan, the guerrillas were being supplied with Blowpipe and Stinger so I would have expected the RAF to have been interested in that as well.

(Afterthought. As I recall, throughout most, if not all of, the 1970s and '80s all RAF aviators were required to be familiar with Operation TESSERAL. Applicable at stations overseas, as well as at home, it laid down the procedures to be followed in the event of a local problem involving MANPADS, although that acronym had yet to be coined. Broadly speaking, there were considered to be two threats, terrorism, which was not confined exclusively to that sponsored by the IRA, and the possibility of *Spetznaz* being inserted during the run-up to a major confrontation. TESSERAL procedures were often rehearsed during TACEVALs. **Ed**)

Flt Lt Larry Williams. I do take your point. But there was, I think, a difference in perception. In Northern Ireland you could *expect* a hostile reaction, that is, after all, why you were there. When we deployed to Bahrain and Dhahran we rather took it for granted that we were going to somewhere friendly and it was a nasty surprise to discover that this was not entirely the case and that to avoid being shot down, before your mission had even started, it was advisable to punch out flares immediately after take off. It was a very uncomfortable feeling, especially as there is no way to know whether you are being tracked by an IR-homing MANPADS and when one knows that the latest systems have a great deal of wizardry packed into them, making them very difficult to counter and thus highly lethal. What I meant to emphasise was that our exposure to these beastly little devices was a bit of a shock.

John Stubbington. You have explained that, for the last several decades, the RAF's philosophy has been to concentrate on platform protection. Do you consider there might not be some advantage in

adopting a broader view, the suppression of enemy air defences over a relatively large area, rather than merely protecting individual aeroplanes?

Williams. I am afraid that it all comes down to money. Systems like COMPASS CALL and dedicated jamming aircraft like the Prowler would be high on my wish list but the cost of such equipment, and of the advanced technologies which are embedded within them, is simply beyond our reach. Even the Americans have got it wrong, incidentally, the USAF had its own high performance dedicated jamming escort in the shape of the EF-111, the Raven. But they got rid of it shortly after the Gulf War only to conclude that that had been a mistake. This gap is currently being filled by US Navy Prowlers which are often used to support operations being conducted by the USAF and/or RAF, even when the USN is not otherwise participating. Furthermore, USAF operators are now regularly being carried in these naval aeroplanes.

The poor man's alternative to a dedicated defence suppression force is to provide an existing aeroplane with some sort of ARM, which is what we did with the Tornado and ALARM. That, I suspect, is as good as we are ever going to get. Even so, there are ways in which we could improve our capabilities, not least by shortening the time taken to introduce new devices. Secure radios, for instance, have been in the pipeline for years but they are only now just beginning to make an appearance. If it takes us four years to do something as simple as installing a radio; how long might it take if we tried to do something really complicated?

Air Cdre Graham Pitchfork. If I might pick up on your comment on the limitations of our budget, I think we should acknowledge that we are not in the game alone. We can almost take it for granted that, in any future conflict, we will be fighting within a coalition. That coalition is almost certain to include the USA whose capabilities we cannot possibly match but, under the circumstances, we hardly need to. I think, therefore, that we should keep this in perspective. We are better off concentrating on the things that we *can* do, rather than hankering after the unachievable goal of having some capability in every field. That would be unrealistic, both in terms of money and in the way in which we are likely to fight in the future.

Williams. Absolutely, after all, I can hardly disagree with my Station

Commander from my days as a student at Finningley (*Laughter*). Nevertheless, while it is plain that we will almost certainly work in coalitions in the future, there's always the time that you don't. Furthermore, if the Americans had had all the capability that they needed, I am not sure that they would necessarily want to involve others. The fact is that, even the Americans have chinks in their armour, in fact I have just returned from a three-month attachment to Saudi Arabia in support of an RAF contribution to the US ENDURING FREEDOM operation

AVM John Herrington. Might I offer a couple of comments on the lack of proper EW protection for our maritime aircraft and for our tactical aircraft based on the Continent? In 1969 I was heavily involved with the introduction of the Buccaneer at Honington, our initial aircraft being acquired from the Royal Navy. The RAF was faced with a completely new role or, at least, one in which we had not operated since the end of WW II. The current Soviet Fleet comprised modern surface ships with state-of-the-art surveillance, missile guidance and gun-laying radars along with a selection of jammers making a Soviet task force a formidable target for any aircraft to attack. When the ex-naval Buccaneers arrived they were already fitted with a wide-band receiver which permitted the crew to determine, at least, the direction of a possible threat. The navigators were trained by listening to tapes of the actual emissions of Soviet task forces at sea and this enabled them to identify, with a fair degree of confidence, the types of ships involved. Having identified the ships, they could deduce the nature of the specific threats that they might have to confront, although the Buccaneer had no active defensive ECM. It was projected to have the Martel TV-guided missile, to give it a stand-off attack capability, and the anti-radar variant of the same system which was, at that stage, still considered to be unreliable. Furthermore, any anti-radar missile suffers from a major drawback in that, unless the enemy switches on his radar, it won't work. In short, there was a major deficiency in the active ECM capability of the Buccaneer force that was assigned to maritime operations.

Over land, the situation for our Germany-based aircraft was probably even worse because, apart from fielding a huge tactical airforce, the Warsaw Pact had an extremely dense ground-based air

defence environment with radars and missiles and guns, reinforced by their armoured divisions which had integrated SAM and radar-guided AAA. Our aircraft based in Germany did have warning receivers but, again, no active jammers.

When I moved from Honington to the Ministry, in conjunction with DSigs(Air), we presented an urgent case for the provision of active jammers. The outcome of this was the purchase in 1972 of seventy-two AN/ALQ-101-4 pods which gave an aircraft a good active radar jamming capability. The intention had been to allocate these jammers to the Phantoms and Buccaneers in Germany and to the Buccaneers at Honington. There was, however, a major snag. The Phantoms operated by the RAF and RN had been modified to UK specifications. Apart from having different engines and navigation equipment, they had also had all the wiring in the wings, which the Americans had installed in anticipation of wing-mounted jamming pods, stripped out. To modify the British Phantoms would have been a very costly and time-consuming project. Fortunately, it had already been decided to replace the Phantom with the Jaguar in the strike/attack and reconnaissance roles and reassign the F-4s to air defence duties, for which jammers would not be required. In the event, therefore, the Westinghouse pods eventually finished up being carried by the Buccaneer and Jaguar and not the Phantom. They were very effective, however, and, with periodic updates, they saw active service in the Falklands and even as late as the Gulf War.

I have kept this brief, but I thought it was a piece of EW history which ought to be included in this seminar, if only to explain why it was that for much of the 1970s our Phantom crews were obliged to operate in the strike/attack role without an active ECM capability.

Ian White. Reference has been made to the reduction in the quality and quantity of electronic warfare training and/or equipment between the end of the Second World War and about 1955. What was the actual state of the Soviet defences during that period? Did they really warrant our having a sophisticated capability?

Streetly. Well, it certainly warranted the Americans putting in three separate Signals Intelligence Units to monitor it. I think there was a degree of complacency. For obvious reasons, finding out what was going on inside Russia was difficult, but I think that there was a

tendency to underestimate their capability. They started to produce indigenous radars of a reasonable quality not too long after the Second World War. I never flew against them myself, of course, but my impression is that they did make some progress.

Price. I would take a rather different view. I would say that the Russians actually took quite a long time to get going with their own radar development programme, to the extent that throughout the Korean War the North Koreans and Chinese were both using Russian radars of WW II vintage. They also used some old Japanese equipment, which enabled the B-29s operating over North Korea to use the same electronic warfare fit that they had used against Japan in 1944-45, all of which would indicate that it was quite some time before the Russians began to make much progress. The first post-war Soviet radar of any significance was the TOKEN, which was based on the American CPS-6, and that did not begin to appear until the 1950s. The first development that really impressed the West was the SA-1 missile system, which they deployed around Moscow, followed, of course, by the SA-2 with which they really got serious when they managed to shoot down Gary Powers in 1960. Before that, however, the threat had been largely confined to radar-laid heavy AAA to counter which the B-36, for example, had a couple of WW II era S-Band jammers pointing down from the nose. Overall, I would say that it did take the Russians quite some time to really get going.

Turpin. From a purely British perspective, I think it is worth stating that, for whatever reasons, and in sharp contrast to the Americans, we were not very good at exploiting the link between intelligence gathering and the need to develop appropriate counter measures - and training. In the US there was much closer co-operation between the SIGINT community and the electronic warfare community and that, I suspect, made a difference when it came to arguing the case for spending money.

Pitchfork. Perhaps I could amplify John Herrington's excellent appraisal of the way in which EW was introduced into our tactical squadrons. It was more than a need simply to defend ourselves; EW was absolutely fundamental to the way we operated. I flew with the Fleet Air Arm before the RAF got the Buccaneer and without the Wide Band Homer we couldn't actually attack shipping in a way that

allowed us to make a discreet arrival. Its use was absolutely essential in that it permitted us to remain below the radar horizon and thus stay undetected for as long as possible. We carried that sort of thinking on into the air force and by the early to mid-1970s we had been fitted with a new Radar Warning Receiver (RWR) which had been developed in the light of the experience accumulated by the Americans in Vietnam. It was an excellent piece of equipment which, along with the active jamming pod, drove all of our tactics. This was to become a key element of the Qualified Weapons Instructors (QWI) Course, since EW in general, and the interpretation and exploitation of the RWR in particular, was fundamental to the way in which we penetrated enemy defences and conducted and co-ordinated our formation attacks. It took a lot to convince some people that this was the way to go but once we had broken through the conservatism and had people manning staff appointments who had had this sort of experience, we found that others, the Jaguars, Phantoms and Tornados, followed where the Buccaneers had led. My point is that, in my view, the developments of the 1970s were quite crucial to the RAF's appreciation of electronic warfare.

(Afterthought – another one. I attended No 5 Electronic Warfare Officers Course in 1973. It involved a dozen-or-so variously-badged aircrew and was only a couple of weeks long, but this was deemed to be sufficient to make us all instant, if notional, experts on EW. Two points arise. First, the date very neatly confirms Air Cdre Pitchfork's contention that it was its experience with the Buccaneer in the early 1970s that re-awakened interest in EW within the wider RAF. Secondly, the fact that it was only the fifth course clearly implies that, prior to this, there had been relatively little promotion of 'EW awareness'. This, in turn, might also help to explain why the V-Force took so long to adapt its EW tactics to respond to changing circumstances, a shortcoming which Rod Powell and Dick Turpin both commented upon. **Ed**)

AVM Nigel Baldwin. A cautionary tale. We have heard something about the Vulcan's automatic chaff dispensers, four big hoppers containing thousands and thousands of bundles. If I remember rightly, however, when I started in the V-Force, whenever the AEOs were permitted to dispense chaff it was only a little bit at a time, a quick

burst and that was it. In the days of the deterrent, of course, wartime readiness was always paramount and as soon as the aeroplane landed the hoppers were topped up. Now, fast forward about fifteen years to 1978 when I led four Vulcans to Nellis AFB to participate in the first ever night RED FLAG. We were permitted to use all of our ECM and could, if necessary, use all of our chaff. The first time the AEOs tried it, the dispensers jammed after having discharged only 20% or so of their contents. On investigation it was discovered from the date stamps on the remaining packages that they were fifteen or more years old! The contents were so compressed that they had defeated the mechanism; we reloaded with fresh chaff and the problem went away. There has to be a moral embedded somewhere in this tale.

Sir Freddie. Always check the Sell By Date, perhaps?

Turpin. Perhaps I can contribute another, possibly apocryphal, story, related to Rod Powell's tale about the sheep. It concerns D-Band WINDOW which was rather like a rope, some hundreds of feet of foil with a square cardboard tag at one end that stabilised it as it fell. On one occasion it is supposed to have draped itself over power lines and cut off the electricity supply in the South West of England for several hours!

Price. I can give you an anecdote too? You will recall that Rod explained how difficult it was to interpret RED STEER Mk 1 and what a relief it was to have the improved Mk 2. It used to be said that there was no danger of the Soviets jamming the Mk 1 because nothing that they could do could make the presentation any worse than it already was!

CHAIRMAN'S CLOSING REMARKS

One of the advantages of a series of interesting presentations, where each one is complete in itself, is that the summing up process at the end of a seminar need not be overlong. This has been the case today. We have been provided with an excellent review of electronic warfare from its earliest use through to the present day, and have been given some tantalising glimpses into the future.

Clearly, because of the ebb and flow of the advances made by the offence and defence, there is seldom an outright winner in this complex field. Every new development ultimately meets a countermeasure, the situation being redressed by a counter-countermeasure. Although it is axiomatic that it will be our armed forces who actually engage in electronic warfare, it is almost exclusively the scientists and technicians working in industry and 'the Establishments' who will have devised and perfected the techniques involved. I believe that the work of these generally anonymous 'boffins', especially in wartime, deserves greater recognition.

While, by their very nature, electronic countermeasures tend to be intangible, they are clearly essential to ensuring mission success, not to mention the survival of the crew. With the ever-present pressure on defence spending, however, it is not easy to argue successfully for the acquisition, *and* the subsequent periodic updating, of very expensive devices which provide only *unseen* protection. Yet, in the kind of combat situation in which our forces are increasingly likely to be deployed in the future, our aircrews could well find themselves facing very sophisticated, but easily acquired, off-the-shelf surface-to-air guided weapons systems and hand-held heat-seeking weapons.

The message that has been embedded within today's seminar must surely be that the provision of area suppression and/or platform protection must be planned beforehand rather than as a belated response to heavy casualties following a particular crisis. But this is a lesson that we have been taught before.

SERGEANTS THREE – RECOLLECTIONS OF No 199 Sqn, 1952-53

John Usher, Brian Petherbridge and George Webster completed their National Service commitments by flying as sergeant air signallers with No 199 Sqn. Many years later they each contributed to a joint memoir. This document sheds a little light on the squadron's activities while providing some insight into the relatively carefree way in which things were done in the RAF of half-a-century ago. This piece, which appears with the sanction of its three authors, has been adapted and condensed from the original by the Editor.

Usher, Petherbridge and Webster arrived together at RAF Hemswell in the autumn of 1952. After reporting to the Admin Office, they were allocated their accommodation and then taken to meet Flt Lt MacGillivray, OC A Flight and the CO, Sqn Ldr Ward, before being introduced to the other aircrew members of No 199 Sqn.

As John Usher recalls, one notable pilot was FS Nash DFC, a Canadian with a very dry sense of humour who preferred his own interpretation of W/T procedures and referred to most people senior to himself as 'slant-eyed Mongolian bastards'. There were two other respected and experienced WW II bomber pilots, FSs Nicholson and Timewell, and two junior officer pilots, Fg Offs Clifford and Bishop.

Brian Petherbridge remembers two other pilots, Plt Off Honour and Sgt 'Chips' Carpenter. The latter was, it seems, 'well nicknamed 'Chips' due to the sizeable one he had on his shoulder regarding those who held the King's (later Queen's) Commission. One of his responses to authority was that he persisted in wearing his sergeant's stripes only partially sewn on!'

No 199 Sqn operated in the Radio/Electronic Counter Measures (RCM/ECM) role for which it had, at the time, six Lincolns and one Mosquito. The crew of a Lincoln comprised a pilot, navigator, engineer and three signallers (one radio operator and two special operators). The squadron's objectives were to confuse enemy radar and to jam enemy radio frequencies. These aims were achieved by dropping WINDOW in set patterns and operating electronic jamming equipment. Flights were usually of 5 to 8 hours duration and more often than not at night.

After being shown round a Lincoln by one of the regular signallers

Usher made his first operational flight on 3 November, his twentieth birthday. He flew as special operator in Lincoln WD122 captained by FS Nicholson. After a few weeks Usher became a permanent member of Fg Off Clifford's crew, taking it in turns to fly as radio op and special operator.

As George Webster explains, 'the grandiose title of 'special operator' meant that we had to learn how and when to switch jamming equipment on and off, interspersed with dispensing packets of WINDOW by lobbing them down a chute at specified intervals, say ten seconds, so that an ability to count was a distinct advantage. These activities allegedly threw into confusion anyone regarding us as hostile and trying to follow us on his radar, the WINDOW apparently causing his screen to be covered by a multitude of dots, but I never actually saw this myself at the receiving end.'

Webster enlarges on the art of handling WINDOW as follows. 'Each packet was about the size of a packet of tea and there would be about two dozen of these in a large cardboard box. On each exercise we would require around fifty of these boxes, which, to avoid undue tail-heaviness on take off due to their weight, had to be stored as close as possible to the aircraft's centre of gravity, roughly in the vicinity of the main spar. Once airborne, however, the boxes had all to be manhandled to the rear of the aircraft because that was where some brilliant designer had decided to put the dispersal chute. This shifting process had to be completed before we reached 10,000 feet, because above that altitude our movements were hampered by our being tethered to an oxygen pipe. Getting rid of the empty boxes could be a problem. I never knew what happened to the ones we brought back but, since most exercises involved some time over the sea, we usually just opened the door and threw the empties out. I did not actually discover that this was how it was done until I flew with a seasoned regular who showed me the ropes. It took me several very hesitant trips to the open door and a lot of gazing down through thousands of feet of fresh air before I finally felt capable of disposing of the rubbish in this way, without inadvertently following it out myself.'

As John Usher recalls, 'life in the sergeants mess was a comparative luxury after the regimented training and rigorous discipline we had experienced as cadet signallers. We now had our own bedrooms, waiter service in the dining room and a comfortable

lounge and bar to while away the evenings, some of which were more hectic than others. We were even treated with some respect, now that we were wearing three stripes, which was another rather novel experience.'

The daily routine revolved around the crew room, pre-flight briefings, the roar of four Merlins on take off, flying out over the North Sea at night, de-briefings on return, bacon and eggs in the early hours and then collapsing into bed. It was a glamorous life that they had previously glimpsed only in films; now they were actually living it.

Most flying was concerned with anti-aircraft gunnery and naval demonstrations, along with the regular annual exercises in which all of the Services participated. Other activities involved jamming the fighter control radars in the UK which, they were given to understand, could be done very successfully. As John Usher recalls, few incidents of note occurred during these flights 'save for the odd warning light indicating low oil pressure on a particular engine. This usually meant feathering the prop on the suspect engine and returning to base. It was quite frightening the first time it happened but it soon became a routine occurrence. In fact, if it happened early enough in the exercise on a night flight it was greeted with some satisfaction as it meant that we could return to base for an early night.'

George Webster agrees that 'there were very few major airborne incidents' but he does remember one rather alarming occasion during a take off from Hemswell. 'I was sat at my usual position below the mid-upper hatch and, just as our Lincoln lifted off, there was a sudden roar of a mighty wind above my head as the hatch came adrift, this being instantly matched by more wind-noise from inside the fuselage due to an involuntary malfunction of the sphincter. I looked up to see an unrestricted view of the stars, the hatch now being well on its way to decapitating some poor soul on the ground. After regaining a little of my composure I reported the incident to the pilot, Bob Nash, who, much to my dismay, decided to carry on with the exercise!'

Having previously noted that flying in Lincolns was fairly benign, Brian Petherbridge also recalls an occasion that could have turned out very badly. He was flying with FS 'Tim' Timewell, who, incidentally, had been a parachute jumping instructor before retraining as a pilot and he still wore his parachuting badge sewn underneath his lapel to

prove it. The incident in question occurred on return from an Exercise JUNGLE KING sortie on the night of 19 March 1953 in Lincoln WD126. 'As we were coming in to land there was a tremendous jolt through the aircraft. Tim had the presence of mind to abort the landing and overshoot on full power.' The aircraft had an undercarriage warning light on and they made several fly pasts to permit the tower to inspect for damage. On being asked to fly even lower and slower, Timewell reminded them that 'we were not a ****ing helicopter!' The presence of the Station Commander, Gp Capt John Searby (of Peenemunde fame), calmed the proceedings and it was eventually decided to attempt a landing. The crew, having been offered the option of taking to their parachutes in the dark, decided to stay where they were.

'Having been instructed to switch off all equipment I, having nervously and fumblingly switched off the radio, etc, proceeded to the prescribed crash position for the Wireless Operator, only to find that a squadron leader navigator (not a crew member) had beaten me to it. He was sitting, rearward facing, against the main spar, and after some hesitation I proceeded to sit in his lap, thinking I would perhaps get a little greater protection by using him as a buffer. On our final approach when the instruction 'Brace! Brace!' came, I think I overdid my reaction a little for the officer later reported that he had been unable to speak for some time through having had all the breath squeezed out of his body by a certain 'Widget' Signaller who had been sitting on his knee!

The landing proved to be one of the smoothest I had ever experienced, thanks to Tim, but as he was reluctant to apply the brakes, due to the uncertain condition of the undercarriage, he steered off the runway onto the grass. We kept on rolling and, under instructions from the more experienced crew members, we jumped from the rear hatch and, in turn, kept placing our parachute packs under the tail wheel in an attempt to slow the aeroplane down. All ended well, but I must confess that I more than once wished I had enlisted as a cook!

It transpired that the obstruction we had hit was a stone enclosure normally used to accommodate a Landrover-mounted BABS system. The cause of the incident was initially attributed to 'pilot error', but it was later established that it been due to a maladjustment of the

lighting system that permitted the pilot to maintain the correct glidepath.'

On a lighter note, Petherbridge was involved in another anecdote involving Timewell. The occasion was a group visit to Lincoln's *Theatre Royal* which had established something of a reputation for its 'girlie' shows. 'We were seated in the front row and it transpired that Tim had brought with him some strips of aircraft fabric. His trick was to wait until a girl did the splits and then tear a piece of this stuff just as she was landing, causing her eyes to open extremely wide, much to the amusement of the audience. This eventually stopped the show until the theatre manager came on stage to restore order.'

Petherbridge also recalls another potentially alarming incident which occurred during a long and boring return flight from a night exercise. The aircraft concerned was known to have a slight hydraulic leak which, over a period of time, would allow one of the flaps to droop. Since this could not be seen from the cockpit, the drill was for the other crew members to keep an eye on the situation and report it so that the air engineer could sort it out, presumably by restoring the pressure by pumping manually. On his way back from a visit to the Elsan, Petherbridge observed that the flap was drooping quite excessively. On regaining his station, before resuming his nap, he called the pilot on intercom but received no response. Assuming that his intercom might be at fault, he made his way forward, past the second special operator who was fast asleep. Further forward still he discovered that the radio operator was also asleep, as were the navigator, engineer and captain. Petherbridge gently prodded the pilot into life, delivered his message and went back to his 'bed', the homeward flight continuing without anything further being said but, ever since then Brian Petherbridge has 'considered the Bermuda Triangle to be anything but a mystery.'

In February 1953, after de-icing the wings of the aircraft, most of the squadron took off from snow-bound Hemswell to touch down at Castel Idris seven-and-a-half hours later. This was the start of a month's exercises with the Mediterranean Fleet and a chance to get their knees brown. Most of the flying was over the sea, with frequent sightings of HMS *Eagle*. Many years later Brian Petherbridge would discover that an old school friend had been aboard the carrier at the time while serving with the Fleet Air Arm and he 'well remembered

the ‘Brylcreem Boys’ playing ‘silly buggers’ when one of the Lincolns flew alongside with its undercarriage down as if intending to land.’

Petherbridge took part in the Libyan detachment as a member of Carpenter’s crew. He remembers that jamming operations always had to be suspended while the RN took lunch. During one of these intervals, Carpenter decided to take a close look at Mount Etna. The commissioned navigator warned him not to fly too close due to the possibility of updraughts. ‘Needless to say this provoked an immediate reaction from Chips and I have dined out on the story of my having flown *inside* the crater of Mount Etna ever since.’

Having also found time to indulge in a little low flying over the Libyan desert, much to the consternation of the locals, the detachment moved on to Gibraltar for a week but, due to an engine failure, this was extended for John Usher’s crew who did not get back to the cold and damp of Lincolnshire until 11 March.

All three contributors now look back on their two years in uniform with affection. George Webster probably speaks for them all of them when he sums up his experience by observing that, ‘starting from scratch, I had acquired sufficient skill to help manage a warplane, spent 312 hours in flight braying away at a Morse key and, quite officially, scattering silver paper to the four winds to mess up the task of some other poor sod on the ground who was trying to find out what we were doing and where we were going from his radar screen.

It hardly seems a lot but I am glad to have had the experience. I often think back to the day I first registered for National Service and was undergoing interviews and medical tests. A kindly gentleman suggested that, being an ex-grammar school boy, I should, of course, apply for aircrew training. I looked at him as if he were unhinged. The very thought of flying frankly appalled me and a lengthy debate ensued, raging on my part and soothing on his. Fear of the unknown can be a powerful impediment to progress and personal development but, thankfully, on that day the other man won the argument. Would that I were able to shake his hand now, after all these years, for talking me into doing something that was so very worthwhile.’

FEEDBACK

Did trainees ferry aircraft back across the Atlantic in WW II?

(*This letter relates to some discussion, recorded in Journals 22 and 23, as to whether any North American-trained observers/navigators of WW II returned to the UK by ferrying an aeroplane across the Atlantic. Some did, before they had even finished their training!* **Ed**)

I trained as a navigator at USNAS Pensacola early in 1942. There were twenty-four of us on the course, which was strong on theory but very weak on practice. My log-book shows that I had less than 30 hours' flying when I finished the course, and most of that was over the Gulf of Mexico, taking drifts on wave-tops! We did no night flying at all. Nevertheless, we were informed that at the end of the course those who finished in the top six in the final examinations would be posted to Dorval, Montreal, to navigate a ferry-delivery aircraft back to the UK. I was lucky enough to be one of those six. None of us was presented with a brevet, however, nor were we promoted from the rank we had held during training, so we were still mere LACs.

At Dorval the six of us were teamed up with very experienced civilian pilots, equally experienced civilian wireless operators and second pilots newly qualified from flying schools in Canada. We familiarised ourselves with the aircraft, Lockheed Venturas, did ditching drills, were briefed and rebriefed, and eventually set off on our first flight, to Gander, Newfoundland. (A friend from my Pensacola course, with whom I am still in close touch, tells me that his crew did a lengthy training flight, much of it at night, but we did no such thing.) At Gander, we spent a fortnight waiting for a wind with sufficient of a tail-component to ensure that our little twin-engined aircraft would make it across the Atlantic. Eventually, the wind relented, and my pilot decided that he could safely set out to make the crossing in one stage; meanwhile some of the other crews had gone via Iceland, and even via the newly constructed American airfield in Greenland. We made landfall in Northern Ireland, eventually landing at Prestwick 11 hours and 20 minutes after leaving Gander. When I climbed out, the reception party were somewhat amazed to see that I was still a brevetless LAC. I believe that many of the Venturas we ferried at that time were lost in the daylight raid on the Philips factory at Eindhoven in December of the same year.

I subsequently spent a week or two at the Personnel Reception Centre at Bournemouth, before going on to an AFU in the Midlands. The course there should have lasted eight weeks, but the rapidly expanding Bomber Command was hungry for new crews, so after only five weeks, and at less than 24 hours notice, we were posted to an OTU. Stores issued us unceremoniously with brevets but there was no time for commissioning interviews so we all went off as sergeants, a fact which most of us resented at the time, but for which I was later wholeheartedly grateful. Had I been a pilot officer, it is very unlikely that I would have crewed up with the exceptional young Canadian pilot whom I did join. He turned out to be a master of his craft, who saw his crew safely through two tours of Lancaster operations, before sadly losing his life over Berlin well into his third tour.

So, in answer to the question posed; 'Did trainees ferry aircraft back across the Atlantic in WW II?' Yes, indeed they did, although perhaps not quite in the context of the article in the Journal.

Arthur Spencer
Weston-super-Mare

Recollections of the Meteor

AVM Dick's recollections of the delights and hazards of flying the Meteor, reproduced in Journal 27, rekindled memories of my own.

Squadron flying with the Meteor was an exhilarating experience - most of the time. But during training several of my contemporaries had their lives and careers brought to a tragic end as a result of flying accidents, including those at the advanced schools of the 1950s; Worksop, Driffield, Merryfield and Weston Zoyland come to mind. Limited ground training aids meant that airborne instruction was the only way of experiencing many aspects of operating the Meteor trainer and its sister single-seat fighter, the F Mk 8, then in service with No 211 Advanced Flying School at Worksop. Competence in asymmetric handling, acceleration to the onset of compressibility and engine re-lighting were all obviously essential, if practised excessively. True simulators were, as yet, on the distant horizon, but perhaps more could have been done to good effect by improvising cockpit mock-ups for instruction on the ground. The cost of training accidents precipitated by simulating unlikely engine failure was

enormous. There were other non-engine related incidents. Altimeters were misread by 10,000 feet, sometimes with disastrous results. In contrast, three year's squadron service on the Meteor NF 11 at Ahlhorn and Geilenkirchen in Germany, saw few incidents and engine shut-downs in anger were rare.

Because descent for an approach and landing was dependent on ground-based air traffic control, radio failure was a serious peril - although almost unknown in practice. Basic aids to navigation in the earlier marks of the Meteor were substantially enhanced in the night-fighter versions by virtue of their two-crew operation. The navigator operated the Airborne Interception radar (AI Mk 10 in the NF 11) and GEE enabled him to plot fixes from signal pulses received from ground stations. Of wartime pedigree and with some limitations, both the AI and GEE were effective in capable hands. To cope with a total radio failure above cloud, however unlikely, the squadron had developed a contingency airfield approach, a so-called 'weapon let down', using these integral aircraft systems. I recall the new Senior Air Traffic Control Officer (SATCO) being briefed on the procedure: 'The navigator directs the pilot across the North Sea coastline and identifies the distinctive shape of the Wilhelmshaven Basin on his AI. He then turns south and picks up the radar returns from the large hangars at the RAF fighter bases at Jever, then Oldenburg, and finally Ahlhorn itself. The let-down can then continue safely to below a cloud base of 600 feet using GEE to home in for visual contact with the airfield. That, Sir, is our weapon let down.' The SATCO knew it was not April Fools' Day, but could all this be serious? 'Deadly serious', he was assured. Bewildered and no doubt duly impressed, he left the briefing commenting impishly, that he was grateful for the briefing, but until now the only weapon let-down he had ever heard of was a cold shower.

There were unexplained losses of the Meteor, including the unpressurised Mk 7 two-seat trainer. The aircraft flew fairly contentedly at 35,000 feet, although by this altitude the crew would be feeling the effects of the thinning atmosphere around them. The onset of decompression sickness could manifest itself in several ways, including, in my case, a tingling feeling as nitrogen, lurking in an old wrist injury, began to expand. 100% oxygen was, of course, vital. Although I cannot recall achieving 40,000 feet in a T.7, much less

A Meteor NF 11 of No 256 Sqn. (MAP)

46,000 feet, the adverse physiological conditions of continued unpressurised operation at these altitudes would have been dire indeed, with the twin Rolls-Royce Derwent engines close to exhaustion.

Within a few months of my joining No 256 Sqn at Ahlhorn, the Command Instrument Rating Examiner (CIRE) entered the crewroom. The CIRE examined the Squadron Instrument Rating Examiner, who in turn checked out squadron line pilots. As such, he enjoyed a revered status and his aura equalled, if it did not actually surpass, that of the Station Commander. On this occasion he was about to take a dual-seat Meteor to Little Rissington where the Central Flying School would renew his own qualification. He had offered a welcome trip home to a ground branch colleague, who, at the last moment, could not take the time off. A squadron pilot seemed to be his best alternative - I was available and was duly 'volunteered'. To fly with this master practitioner was a privilege. We were to take off from Ahlhorn and set a westerly heading for Tangmere, where we were to clear customs and refuel before completing the short leg to Little Rissington. As safety pilot in the front seat, I started the engines, taxied to the take-off point and confidently handed over to my expert back-seater for an instrument departure.

Take-off and climb were examples of precision instrument flying, par excellence. No surprises here, while my job was to maintain a look out and clear the flight plan with air traffic control. To my astonishment, after about twenty minutes, now level at 35,000 feet and

approaching Rotterdam, our heading and altitude began to waver - at first by only a few degrees and a couple of hundred feet, but soon by larger margins. I checked over the intercom with my CIRE rear pilot that he was indeed aiming for a heading of 270°, while maintaining 35,000 feet. No response. I checked again; still no acknowledgement. 'I have control,' followed and on looking rearwards, I could just make out a slumped figure who was clearly unwell. Was he hypoxic, or, in the preferred aviation medicine term of the day, suffering from anoxia? There was no time for any delaying analysis at this point.

Out went the air brakes and an immediate descent was almost instinctive. With a diminishing fuel state, I turned back towards Ahlhorn and called for a priority landing and medical services. The ambulance crew and OC Flying met the aircraft. My unconscious companion was removed from the rear seat of the Meteor and rushed the few miles north to the RAF Hospital at Rostrop. Sadly, he did not recover. Decompression sickness was diagnosed. Coupled with oxygen deficiency, could such a lethal cocktail have contributed to several unexplained losses? With no other pilot on board, as was the original intention, could my sortie across the North Sea, otherwise have been yet another mysterious disappearance - 'cause unknown'?

Gp Capt R D Bates
Blockley

BOOK REVIEWS

There is a surfeit of reviews in this edition because, being a 'stand alone' hardback, our previous publication contained none at all. **Ed**

German Jet Engine and Gas Turbine Development 1930-1945 by Antony L Kay. Airlife; 2002. Price £45.

With 296 pages of text and photographs, this formidably priced large-format book is weighty in all senses of the word. Yet if one were to price this book in terms of pence per item of information not previously published, it would undercut by a wide margin a large proportion of the aviation books currently on sale. Anthony Kay's service to history is that his book reveals how many gaps exist in the other published accounts on this subject.

During the late 1930s and early 1940s, engineers trying to produce working gas turbine engines had to work from first principles on many aspects of their designs. But for those in Germany trying to design an jet engine suitable for large-scale production, it was if they had to work with one metaphorical arm tied behind their backs. Metallic elements such as chromium, molybdenum, nickel and tungsten, the ingredients of choice for high temperature resistant alloys and readily available to everyone else, were always in short supply in the Third Reich. And things got progressively worse as the war situation deteriorated.

The German engineers worked with great dedication and imagination looking for ways around the various problems, but to the end their gas turbines remained short-lifed, unreliable and intolerant of rough handling. The Jumo 004, the German jet engine produced in the greatest numbers, used flame tubes fashioned from mild steel with a coating of aluminium baked on to prevent oxidisation. That material was clearly not up to the task, and after just 25 hour's running the combustion chambers had usually to be replaced in an overhaul that involved stripping down the engine.

One passage in the book underlines the profound difference between the running lives of Allied and German jet engines in 1945. The Americans had captured intact BMW's high altitude test chamber near Munich, a facility which had no Allied equivalent. Allied turbojet engines were brought there for testing, including the De Havilland Goblin which powered the Vampire fighter. Kay recounts that: 'After

the first period of running, the German engineers assisting with the work asked if they should open the test chamber for inspection of the engine. When told this was unnecessary, they were greatly surprised, since they had no experience of a turbojet running for more than five hours without some attention…..' The Goblin I engine ran for 42 hours before it needed to be examined, while the later Goblin II ran trouble-free for 71 hours.

Anthony Kay is to be complemented on his diligent and lengthy research. The word 'definitive' has been devalued by overuse in the publishing world, but Anthony Kay's book is worthy of that accolade.

Credit is also due to Airlife Ltd for publishing this important work. One can imagine that there was much sucking of teeth by company executives, before they agreed to put up the money to publish so large a work on so limited a subject. But this reviewer for one is grateful that they did.

Dr Alfred Price

Desert Wings - A Hurricane Pilot in the Western Desert by Peter Holloway. Melverley Publishing (Bryn Mair, Alaxandra Park, Penmaenmawr, LL34 6YH); 2001. Price £15.

This is the story of Flt Lt Arthur Weller DFC who flew Gladiators and Hurricanes with Nos 80 and 274 Sqns before he was killed in a flying accident in the Sudan in 1941. The author, who is 'Sam' Weller's nephew, became interested in his late uncle's flying career five years ago and has carried out a great deal of research from official documents and discussions with pilots and ground crew. Initially, he set out to record the events of Sam's life, but he has ended up producing much more than a simple biography.

Sam Weller joined the pre-war RAF when his career in the cavalry was cut short by a knee injury. He trained in Egypt and was selected to fly fighters with No 80 Sqn based near Alexandria. He was in action as soon as Italy entered the war when he flew alongside the legendary 'Pat' Pattle and 'Imshi' Mason. He transferred to No 274 Sqn, the first Hurricane squadron in Egypt, and flew with no less than four future air marshals. He was selected to fly a daring, lone armed-reconnaissance flight of almost 900 miles for which he was awarded the DFC. Later, he was stranded on Crete but managed to escape and was then posted to the Sudan as an instructor where he was killed

flying a Tomahawk.

The author has avoided the pitfall of concentrating on a blow-by-blow account of Weller's career. He has very skilfully woven his uncle's gallant exploits into a wider fabric relating the life, loves, deaths and excitement of the period. The book provides a superb account of what life was like as a young fighter pilot in the peacetime colonial air force and then in wartime with the Desert Air Force. It is probably the best book written on this period of the RAF's role in Egypt and the early North African campaign and is highly recommended.

Air Cdre Graham Pitchfork

The Development of Piston Aero Engines by Bill Gunston. Patrick Stephens; 2001. Price £19.99.

Having been an RAF pilot, a longtime staffer on *Flight* magazine and editor of *Janes Aero-Engines*, Bill Gunston's aeronautical credentials are impeccable. But it takes more than technical expertise to be a successful author and this book shows why Gunston is one of (perhaps the) most widely read of aviation writers.

That having been said, it is still not the easiest book to read because it is simply impossible to deal with aero engines without using technical terms. One is obliged, therefore, to wade through a sea of poppets, tappets, flanges, gudgeon pins and shims while trying to bear in mind the implications of manufacturing components by casting, forging, milling or brazing. Then again, there are lots of numbers, because it is conventional to compare piston engines by capacity (cylinder bore and stroke) and/or by power output; in the latter case I learned that whereas horse power used to suffice in days of yore, we now have to talk of BMEP – perhaps engineers always did, but if so, it never filtered down to my corner of the crew room. I learned a lot of other things too, about octane ratings, for instance, and of the significance of stoichiometric ratios (you'll have to read the book).

If this all sounds like heavy-going, it is, but only a bit, and it is an inevitable consequence of the author's providing a primer on piston engine technology. Mechanical engineers can probably skip the first third of the book where the rudiments of the 'science' are explained, but, if they persevere, most lesser mortals will have a far greater

appreciation of the more entertaining history which follows. The bulk of the book, which is extensively illustrated with photographs and explanatory diagrams, effectively chronicles the evolution of its subject throughout the 20th Century, from the efforts of the early pioneers, through the WW I heyday of the rotary, via the increasingly powerful static engines, culminating in the 3,500+hp monsters of the late 1940s, to the relatively low-rated engines which are still to be found in the general aviation and agricultural sectors of the market today. Along the way, one learns many interesting things, like the difference between a Gnome, a Clerget and a le Rhone, and how the Hispano-Suiza company came by its rather odd name. Then again, there are numerous incidental 'compare and contrast' exercises which provide some insight into the pros and cons of, for instance: the Merlin versus the opposition's Daimler-Benzes and Jumos; Wright's Cyclone family versus Pratt & Whitney's nest of Wasps; Soviet engines compared to those of the West; sleeve valves versus poppets, and so on.

This is not a new book incidentally; it first appeared in 1993 and was reprinted three times before being updated in 1999, the copy under review was printed in 2001. It is self-evident that for a book to have remained in demand for so long, its author must have got something right. That having been said, it is not an easy read, but it is a very worthwhile one and, once you are familiar with the content, if you have this book in your library, I suspect that it will answer most questions to do with the 'Otto cycle' that you are ever likely to ask.
CGJ

The RAF Regiment at War 1942-1946 by Kingsley M Oliver. Pen and Sword; 2002. Price £19.95.

Do not be mislead by the modest size of this 166-page hardback, because the author has packed a remarkable amount of information into a relatively slim volume.

The RAF Regiment was raised in response to wartime conditions and in a somewhat haphazard manner. Units were allocated inherently unmemorable four-digit designations and, because of duplication between batches of numbers assigned to the UK, the Middle East and the Far East, there were bouts of re-numberings which further diluted the identities of the scores of wings and squadrons which made up the

wartime Regiment. These cumbersome designations did not survive for long in peacetime and with their demise went much of what should have been a rich heritage of military achievement. Kingsley Oliver has succeeded in rescuing many of the Regiment's wartime exploits from obscurity and has presented them in a very readable style, supported by more than fifty well-produced photographs plus a variety of maps and significant documents.

Many of the pictures have been drawn from the IWM and they have probably been reproduced with their original captions. The only one with which I would take issue is of the 'wreckage of a Japanese BD17 (*sic*) shot down at Mingaladon' by Regiment gunners. I fancy that there is some journalistic licence here as the aeroplane is actually an obsolete Mitsubishi Ki 30 and it appears to be far more derelict than damaged. There are a few typos, oddly enough often involving place names, eg Giola (rather than Gioia) del Colle, Grottalie (*vice* Grottaglie) and Dom (instead of Don) Muang, but these do little to interrupt the flow.

Many Society members will doubtless already know far more than I did about the activities of the wartime Regiment, which, I confess, I had understood to be confined largely to occupying and defending airfields, and lending a hand with re-arming and refuelling when necessary. That was demanding enough on occasion, of course, and the accounts of the unsuccessful attempt to seize and hold the airstrip at Antimachia on Cos and the struggle for control of Meiktila are impressive. What I had not previously appreciated, however, was the frequency which the Regiment fought alongside the army and the nature and extent of the 'proper' soldiering activities that ensued. Working directly with the army meant that the Regiment sometimes found itself 200 miles forward of the nearest flying unit, which was stretching its job description of 'airfield defence' about as far as it would go. As a result of these forward deployments, the Regiment was often among the leading troops entering captured cities, indeed No 2798 Sqn was the first British unit into Paris. Then again, did you know that the Regiment conducted amphibious operations in the Adriatic, or that it frequently held sectors of the front line, notably at Cassino?

I found one anecdote particularly appealing. It was symptomatic of the fact that the Regiment was often poorly equipped that it sometimes

had to make do with inappropriate weapons. One of these was the 20mm Hispano cannon which had some value as an anti-aircraft gun, although its utility was limited by the fact that (unlike the 40mm Bofors) its ammunition did not self-destruct. What goes up must come down and in attempting to ward off air attacks against its own landing ground during the fighting in Sicily, No 2859 LAA Sqn managed to damage six Spitfires parked on the airstrip next door. The unit's effectiveness was subsequently seriously compromised by the inevitable constraints that had to be imposed on its field of fire.

We should probably all know rather more about the wartime exploits of our Regiment, not least because it clearly did a great deal more than most of us give it credit for. This handy and easily assimilated volume makes a significant contribution towards filling that gap.

CGJ

Stapme. The Biography of Squadron Leader Basil Gerald Stapleton DFC DFC(Dutch) by David Ross. Grub Street; 2002. £17.99.

Stapme is a Battle of Britain Ace who took a short service commission in 1939 and served during the Battle with No 603 Sqn. After time with the Merchant Ship Fighter Unit came Typhoons and Rhubarbs with No 257 Sqn and periods as a Gunnery Instructor at Kenley and at the Central Gunnery School at Catfoss. Then he was back in the thick of things again as CO of No 247 Sqn, flying Typhoons with No 124 Wg of 2nd TAF. His Dutch DFC was awarded for his leadership of his squadron during the Arnhem operation. He saw a great deal of action before his aircraft was damaged by the debris from the explosion of a locomotive he had hit with a rocket and he crashed, ending up as a POW. The two chapters dealing with the POW period are very interesting. After the war he flew for a while with BOAC before returning to his native South Africa where he had a number of jobs before becoming a tour guide, at first in Botswana in his own business and later with other companies which saw him taking tourists on trips over much of southern Africa. It seems to have been the sort of job which admirably suited his likeable and outgoing personality. He now lives in retirement in the UK. He is an interesting man who has done interesting things and fully deserves a biography.

What are we to make of this one?

The publisher's flyleaf blurb refers to what it calls the author's 'encyclopaedic' study of the life of Richard Hillary, which I reviewed for this journal recently. I commented then on the detail supplied by that book. Encyclopaedias are full of information of course but they do not make for easy reading. This book could also be described as encyclopaedic. It is packed with factual data; day by day, even hour by hour, records of activity; reproductions of Combat Reports and ORB entries; verbatim extracts from diaries, etc, where paraphrasing would often have sufficed, and appendices containing yet more factual data of one kind or another. While it is a primary task of the historian/biographer to root out all of the facts he can discover about his theme, when he comes to write his book he must jettison a sizeable chunk of such material (a painful thing to do!) and construct a story from it instead. I think this is an observation which the author would do well to take on board in his future writings. He is a most assiduous and reliable collector of data but he needs to polish his storytelling skills. That he has such skills is evident in parts of this book, for example in his accounts of the POW episode, Stapme's post-war adventures and the pre-Battle life of No 603 Sqn, although a lot of the latter is familiar from both Richard Hillary's *Last Enemy* and the author's biography of him. His short biography in Appendix F of the German Ace Franz von Werra, who was shot down by Stapme and subsequently escaped from both British and Canadian POW camps to make his way back to Germany via Mexico, also shows what he can do.

This book is worthwhile because the stories of men like Stapme who put their lives on the line in the service of their country and then had to find a place in the post-war world deserve our attention – but I did find it heavy going in places.

Dr Tony Mansell

The Daily Telegraph Book of Airmen's Obituaries by Edward Bishop. Grub Street; 2002. Price £17.99.

Many members will be familiar with Edward Bishop's obituaries in the *Daily Telegraph*. This substantial A5(ish) hardback is a compilation of 100 of those which have appeared over the past fifteen years. There are no illustrations. The subjects are grouped under

convenient, if not always entirely appropriate, headings: First World War Veterans; Fighter Boys; The Yanks; Bomber Boys; The Girls; Planemakers and so on.

Why 'not always appropriate'? My reservation arises from the fact that I am (was) of the back-seat fraternity. As such, I naturally had a look for navigators. I did find one, but only one (out of a 100!). He was a notably successful wartime AI operator which should surely have entitled him to be included among the 'Fighter Boys'. Evidently there was no room at that particular inn because it had been reserved exclusively for pilots so he had to be stabled under 'Jokers in the Pack'. Not sure that is appropriate.

Beyond that, however, there is little to carp about. The format generally involves an anecdote or two, focusing on the more spectacular of the subject's achievements, accompanied by a summary of the rest of his career. Since most of the featured personalities achieved a degree of prominence in one field or another, their stories are interesting and/or entertaining and the book makes a handy reference to some of the great and good, and to one or two of the less conventional members, of the aviation community. Recommended.

CGJ

Sledgehammers for Tintacks - Bomber Command Combats the V1 Menace, 1943-1944 by Stephen Darlow. Grub Street, 2002. Price £17.99.

The key to this book lies in its subtitle; the main title comes from an analogy used by the Deputy Supreme Commander, Sir Arthur Tedder, who wrote 'from 23 June the offensive went forward with vigour....Though,....I advised that air action could reduce, but not exterminate, the menace', since bombing the sites was 'using a sledgehammer for a tintack.'

The author, grandson of a Lancaster pilot, emphasises that the main thrust of the book is to detail the attacks on V1 targets, particularly the launching sites (original and modified); supply sites and dumps; relevant industrial targets; and, later, the airfields harbouring the obsolescent Heinkel 111s which were air-launching flying-bombs. This campaign was spread over almost nine months from mid-December 1943, intensifying urgently after the first V1s landed in England seven days after D-Day. The USAAF and 2nd TAF were also

heavily involved in these counter-offensive measures.

In the Introduction the reader is told twice that it was the population of Southern England who were mainly under attack; the Prologue gets much closer to reality when it becomes London and the South-East, but then reverts again to 'The population of Southern England' as though these descriptions were interchangeable. This came as a surprise to me, for at the time I was a youth living on the border of North-West Kent and working in SE London, both part of the area which became known as 'Doodlebug Alley'. As the author points out, flying-bombs were accident prone at and around the launching areas, resulting in German and French casualties; nor were they exact performers at the delivery end. In cricketing parlance, there were a lot of short balls, together with wides and overthrows.

The early chapters set the scene; intelligence, photo-reconnaissance and some of the important preliminary raids carried out in 1943, for instance: Friedrichshafen on 20/21 June, to attack *Würzburg* radar manufacturing plants, but where some V2 production was apparently planned; the critical attack on Peenemunde on 17/18 August, about which so much has already been written; Watten, south of Dunkirk, by USAAF B-17s on 27 August and 7 September; and finally the two very heavy October raids on Kassel, where the Fiesler and Henschel factories were engaged on V1 production

The book moves on to the experimental stage against the original ('Ski') launching sites, commencing 16/17 December until late January 1944. These were night raids, generally using OBOE with Mosquitoes doing the marking, but they were not very successful to start with against such small targets. Daylight raids against the sites were continued by the USAAF. Apart from occasional skirmishes, Bomber Command was not involved again until mid-June when Germany eventually began its offensive. Allied activities thus far, having bought vitally important time, had imposed critical, and perhaps decisive, delays on the Germans.

The remainder, indeed the majority, of the book deals with all of the V1 raids in considerable detail, including: operational reports from official records; aircrew casualties (mainly drawn from Chorley's *Bomber Command Losses*); and a host of first-hand reports from surviving aircrew of the period. The author also spent time in France talking with survivors, and some of these conversations are reported.

This section is very thorough and is certainly the most useful part of the book. It does not make for easy reading, however, since, it is, in effect, a series of valuable references and reports on this aspect of Bomber Command's very considerable efforts and sacrifices.

I recommend reading a library copy first before buying.

Roy Walker

The Battle of the Atlantic by Roy Conyers Nesbit. Sutton; 2002. Price £25.

The title of the prolific Roy Nesbit's latest opus tells you exactly what it is about. The story of the war in the Atlantic is recounted chronologically with the tonnage of merchant shipping sunk versus numbers of U-boats lost being toted on a monthly basis. This statistical skeleton is amply fleshed out with descriptions of the technical innovations introduced by each side, the evolution of tactics, the contribution made by Bletchley Park, accounts of significant engagements and so on. While the narrative is clear and concise I doubt that it contains very much new information, although I was rather taken by a statement to the effect that some 30% of the Allied shipping sunk by submarines was attributable to the efforts of a mere 2% of U-boat captains (which is an interesting statistic, not too dissimilar to that which demonstrates that, taking the WW II air forces of the Commonwealth as a whole, only one fighter pilot in about twenty became an 'ace').

In telling the story of the Battle of the Atlantic, the author relies as much on pictures as he does on words and there are well over 300 illustrations in this large format (12ins×8¼ins) hardback. Incidentally, and rather curiously, the text uses less than 5 inches of the page width, leaving extraordinarily wide outer margins; this is probably a triumph of 'design' but, Philistine that I am, it seems to me to be rather a waste of space. The selection of illustrations is excellent and the captions are both relevant and informative. Many of the photographs take advantage of the book's large size, some of them being spread across the centre margin to occupy two pages. The quality of reproduction is variable. Colour is used where appropriate and many of the monochrome originals are printed in sepia or blue – the reader must decide for himself whether this practice does anything to improve the image. Many of the photographs are crystal clear while others are less

than perfect, owing to the circumstances under which they were taken, these flaws actually serving to provide a certain texture and to convey a sense of immediacy. On the other hand, a third category appears to have been copied from other publications; this may not be the case but they certainly exhibit the sort of interference patterns that can result from scanning an image that has previously been screened.

It is usually possible to find factual errors in any book, and this one is no exception. If only to prove that I did more than simply flick through the pages, I could point out, for instance, that the caption to a picture of Hamburg docks (page 5) makes sense only if the photograph is rotated through 90^{o} clockwise and I am pretty sure that the port identified as La Pallice (on page 194) is actually St Nazaire. The 'Tsetse' Mosquito was the Mk XVIII, not XIII (page 223); the Mosquito on page 251 is a Mk VI, not a Mk IV and on page 229 a Type XIII U-boat should, I think, read Type XXIII – those pesky Roman numerals! There are a few other errors/typos, eg Parnell (for Parnall), Patten (for Patton), Kaldarnes (for Kaldadarnes) and MAD stood for Magnetic Anomaly (not Airborne) Detector but few of these are of any real consequence and they detract little from the overall quality of the book.

This is a well-illustrated, well-told, well-balanced account of the conduct of the Battle of the Atlantic, reflecting the fact that it was a joint naval-air campaign from start to finish and giving due recognition to the courage exhibited by the participants on both sides. Recommended.

CGJ

Amy Johnson Enigma in the Sky. An Official Biography by David Luff. Airlife: 2002. £16.99.

Amy Johnson's name is a marker for that period of aviation history in the 1920s and '30s which saw a mania for setting records for long distance solo flights. They were made by both men and women usually, as in Johnson's case, with sponsorship from such interested parties as newspapers, aircraft manufacturers, oil magnates and philanthropists. Sponsor's commercial interests were amply repaid by the public response, with mass crowds of welcome, ticker-tape parades and media frenzy. The government had its own reward in the stimulation of air-mindedness promoted by such ventures. However,

by the late 1930s public interest had begun to wane and the magnificent persons in their flying machines had come to be referred to scathingly as stunt fliers. Most record attempts were made in contemporary light aircraft which were modified so as to become flying petrol tanks. However, the De Havilland DH88 Comet, was designed specifically to compete in the Mildenhall-Melbourne event of 1934. Johnson and Jim Mollison flew one of the three which were built but failed to get beyond Allahabad where the Comet packed up forcing them to withdraw from the race. The interior of their machine, apart from the cramped quarters allocated to the two pilots, seems to have been filled with volatile liquids in the shape of petrol for the engines and alcohol for Mollison. Although a Comet won the race the DH88 had no future but the DC-2 airliner of KLM, carrying three fare paying passengers in addition to its crew and radio, which arrived in second place certainly did - as the forerunner of the magnificent DC-3.

Johnson's life began in the sort of milieu which would have been familiar to the characters who appear in the journals of Edwin Carp or Charles Pooter. From a conventional lower middle-class non-conformist background in Hull she made her way, somewhat shakily, through a degree course at Sheffield into a variety of mundane and poorly paid jobs in offices and London department stores until, thanks to the government subsidies available to flying clubs, she could afford to learn to fly at the London Aeroplane Club. She was not afraid of getting her hands dirty and became a competent mechanic – an achievement which served her well on her flights where she could deal with most engine problems herself.

At the peak of her popularity she had moved into the frenetic world of the *glitterati* of the day, surrounded by wealthy socialites, aristocrats and show-biz personalities. Her exploits had also earned her a good deal of money. There is no doubt that those who undertook these record breaking flights were brave and resourceful people and the good account given here of Johnson's flight to Australia has all the ingredients of a 'Ripping Yarn'. Her life was to end tragically in her death with the Air Transport Auxiliary (ATA) in circumstances which, although carefully examined in this book, remain obscure.

The author thoroughly explores Johnson's personal life and one has to conclude that it was deeply unsatisfying to her in terms of her relationships with men. Her romantic activities began with a long

drawn out affair with a Swiss businessman, dealt with in some detail in this book, who she desperately wanted to marry but who kept her at arms length whilst enjoying her favours in a series of clandestine 'honeymoons'. He eventually married someone else leaving her very embittered and perhaps one might see her career as an aviatrix as a kind of rebound activity. Her marriage to Jim Mollison was not a happy affair and soon ended. A clash of egos, often seen in the marriages of celebrities, was probably a major contributory factor in its failure. The enigma of the title might refer to the problem of getting inside the complex mind of Johnson but probably refers primarily to the circumstances of her unhappy end which are examined in depth here.

She took off from Squires Gate in an Oxford belonging to the ATA on the morning of Sunday 5 January 1941 intending to fly to Kidlington so as to be able to attend a party celebrating the formation of the ATA Women's Pool at Hatfield the following day. The weather conditions were not good and were approaching the limit imposed by ATA practice but she went ahead. She flew, without radio, above the clouds which covered virtually the whole country on that day and descended to get a land fix in just about the most hazardous place she could have chosen. She was a long way off course and seems to have abandoned Kidlington, perhaps in favour of Hatfield, but eventually settling for an attempt to land at Rochford. She emerged from the cloud base in conditions of poor visibility and at an altitude of about 800 ft, above a coastal convoy making the final stage of its journey up the Thames estuary. Below her was a line of ships escorted by naval vessels bristling with barrage balloons and with guns, manned by men in a high state of alert for Ju 88s and not noted for their skills in aircraft recognition. Eyewitness accounts reported variously no parachutes, one parachute, two parachutes and in one case no less than eight parachutes. One reported the break-up of the Oxford as it hit the water, another reported it making a smooth landing on the surface, as though still under control. There were no reports of gunfire but the author suggests that perhaps the eight parachutes reported were in fact puffs of smoke from exploding shells. Eyewitness accounts are notoriously unreliable, as witnessed by numerous experiments and the daily experience of both prosecution and defence advocates in the courts. When such accounts are derived from persons under stress,

even when they are skilled professionals in the arena concerned, they have been shown to be yet more prone to error.

The author raises the possibility that she met her end in a blue-on-blue situation. Probably the Navy was in the best position to offer a solution but seems to have been reluctant to do so; as an ATA official commented, it is not known as the silent service for nothing! If blue-on-blue it was, then the Navy's reluctance to admit any involvement in the demise of such a national heroine as Johnson is perhaps understandable in the climate of the times. There is, of course, another judgement which would also have been difficult to publicise in that climate; namely that Johnson had behaved foolishly in flying under such adverse weather conditions and that her piloting skills were not up to the task when she got aloft – simply a case of poor airwomanship ending in a crash landing.

This book is well written and gives a good, amply illustrated, account of the salient features in the life of a remarkable woman. I can only fault it when the author refers to the Civil Air Guard as being equivalent to the Territorial Army or the RNVR when the RAFVR is the proper candidate for such a comparison. It is an interesting read but not something which one would necessarily want to invest in for one's own shelves. It is, however, certainly worth borrowing from those of the local library.

Dr Tony Mansell

McIndoe's Army by Edward Bishop**.** Grub Street; 2002. Price £16.99

As a callow youth, I was awakened to the harsh realities of war by reading Richard Hillary's *The Last Enemy* and so I learned of Sir Archibald McIndoe and the remarkable happenings at Ward 3, Queen Victoria Hospital, East Grinstead.

The Guinea Pig Club will be known to almost all students of air warfare in WW II as the association of those who had been burned or disfigured whilst serving, almost exclusively as aircrew in the RAF and Dominion air forces, and who were treated and rehabilitated at East Grinstead. Edward Bishop, who had established a close relationship with the Guinea Pig Club, first wrote about them and those who helped them in a book published in 1963. To mark the 60th anniversary of their foundation, he has rewritten his account and enhanced it with hitherto unpublished photographs and personal

recollections.

The book, which runs to 180 pages, includes a bibliography, a listing of all known Guinea Pigs, an index and sixteen pages of monochrome photographs.

Although the book is an interesting account and is certainly well worth reading, I was disappointed by it for several reasons. Although not intended as a biography of Sir Archibald, I felt so central a figure was given relatively little space, apart from mentions of help he gave to Guinea Pigs when this was germane to the individual accounts. Likewise, some other characters, such as Matron Hall (who seems not to have been endowed with a Christian name), were glossed over and occasionally treated as some sort of paragon rather than a real person. The style of writing seemed to me to be old fashioned and I found the reintroduction of characters, each time they appeared in the narrative, a little irritating. It was also difficult to identify when many of the individual stories of Guinea Pigs in later life were actually taking place and hence to place these stories in the context of the wider social scene and attitudes in general. I found some references to comparisons between Bomber Command and Fighter Command personnel to be disingenuous and frankly offensive.

Most readers attracted to this book will find it a sobering account and a fitting testament to a remarkable group of people who have suffered greatly as a consequence of war but who have fought back. Whilst some have found the struggle too great to bear, many others have established exceptionally successful professional lives and accomplished more than many an able bodied individual.

All in all, and despite my comments above, this is a book worth reading.

Wg Cdr Colin Cummings

RDF1:The Location of Aircraft by Radio Methods 1935-1945 by Michael Bragg. Hawkhead Publishing; 2002. Price £17.99 (including p&p if ordered direct from publisher at 6 Hawkhead Road**,** Paisley, PAl 3NA).

A great many books on the history of radar have appeared in recent years, covering various aspects from the purely technical to the largely autobiographical. These vary in accuracy from the excellent to the indifferent, but amongst the best is *RDF1* by Michael Bragg. Based on

official correspondence held on file in the Public Record Office, this book tells the story of the development of Britain's ground radar defences. It is a fascinating story, told often in the form of quotes from the files, relating the incidents in the words of those involved. For example, the debates with the Treasury on the salary payable to Watson Watt provide a most interesting insight into the political infighting, personal disagreements and inter-departmental debates which went on behind the scenes.

The drama of the Daventry experiment comes through quite clearly in this book. The trial was laid on in February 1935 to prove that the detection of aircraft by radio reflections was a practical proposition. A Heyford bomber flew through the radio waves from the BBC transmitter at Daventry. In view of the fact that the first run by the target Heyford was not detected, the anxiety of the scientists can be easily imagined!

Michael Bragg corrects many errors which have been repeated over and over again in previous works on this subject. Many books have referred to the fact that radar stations had to be sited such that they 'must not gravely interfere with grouse shooting.' Michael Bragg reveals that this was not a siting requirement but rather first appears in a press release as a result of a misinterpretation of documentary evidence. He even corrects Watson Watt, who told historians in 1945 that he had prepared a memo that was taken to the first meeting of the Tizard Committee, when this was not the case. Such detailed research has resulted in a highly authoritative work which not only corrects existing books but adds much that has not previously been published.

The technical and scientific details of developing a complete air defence system from scratch, with the imminent threat of war looming, are vividly described. Constant changes and improvements to equipment, setbacks in the form of unsuccessful demonstrations and the difficulties of working without any clear command structure all combined to make one wonder how the radar chain was ever put in place in time to achieve its undoubted wartime success. The complexities of governmental committees might appear dry reading, but in fact this book proved a most interesting account. The disputes between Signals, Works, the Ministry of Aircraft Production, Fighter Command, the Air Staff and other interested parties show the difficulties of working when there are no clearly defined boundaries of

responsibility. It was only slowly that such boundaries were defined with the emergence of a new organisation specifically for the growing radar chain.

A particularly interesting feature of Bragg's book is the collection of written accounts by wartime radar personnel included at the end of the text. These have been written by both RAF and WAAF personnel (plus one by a US civilian) and cover a fascinating variety of experiences. It seems unfair to single one out, but the narrative by Reg Townson is particularly interesting. After training at Bawdsey, he was posted to the Air Ministry Experimental Station at Canewdon, Essex, in February 1938, leaving for Malta in January 1939 to set up the first overseas radar station. Such recollections make particularly atmospheric additions to the political and scientific developments outlined in the body of the book.

Although there are a few minor typing errors and other minor mistakes (the president of Canadian National Railways is described as being the president of the Canadian-Pacific Railway, their main competitor), these do not detract from the authoritative nature of the book. Anyone interested in the history of radar or air defence, or in the complexities of military politics is strongly recommended to read this account.

Ian Brown

The Smithsonian National Air and Space Museum Directory of Airplanes; Their Designers and Manufacturers, edited by Dana Bell. Greenhill; 2002. Price £25.

This hefty hardback grew out of the NASM's need to impose a more disciplined structure on its archives which had, with expansion and the passage of time, become increasingly disorganised and thus less accessible. It was soon discovered that there was no authoritative system for identifying aeroplanes and, since such a mechanism would be an essential cataloguing tool, the museum set about creating one. The *Directory of Airplanes* represents the state of play after about ten years of work. It deals with man-carrying heavier-than-air vehicles supported by dynamic lift. That is to say, conventional aeroplanes plus gliders, autogiros, helicopters and ornithopters, including ultra-lights and homebuilts in all categories, constructed (but not necessarily flown) anywhere in the world over the last 100 years or so; balloons,

dirigibles, drones, spacecraft and so on will be dealt with separately in due course.

So what do you get for your £25? A 368-page, three-column list of about 25,000 aircraft types. The entering argument is by one of 5,000-odd manufacturers and thence by designation and sub-variant. Where appropriate, entries are preceded by a concise account of the organisational changes which a manufacturer has undergone. This permits one to see the impact of the pre-war nationalisation of the French aircraft industry on each of the old companies like Potez and Dewoitine. Similarly, the shotgun marriages that characterised the rationalisation of the British aircraft industry in the 1960s and '70s can be traced, as can the progressive merging of US manufacturers in response to market forces. Where necessary, cross references are provided so that, for instance, enquirers after Chance Vought and/or Ling-Temco-Vought are redirected to Vought. There is also a 65-page, four-column cross-reference by aircraft name. One can, therefore, confirm that the Tiger Moth is still to be found under De Havilland, and not Hawker Siddeley or BAE. This section also addresses the allied code name system for Japanese aircraft in WW II, permitting one to find the Mitsubishi J2M by entering with either Raiden or *Jack*. NATO designations are similarly included, although there seem to be a few omissions in this instance, for example, *Buck* for the Petlyakov Pe-2, *Brawny* for the Ilyushin Il-40 and *Hat* for the Kamov Ka-10.

Having traced your specific type of aeroplane, what does the book tell you about it? Not very much. In fact, beyond a list of variants, nothing at all. To take a familiar type as an example, the Gloster (and Armstrong Whitworth) Meteor has twenty-seven discrete entries, including some for flying test-beds, although, a little surprisingly, the list omits the well-documented NF(T) 14 and TT 20 service variants while including a PR Mk 19 (a model to which I never seen any other reference).

So, what we have here is a huge list of aeroplane names, but that is all. Leafing through it is like flicking through the index pages of a reference book; but there is no book. It presumably serves its original purpose of easing one's way into NASM's archives, but this is a very parochial aim. I fail to see that this publication will be of much use to the more general reader. In the fullness of time, it is just possible that it may come to be accepted as the standard international reference to

aircraft names and designations but, because new types are constantly being added to the list and the structure of the increasingly international aircraft industry continues to evolve, new editions will be necessary on a fairly frequent basis.

I do not wish to seem uncharitable but I simply cannot see the market for this book. It is not that I consider it to be particularly flawed; I just don't see the point. Or am I missing something?
CGJ

Billy Drake, Fighter Leader. The Autobiography of Group Captain B. Drake DSO, DFC & Bar, DFC(US) by Billy Drake, with Christopher Shores. Grub Street; 2002. £17.99.

Billy Drake put in only a token appearance in the Battle of Britain, amounting to three weeks with No 213 Sqn in October and about a week with No 421 Flight before the Battle ended on the 31st. Given his talent for destroying its men and materiel this was a bonus for the *Luftwaffe* and, as it turns out, for readers of this book because it frees him up for telling us about his activities in such places as France before the Battle, with an OTU during it, with the Desert Air Force and with 2nd TAF. The text is not littered with accounts of individual combats and is all the better for that. Instead it deals with the kinds of action he took part in and it does it well. He writes in a lively style about service attitudes, his own peccadilloes and about some of his fellow pilots, one of whom is referred to as 'rather a cocky little bugger', a turn of phrase which crops up in other places and is both refreshing and amusing. As befits an officer and a gentleman, of course, ladies names are not mentioned!

When he joined No 1 Sqn in 1937 Drake found a wall on the ground between the officers and sergeants. The latter were respected for their professional skills but ignored socially. This, as he rightly notes, was a reflection of the class-based structure of British society at the time but he found a totally different picture in the Desert Air Force where pilots of all ranks mixed together and shared the same messing facilities. However, No 1 Sqn's attitudes may not have been adhered to in all places even during the Battle of Britain. The ORB of No 73 Sqn records the surprised looks on the faces of some army officers when a bunch of 73's officers and sergeants turned up together at a social do in Saffron Walden. There was also an occasion when Sgt

John Griffin reported a 'long nosed Blenheim' which required investigation by a couple of officers and which turned out to be an Anson. Griffin was debagged and drinks all round demanded of him – without success it appears. Such episodes do reveal some breaking down of walls I think. On a more serious note, Drake makes interesting and informed comments about the different styles to be found in the RAF compared to those of the Army and Navy, particularly in terms of the involvement of senior officers at the sharp end and, in the RAF itself, about the wide operational gulf separating the aircrew – 'a *corps d'élite*' – and the very large number of ground personnel required for their support. These are but examples of the kind of reflective writing which sets this book apart from the usual run of the mill.

With the Desert Air Force he flew Kittyhawks in actions in support of the armies which he describes as forerunners of the tactical ground-attack role which was later to characterise the work he became involved in with 2nd TAF. He liked Kittyhawks for their stability as gun platforms and for their armament of six 0.5 inch guns which, he says, were superb and produced 'a hell of a punch'. In the 1930s the RAF had considered using 0.5s but rejected them in favour of 0.303s and 20mm cannons. The Americans certainly had no doubts and used them throughout the war in such successful aircraft as the Thunderbolt and Mustang. Dowding did not like them. In the notes he supplied to Robert Wright for the latter's *Dowding and the Battle of Britain* he describes an experiment he personally carried out by firing a 0.5 at the fuselage of a Bf 109 and finding that, at 30 yards, it produced only a dent in the German armour plate behind the pilot. He does not say whether he tried the same experiment with a 0.303 and his findings would certainly have come as a surprise to the Thunderbolt and Mustang pilots who decimated the *Luftwaffe* in the aerial battles over Europe.

Back in the UK, Drake was posted as Wing Leader to No 20 Wing of 2nd TAF flying Typhoons. Later came an appointment to command the Armament Wing of the Fighter Leaders School at Milfield which by then incorporated the Specialised Low Attack Instructors School. As he points out, the need for such a training establishment was essential to help perfect the conventional skills required by fighter pilots and also to induct them into a new role as ground-attack experts.

From his own experience in OTUs he deplored the fact that in the early years of the war no training in aerial gunnery was provided for the pilots of the RAF. During this period he also managed to see some action himself by flying sorties with his old Wing. He went on to staff appointments with SHAEF, which brought him into contact with senior people such as Eisenhower, then returned to post-war flying and staff appointments as jets ousted his beloved Spitfires. Following an appointment as Air Attaché in Switzerland he retired as Station Commander at RAF Chivenor.

At the age of 45, this accomplished professional airman with 24½ confirmed scores in the air and 13 on the ground, faced a different set of challenges in finding a role in civilian life. In that, of course, he was not unique but, as his honest account of his efforts shows, he did not have an easy time of it. In the 1930s public school Masters were not keen on their boys taking, as Drake did, Short Service Commissions in the RAF - a source of frustration to the Air Council which did its best to change their attitude. One of the reasons for the Masters' reluctance was because they considered a period of time flitting about in the air to be a poor preparation for any long-term career on the ground. Possibly they were right. Drake, with characteristic frankness, describes himself as ill-prepared for his new life having been 'cocooned by the service, still little more than a young fighter pilot.'

This book has been written in conjunction with Christopher Shores, an experienced and respected writer himself. Ninety-six pages of text deal with Billy Drake and a further forty-two consist of biographical details of pilots mentioned in the text derived from Shores' *Aces High* (1994) and its supplementary Vol 2. It is a book well worth having for Drake's frequently amusing, but always highly professional, account of his service life and for his reflections on that Service and its ways.

Dr Tony Mansell

Flight Path. The Autobiography of Sir Peter Masefield by Sir Peter Masefield with Bill Gunston. Airlife; 2002. £19.99.

In 1935 Peter Masefield, a Cambridge engineering graduate, commenced his working life in the drawing office of Fairey Aviation at a salary of £3.50 per week. He had started flying lessons as an undergraduate and later took advantage of the subsidies available to complete his training as a pilot with the Civil Air Guard. He became

the Technical Editor of *The Aeroplane*, during which time he launched *The Aeroplane Spotter*, a publication of great value in the development of aircraft recognition skills. Experience as a war correspondent with the US 8th Air Force led to a tour of the American aircraft industry followed by major advisory appointments in civil aviation for the British Government under the aegis of Beaverbrook. In the post-war period he became the Chief Executive of BEA, Managing Director of the Bristol Aircraft Company and later of Beagle, a firm producing light aircraft which ultimately did not succeed. Then came the post of Chairman of the BAA. His career ended with a short period as Chairman of the London Transport Authority but he and 'Red Ken' Livingstone did not hit it off and he finally retired from public life. This is an important book because it has been written by a man whose extensive knowledge of his field and the fact that he saw British civil aviation from the perspectives of both user and manufacturer of aircraft place him in an informed position as a commentator on events. In telling his story he has had the able assistance of Bill Gunston, an authority himself on aviation affairs. To do justice to the many themes and issues raised in this book would require a great deal of space so I will limit myself to comments on an aspect which should be of particular interest to Society members - the performance of the British aircraft industry in the post-war period.

In 1943, at the invitation of General 'Hap' Arnold, the author embarked on a tour of American aircraft factories and was amazed by the drive and enthusiasm he found wherever he went. He returned convinced that America would present formidable challenges to British civil aviation and he was right. During the war Britain had concentrated on the production of military types and had entered it with only one world class airliner in the shape of the Empire Flying Boats. Even these had proved inadequate for Atlantic passenger services after trials by Imperial Airways, which led BOAC to use Boeing 314s for the purpose. BOAC comes in for criticism in this book for not being sufficiently eager to buy British aircraft but one can see their point. In the 1940s and '50s it was the pressurised Lockheed Constellations, Boeing Stratocruisers, Canadair C-4 'Argonauts' and Douglas DC-7Cs which made up their long haul fleets and which were delivered on time and performed well for them. What had the British aircraft industry to offer? The Handley Page

Hermes flew for a time with BOAC in the mid-'50s but the Avro Tudor proved to be unsatisfactory and when the Comet 1 came along it suffered catastrophic structural failures whilst in service. Then there was the saga of the Bristol Britannia. This beautiful aircraft made its maiden flight in 1952 but needed a further five years of development before it was ready for BOAC – just at the time when the world's airlines were queuing up with orders for the DC-8 and the Boeing 707. This 'snails pace' progress is again contrasted with American practice. The author says that they would have 'trampled problems to death' with sheer engineering manpower.

By contrast, BEA, with its short and medium haul routes, was not badly served by British industry as its initial heavy reliance on Dakotas – and even a few Ju 52s – was relieved at first by the Vickers Viking and then by the excellent Viscount, another British first with turboprops. The Airspeed Ambassador was another good machine but its entry into service was delayed by the usual lethargy displayed by the aircraft industry in meeting its deadlines. There is no doubt that Britain had some first class innovative engineers so what is the explanation for the poor performance of an industry which had done so well in wartime? One answer might lie in the British habit of issuing specifications from central government sources, as with the various proposals which emanated from the Brabazon Committee, but perhaps the author's account of his experience as the Managing Director of the Bristol Aircraft Company contains important clues.

At Bristol he found a company ruled by, what he describes as, a tight-knit family clique of non-engineers who appear to have kept all decision making in their own hands. There was a lavish atmosphere in the company's headquarters at Filton and he was made to understand that it was a place for gentlemen who were 'above such things as balance sheets.' As Managing Director of the Aircraft Company he did not even have a seat on the Board and recalls that in 1943 he had found American aircraft companies with administrative structures and supporting departments in place supplied with all manner of special equipment that the Filton works seemingly had never heard of. There is no doubt that he did not enjoy his time at Bristol and came to regret that he had ignored several warnings from well-placed sources at the time of his appointment, when the Chairmanship of BOAC was within his grasp. However, he does not extend his criticism of the malaise of

the British aircraft industry to De Havilland or to Vickers, where Sir George Edwards was said to have led a happy ship with a big design team in the American style, determined to beat all comers.

Many of Masefield's critical comparisons between British and American firms find their echoes elsewhere. Sir Roy Fedden, a brilliant aero-engine designer who was fired by Bristol, had led a mission to America as special technical advisor to the Minister of Aircraft Production (Stafford Cripps) in 1943. His report pointed to the huge scale of American research and development made possible by the wealth of engineering talent available from the American universities and to the advanced production techniques which Masefield had also seen. Perhaps many of Britain's problems can be traced back to their source in its pre-war aircraft firms, described by Corelli Barnett in his *Audit of War* as 'cottage industries', which rose superbly to the challenge of wartime production but exhausted themselves in the process. I think that there may be a book waiting to be written which would deal with a comparative study of the American and British aircraft industries in the 1930s and the immediate post-war world (or does one already exist?).

Autobiographies have some inherent features which are to be found in this book as well. There is the single perspective they offer on events and the fact that they contain some material which is of significance to their authors but not necessarily to their readers, in this case, for example, the twelve illustrated pages listing 'Selected Flights' made by the author. Some of that space would have been better devoted to a more extensive index to the rich text, the three pages provided being inadequate for the purpose in my view. Nevertheless, this book is a must for anyone interested in the history of British civil aviation and for the insights it provides into the life story of a man of quite phenomenal energy and ability.

Dr Tony Mansell

Hornchurch Offensive: The Definitive Account of the RAF Fighter Airfield, its Pilots, Groundcrew and Staff by Richard C. Smith. Grub Street Publications; 2001. Price £17.99

At first glance, this book presents well. It is in the well-established format for this publisher, and offers a range of excellent appendices. These are of a nature to be of considerable interest and use to the

researcher and historian, although a glaring omission is any list of the claims submitted for enemy aircraft shot down by the squadrons operating from Hornchurch, despite the totals being referred to on several occasions throughout the main text.

The book commences with a Foreword by that great Belgian fighter pilot, Michael Donnet, and this is followed by a thoughtful, highly relevant, and quite lengthy Introduction by Sqn Ldr Peter Brown. In this he highlights the considerable over-claiming which occurred during the cross-Channel offensive, certainly as far as the years 1941-42 are concerned. Unfortunately, the author seems to have taken no note or account of these comments in the body of the book itself.

The first chapter opens promisingly and the impression given is that the reader is to be presented with a comprehensive diary of events, both operational and domestic. Quite soon, however, it becomes clear that this is not in fact the case. Had the book been arranged in a diary format, with a clear division daily or weekly between operational and administrative events, it would have been much easier and clearer to follow. As it is, such events increasingly impinge upon each other in a somewhat haphazard manner; frequently, almost totally unrelated happenings share the same paragraph.

There is also a sad lack of explanation. On page 8, for example, the loss of Sqn Ldr Aeneas MacDonnell (referred to as Donald MacDonnell) is recorded, and it is stated that Flt Lt Barrie Heath was posted from No 611 Sqn to take over command. The text then states that 'Squadron Leader Stanley Meares, the senior controller, took up his new job as flight commander in 611 Squadron...' to replace Heath. There is no explanation as to why a squadron leader should be taking over as a Flight Commander, nor of what his credentials and experience were for doing so. He is not mentioned again. Was he perhaps mentioned in the previous volume Mr Smith produced on Hornchurch? If so, a footnote would have been helpful.

Thereafter, whilst only certain chosen operations are mentioned – surely Hornchurch's main *raison d'être* in wartime – the pages fill with detailed reports of every visit to the station by 'bigwigs', and indeed 'littlewigs'. Every visit by ATC cadets seeking a flight seems to be mentioned, whilst an exhaustively full report of a visit by the

Duchess of Gloucester, detailing her satisfaction with the 'cleanliness and homeliness' of the WAAF's quarters, is provided.

Regarding the defence of the airfield and its buildings, early reference is properly made to the presence in this capacity of the 70th Essex Regiment. When this role was taken over by the RAF Regiment, however, various squadrons of this force skitter in and out of the pages with little explanation of when and for how long they served at Hornchurch, where they came from or went to, etc. At least five Defence Squadrons are mentioned, but all without adequate explanation.

Turning to the operational side, on page 18 a news report of 29 June 1941 is mentioned, which records that No 611 Sqn had 'destroyed 18 Me 109s, probably destroyed nine more…..during the past ten days'. Refer back, and the reader will find that 611's apparently splendid performance has in fact received little coverage in preceding pages. A check on the veracity of the reporting of this unit's activities then becomes appropriate. Mention appears that certain Dutch pilots were attached to the unit to gain operational experience. One of these was Flt Lt T F A Buys, who claimed three Bf 109s shot down and a fourth probable between 4 and 23 June 1941 before being shot down and killed on the 24th. The presence, achievements and fate of this officer are totally lacking from any of the appendices listing his squadron's personnel and its operational losses. How many other errors or omissions exist is the question which immediately comes to mind. And, of course, in most references to pilots and their victories, they 'shot down three enemy aircraft', rather than the more appropriate 'they claimed…..', despite Sqn Ldr Brown's introduction. Acceptable in publications of the 1950s and '60s perhaps, but careless and misleading today.

There are many frustrating loose ends and inconsistencies, a selection of which follows.

a. On page 30 we are told that a pilot of a detachment from No 11 Group Flight crashed a Blenheim on a test flight and was killed. What was this Flight? What was it doing at Hornchurch? No explanation; no further mention.

b. On 15 October 1941 Hornchurch 'witnessed the arrival of the most strange flying machine.' This proved 'to have a very disappointingly long take-off run' and is described as being 'one of

the first experimental helicopters.' In England, at that time? Long take-off run? What on earth was it? No explanation.

c. At least two notable sportsmen served at Hornchurch as Physical Training Instructors. Both are mentioned, but with no indication of when one replaced the other; they simply appear once and are not mentioned again.

d. Various senior officers, who receive several mentions, are suddenly, on a subsequent reference, included with their full rank and decorations for no apparent reason. The postings in and out of the various Wing Commanders Flying (surely one of the most important men present) are not always clear in the text and reference to the relevant appendix requires to be made. Wg Cdr Crawford-Compton is referred to thus on some pages, and as Wg Cdr Compton on others.

e. On page 76 it is recorded that 'Sqn Ldr Jack Ratten, officer commanding No 453 Australian Squadron, was appointed Wing Commander Flying at Hornchurch on 7 May, while Flt Lt K M Barclay was appointed to take over command of the squadron.' Yet, two pages later, 'Wg Cdr J Ratten, commanding officer of the Australian 453 Squadron, was awarded his DFC.'

f. On page 87 we are told that the commanding officer of No 164 Sqn was presented with a new squadron badge and, on page 91, that this unit was 'to co-operate with the army.' But there is no mention of this unit being based at Hornchurch or its satellites within the text, and it is not referred to in any of the appendices!

g. On page 98 No 80 Sqn is reported to have arrived for refitting and reorganisation 'before passage to the Italian front.' In fact it had just arrived *from* Italy and was about to commence operations over Western Europe.

h. On page 130 mention is made of the Queen Mother and Princess Margaret, although in the index Queen Elizabeth II is listed as appearing on this page. On page 134, however, reference is made to a flypast 'in honour of the return of Her Majesty, Queen Elizabeth II', but with no indication of where she was returning from or to.

One could continue *ad nauseam* in this vein. In summery, the distinct impression is given that the author has concentrated his research purely on RAF Hornchurch, and has relatively little in-depth

knowledge of either the RAF or military aviation generally. Much of what he has included seems to have been taken directly from the Station Diary without being put into proper context, and without the importance or otherwise of the various entries being properly analysed before inclusion.

A much more structured approach would have helped considerably, and might have avoided or corrected the myriad careless, annoying errors and discrepancies which are included. Some tight editing may also have helped.

In conclusion, this reviewer undertook his trade training at RAF Hornchurch in 1956 at the Personnel Selection Training School, returning there in 1958 to attend an advanced course in order to obtain promotion to higher substantive rank. He was, therefore, more than a little disappointed to find not even a mention of this establishment anywhere in the text, despite its role for a number of years in producing the full output of Personnel Selection assessors for the RAF.

Christopher Shores

Wight Air Wrecks by A T Gilliam. Tempus; 2002. Price £15.99.

Wight Air Wrecks is a 158-page softback which sets out to provide a 'definitive' (there's that word again) history of military aircraft losses that have occurred on and around the Isle of Wight. There are sixty-five photographs about half of which are directly related to the text in that they depict wrecks, accident sites or concerned personalities; the rest are simply generic pictures of aeroplanes. A glance at an appendix suggests that there have been over 300 such incidents but closer examination reveals that this remarkable figure includes contemporary claims for enemy aircraft destroyed during WW II which, as we now know, were considerably inflated. Furthermore, despite the stated aim of the book, the list also includes civilian aircraft. The total is further expanded by a fairly liberal interpretation of the 'around' parameter, in that it includes, for instance, Spitfire AR377 which was lost as far from the IoW as 75 miles south of Littlehampton. The same appendix reveals some curious inconsistencies. For example, if Thorney Island is sufficiently close to the IoW to warrant the inclusion of a Meteor which crashed on the local mudflats in March 1950, why not record the Marathon

which straddled the sea wall and the, at least, three Whirlwinds which fell into adjacent waters while engaged in winching drills?

Sticking with the appendix for the moment we can find other problems, including references to a 'Lockheed' Avenger and a 'Vickers' Vampire, misspellings of Martlett (*sic*) and Vildebeast (*sic*) and typos resulting in a Martin Bf-26, serials rendered as Bf634, Wd920 and R1116 (for RL116) and a 1926 date for a Felixstowe F.5 that was actually lost in 1924. Inevitably, the offending appendix, which mirrors the content of the book, tends to reflect the sort of errors which crop up within the main text where we can find mention of Harry Bustead (for Busteed), an Avro niplane (*sic*), Rippon (for Ripon), Aquilla (for Aquila), Needs Ore (for Oar) Point and so on.

I suspect that many of these problems can be traced to the author's being primarily a local historian rather than an 'aviation person'. This impression is strengthened by his evident lack of familiarity with the lore and terminology of the trade. For instance, in dealing with an accident which occurred in 1936, he quotes Sir Philip Sassoon. The reason for Sassoon's making a statement on this occasion, however, was because he was the Parliamentary USofS for Air at the time and not, as we are informed in a footnote, because he had been Chairman of the Royal Aero Club in 1931. Similarly, there is some confusion over early aeroplanes built on the island. Although they were all constructed under the auspices of J S White & Co, it is conventional to identify all of the firm's products as 'Wight' types; this book confuses the issue by making references to the White, White's and Wight Quadruplane and to the White's, and the Wight, Landplane. Then again, the TDU was the Torpedo Development (not Dropping) Unit and it does not automatically follow that a Blackburn Roc had to be owned by the Royal Navy; the one lost on 1 August 1941, for instance, had been transferred to the RAF. Clearly intending to be helpful, the author has provided an appendix to explain the unit designation system employed by the *Luftwaffe*. Sadly, this is not entirely accurate and he compounds the problem by using the system incorrectly himself.

I could go on but it would hardly be fair. The difficulty is that *Wight Air Wrecks* has been submitted for review to an aviation society and, as such, it must be able to withstand its scrutiny and, in view of its shortcomings, I can hardly recommend this book wholeheartedly to

the membership. On the other hand, I would not take issue with most of the core facts which it presents. These generally include the precise location of an incident (a map would have been very helpful), details of the event, the identities of the crew and their fates, and information on the responses of local personalities and emergency services. This is where the book's strength lies and the author is to be congratulated on assembling all of this data. It is a good slice of local history, but the reader's enjoyment of this book will probably be in inverse proportion to his familiarity with the subject matter – the more you know about aeroplanes, the more uncomfortable it will be to read.

My final comment is aimed at the publisher, rather than the author. While the former may decline to accept any responsibility for the factual content of a book, he surely has some obligations in the context of the presentation of his products. In this case, the author's basic syntax is almost faultless but, from the number of typos, missing apostrophes and the like, it seems clear that the publisher elected not to bother with an independent proof reading. Shame.

CGJ

A Walker's Guide to the Pathfinder Long Distance Walk by Gavin Sugden**.** J&KH Publishing (PO Box 13, Hailsham, BN27 3XQ); 2001. Price £10.00

Many guide books cover formal walks throughout the countryside, often relating to the more famous or popular trails. *A Walker's Guide to the Pathfinder Long Distance Walk* will be of particular interest to both walkers and students of wartime RAF history.

This 128-page pocket book is, as its name suggests, devoted to a 46-mile route which links a quartet of bases from which the Pathfinder Force operated in the three eventful years during which it spearheaded the bomber assault on Europe.

The Pathfinder Force was formed in 1942 by the simple expedient of creaming off one squadron from each of the bomber groups and moving it, lock, stock and barrel, to airfields in the Huntingdonshire/Cambridgeshire area, centred around the 'permanent' base at RAF Wyton. As the war progressed, some squadrons were detached to No 5 Gp and a number of new elements, such as the Light Night Striking Force, were added. The Force itself soon became No 8 Gp, its founder, AVM Don Bennett, being its only

wartime AOC. The inevitable consequence of expansion was that new airfields were taken over and the Group Headquarters migrated from Wyton to Castle Hill House in Huntingdon. With bases spread as far apart as Little Staughton, to the west of St Neots, Upwood, on the road to Peterborough, Gransden Lodge and Bourn to the south and with Downham Market, close to Kings Lynn, marking the northern boundary, it would be a monumental journey if the walk were to attempt to link them all. Sensibly, therefore, it is confined to a route which links the inner circle of four stations; Wyton, Graveley, Oakington, Warboys and back to Wyton.

The book is a remarkable mix of history, detailed route information, including a wide range of photographs and extracts from 1:50,000 scale Ordnance Survey maps, coupled with a wealth of general advice about walking and some specific information about how best to get the most out of the Pathfinder Walk. It is written in an open, friendly and conversational style which suggests that the author is right there with you as you pound away the miles.

The walk is divided into six legs and each is described in detail in a chapter of its own. These chapters are separated by summaries describing the airfields and the squadrons and units which they sustained, and there are several annexes full of useful information, historical context and a decent bibliography.

All in all a remarkable book which has been thoroughly researched by the author and is exceptionally well produced. As indicated already, it is a 'must' for walkers in the area but, equally, it is a very good starting point for any military aviation enthusiast wanting a 'primer' on the Pathfinders.

Wg Cdr Colin Cummings

Torpedo Leader on Malta by Wg Cdr Patrick Gibbs DSO DFC*. Grub Street; 2002. Price £9.99.

Having already completed (some might say survived) a tour of maritime attack ops with No 22 Sqn in the UK, Sqn Ldr Patrick Gibbs arrived in Egypt in March 1942, expecting, indeed eager, to begin another. There was only one Beaufort squadron in Egypt, however, and that was desperately short of aircraft. There being no vacancies for a surplus torpedo bomber pilot, a frustrated Gibbs was obliged to cool his heels on the air staff of the HQ in Cairo. The silver lining to

this cloud was that it gave him a privileged oversight of the war situation within the theatre and time to think about tactics. He eventually managed to join No 39 Sqn which, via its participation in Operation VIGOROUS, took him briefly to Malta. Realising that anti-shipping operations mounted from there could be the key to cutting Rommel's supply lines, Gibbs managed to sell the concept to the AOC, AVM Hugh Lloyd. On returning to Egypt, he used his contacts in the Cairo HQ to close the loop. It did not happen quite as quickly as the impatient Gibbs had hoped but within a few weeks he was back at Luqa where he was to play an increasingly prominent role. Before the end of July he was a wing commander, leading a somewhat heterogeneous collection of torpedo bomber crews drawn from Egypt's No 39 Sqn plus a substantial contingent on the nominal strengths of Nos 86 and 217 Sqns, the latter having, in effect, been kidnapped while on their way to the Far East.

The delivery of airborne torpedoes required closing with the target (usually an armed merchantman escorted by several destroyers) in a straight and level run at about 60 feet. Attacking in ones and twos was virtually suicidal, as it permitted the convoy to concentrate its fire. Gibbs was eventually able to mount massed attacks, typically using three or four three-aircraft formations of Beauforts, approaching simultaneously from several different directions, while a dozen escorting Beaufighters further distracted the attention of the gunners by dive-bombing and straffing, in addition to providing top cover. This level of force delivered in a well co-ordinated fashion minimised losses and increased the chances of a sinking, but fuel was in such short supply on Malta that the AOC had to be persuaded that mounting operations on such a scale had a high probability of success. That meant that Gibbs had to guarantee that he could find the target at sea. This required very close co-ordination with the reconnaissance effort mounted by the Spitfires, Baltimores and Wellingtons of Adrian Warburton's No 69 Sqn and the skills of an expert navigator; Gibbs' observer was John Creswell, to whom he gives fulsome praise.

Patrick Gibbs' book was written during the war, which may be why there are one or two slightly confused accounts of events, as it would have been very difficult to establish the facts at the time. For instance, on page 112 Gibbs recalls the first Hurricanes being despatched from the UK to Malta by carrier in June 1940, whereas

they actually sailed in July to arrive in August; the batch that went in June were flown out via France and North Africa. Similarly, we are told (on page 160) that, the Spitfires that had been launched towards Malta from HMS *Eagle* were still circling the ship when it was sunk by torpedoes in August 1942. In fact the Spitfires had been ferried by *Furious*; *Eagle* had not carried any Spitfires and all but four of its complement of Sea Hurricanes went down with the ship. Fortunately, I spotted only a few such instances and those that did crop up were in peripheral scene-setting passages. I harbour no reservations over the accuracy of Gibbs' accounts of the events in which he actually participated.

When he is not dealing with operations, Gibbs' writing tends to be a little too introspective for my taste but when he is describing the evolution of tactics, the conduct of each specific attack and the painful process of analysing failure in order to learn from mistakes, the author tells a gripping tale, and he tells it well. The book features an eight-page insert of photographs, including a dozen pictures taken during attacks. Because they are rather small, they fail to make much impression until one reads about the actual mission that each one portrays which brings them vividly to life.

Gibbs was an inspirational and innovative leader who was in the right place at the right time. When he arrived at Luqa in June 1942 Malta's handful of Beauforts was making little impact on the outcome of the war in North Africa; when he left, just three months later, his successor inherited a powerful striking force that could more or less guarantee to find any convoy within range and ensure that at least one of its transports would fail to deliver its vital cargo to Rommel. Keith Park is, rightly, credited with having been the commander who presided over Malta's conversion from defensive bastion into offensive launch platform, but it was men of Gibbs' calibre who actually made this transformation possible.

Originally published in 1992 *Torpedo Leader* is now available as a 206-page paperback and at less than £10 it is real value for money.
CGJ

Skies of Fire by Alfred Price. Cassell; 2002. Price £18.99

Dr Alfred Price is one of our foremost aviation historians. His studies of such subjects as the Spitfire, the *Luftwaffe*, the Battle of

Britain and electronic warfare are meticulous and riveting. In *Skies of Fire*, Alfred follows on from his *Sky Battles* and *Sky Warriors* in letting air stories speak for themselves. *Skies of Fire* recounts twenty-two air actions from the first heavier-than-air raid by Italian airmen over Libya in 1911-12, to the shooting down in less than two minutes of two MiG-29s by USAF fighter pilots over Bosnia in 1999. On the positive side, the stories recounted in this book weave an interesting thread though the first successful strike by carrier-borne aircraft in 1918, past the highest combat of the Second World War and thence through Vietnam, the Falklands and Kuwait. The constant theme is that cool and experienced human brains are vital, no matter how much the technology improves. Alfred writes a short commentary on each engagement in his typically knowledgeable, punchy ex-aircrew fashion, and I have to say that these are often the highlights of the book. The twenty-two stories themselves are well worth reading, and they are valuable in telling new generations about bygone days of daring human bravery and endeavour that are in danger of being forgotten in an increasingly risk-averse, stand-off electronic age.

In sum, this is a good read because Dr Alfred Price is a master of the genre.

Wg Cdr Andrew Brookes

The Air Battle for Malta by James Douglas-Hamilton. Airlife; 2001. Price £9.95.

In assessing a new softback edition of *The Air Battle for Malta* in Journal 22, while recommending it as a ‘good buy’, this reviewer was obliged to point out that it did contain a number of factual errors. The book is now available in a second impression which incorporates appropriate amendments.

CGJ

ROYAL AIR FORCE HISTORICAL SOCIETY

The Royal Air Force has been in existence for over 80 years; the study of its history is deepening, and continues to be the subject of published works of consequence. Fresh attention is being given to the strategic assumptions under which military air power was first created and which largely determined policy and operations in both World Wars, the inter-war period, and in the era of Cold War tension. Material dealing with post-war history is now becoming available under the 30-year rule. These studies are important to academic historians and to the present and future members of the RAF.

The RAF Historical Society was formed in 1986 to provide a focus for interest in the history of the RAF. It does so by providing a setting for lectures and seminars in which those interested in the history of the Service have the opportunity to meet those who participated in the evolution and implementation of policy. The Society believes that these events make an important contribution to the permanent record.

The Society normally holds three lectures or seminars a year in London, with occasional events in other parts of the country. Transcripts of lectures and seminars are published in the Journal of the RAF Historical Society, which is distributed free of charge to members. Individual membership is open to all with an interest in RAF history, whether or not they were in the Service. Although the Society has the approval of the Air Force Board, it is entirely self-financing.

Membership of the Society costs £15 per annum and further details may be obtained from the Membership Secretary, Dr Jack Dunham, Silverhill House, Coombe, Wotton-under-Edge, Gloucestershire. GLI2 7ND. (Tel 01453-843362)

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