HISTORIC·MICROWAVE

EXHIBITION CATALOGUE

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MM 90

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MM'90

THE HISTORIC MICROWAVE EXHIBITION AT MM'90

The Historic Microwave Exhibition has been arranged as part of Military Microwaves '90 Conference and Exhibition at the Wembley Conference and Exhibition Centre, London, UK, from 11-13 July 1990.

The organisers, Microwave Exhibitions and Publishers Ltd, would like to thank all those who have contributed to the exhibition, and in particular the following:

Rod Burman, Pascall Electronics Ltd
Graham Winbolt, Communications and Electronics Museum
Roger Michael, Microwave Engineering Europe

EXHIBITION HOURS:	Wednesday	11 July 0930 – 1800
	Thursday	12 July 0930 – 1800
	Friday	13 July 0930 – 1600

THE COMMUNICATIONS AND ELECTRONICS MUSEUM

Innovation and change are the very essence of the communications and electronics industries, and the theme of this conference and exhibition. Our industry's history of invention and development is one of the most fascinating in our heritage; but in the past that same rapid pace of change has caused much of the equipment and literature illustrating this story to be lost or destroyed.

The Communications and Electronics Museum (CEM) was formed in 1983 to protect, conserve and display historic artefacts and documentation relating to all aspects of communications and electronics, from their earliest history to the present day. The Museum, which is a non-profit making registered charity, brought together the military material of the Winbolt Collection and the civilian equipment of the National Wireless Museum. With the assistance of the Manpower Services Commission, CEM pursues an active programme of collection, conservation, refurbishment and display, of which the exhibition today is an example. CEM has exhibited, among other venues, at the IEEE, the House of Commons, and the Commonwealth Games in Edinburgh, and provides displays and equipment both for companies' own internal or trade use, and for the general public.

If you or your organisation wish to help in the vital work of CEM, whether by loan or gift of relevant equipment or papers, by direct sponsorship of secondment of staff, or simply by exchanging information with us, we would like to hear from you.

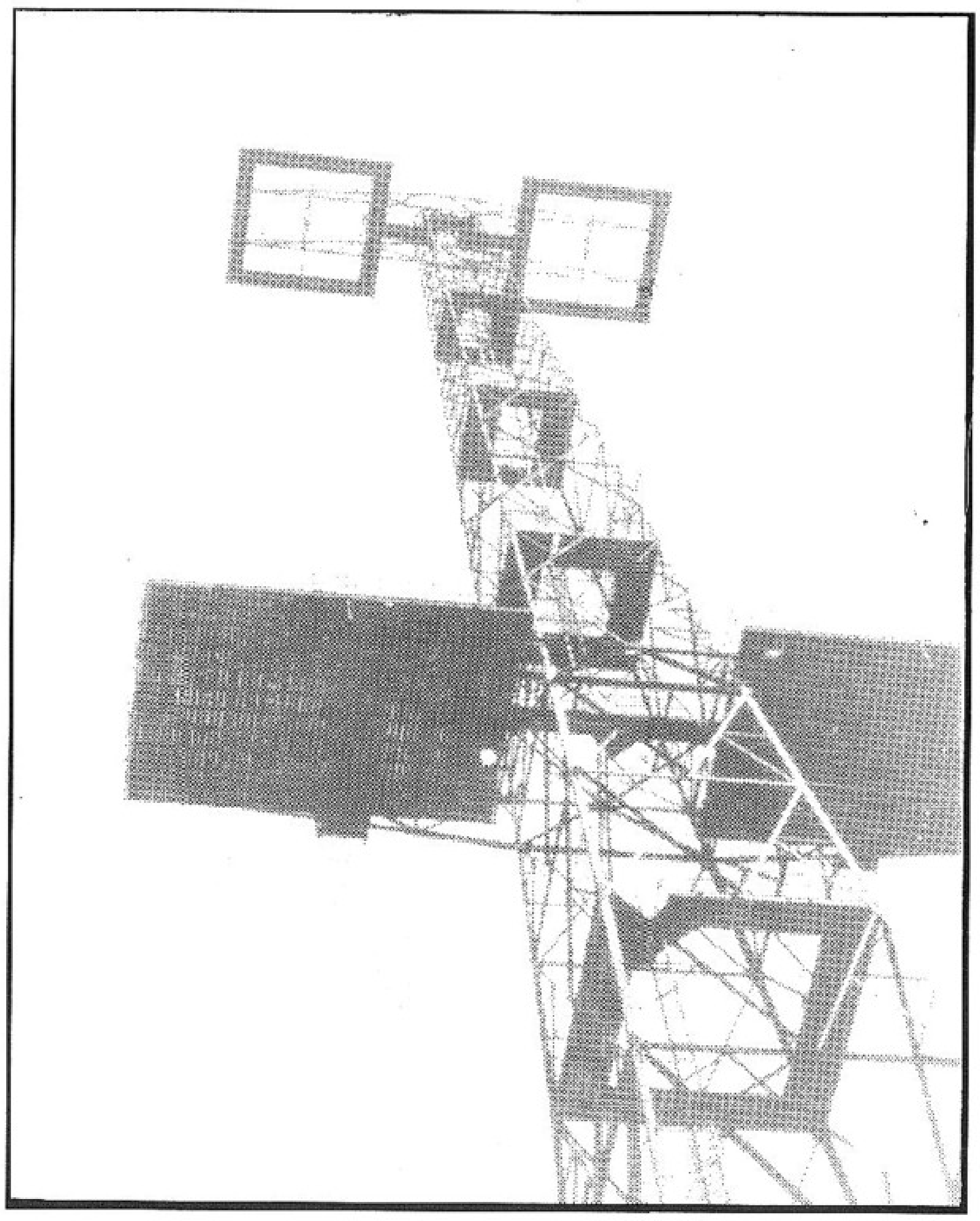
All enquiries would be particularly welcomed by the Chairman of the Trustees:

Dr Graham Winbolt
Castle Road
Pucklechurch
Bristol
BS17 3RE

HISTORIC EXHIBITION:
COMMUNICATIONS AND ELECTRONICS MUSEUM (CEM)

THIS will be the third microwave exhibition at which there has been an historical display and it seems that the previous occasions, namely MM '88 and EuMC '89, were enjoyed very much by those who attended.

The Communications and Electronics Museum is exhibiting again this year and the display is so organised as to demonstrate some of the history of the development of radar before, during and after World War II. This year marks the 50th anniversary of the Battle of Britain and I think it is doubtful if the outcome of this battle would have been successful had it not been for the existence of a tried and tested radar chain – the famous Chain Home stations. It has been said that radar alone did not win the war but that it almost certainly prevented the Allies losing it.



Typical CH Transmitter Tower.

Television had been developed in the UK prior to the onset of the Second World War and this led to a pool of knowledge being generated which could be applied to the radar programme. So we are showing a series of artefacts relating to the early days of TV.

Graham Winbolt
Chairman of the Trustees
Communications and Electronics Museum

1 A Baird 30 line TV receiver of about 1927 vintage which is in its original case and internally is untouched. These sets were produced by the Plessey Company at their works in Vicarage Lane, Ilford.

2 A Baird 30 line TV receiver which is displayed without the usual tinplate cover. This set is in working order and appeared on modern TV a few years ago. It dates from about 1930.

3 'Stookie'. This is a dummy head used by John L Baird in his early experiments with TV. The photographs at the base of the plinth show the hut which was used by Baird on the roof of the Plessey factory at Ilford as it was in 1930 or so. The left hand photograph is a general external view of the hut, whilst the right hand picture shows the dummy being photographed and recorded on a video disc.

4 Scanning mirror drum

This drum has 30 mirrors each of which is slightly angled compared to its neighbour. It is therefore a 30 line scanning device. Light is reflected onto the subject and the image received is a photo-electric cell whose output will be modulated by the amount of incident light. The reverse process can be used for reception of the transmitted picture.

Experimental TV transmissions began in September 1929 and were controlled by the BBC. Originally this was low definition 30 line television. This changed in August 1936 when the Marconi-EMI electronic system using 405 lines was transmitted on alternate weeks with a Baird mechanical system then developed to 240 lines.

The electronic system prevailed and was adopted as the standard for the UK by the Postmaster General in February 1937.

Baird was thus severely disadvantaged. It seems however that he simply shrugged his shoulders and started to develop colour and three-dimensional TV!

5 Baird Electronic TV receiver Model T18

Manufactured, probably by the Plessey Co, for the Baird Co round about 1937 or 1938. This is a true electronic receiver with a 12" circular cathode ray tube built into the typical console cabinet of the time and incorporating a 3 waveband radio receiver.

6 Pye 45 Mc/s IF Strip

This is the classical radar (and TV) receiver IF strip from the war. Known as Receiver Unit Type 153 it found its way into many radar sets and also into many immediate post-war television receivers. It appeared on the surplus market in huge numbers in the 1950's. This specimen was still brand new in its original carton.

This is a copy of the first photograph taken of a TV image from a Baird Televisor.

You will notice the two blue and copper panels mounted over the dummy. These were prepared for the BBC Golden Jubilee in 1972 and like all the artefacts shown here were presented to the Communications and Electronics Museum by the Plessey Co just prior to the recent merger with GEC and Siemens.

7 Ekcovision Portable Receiver Type TBM 272

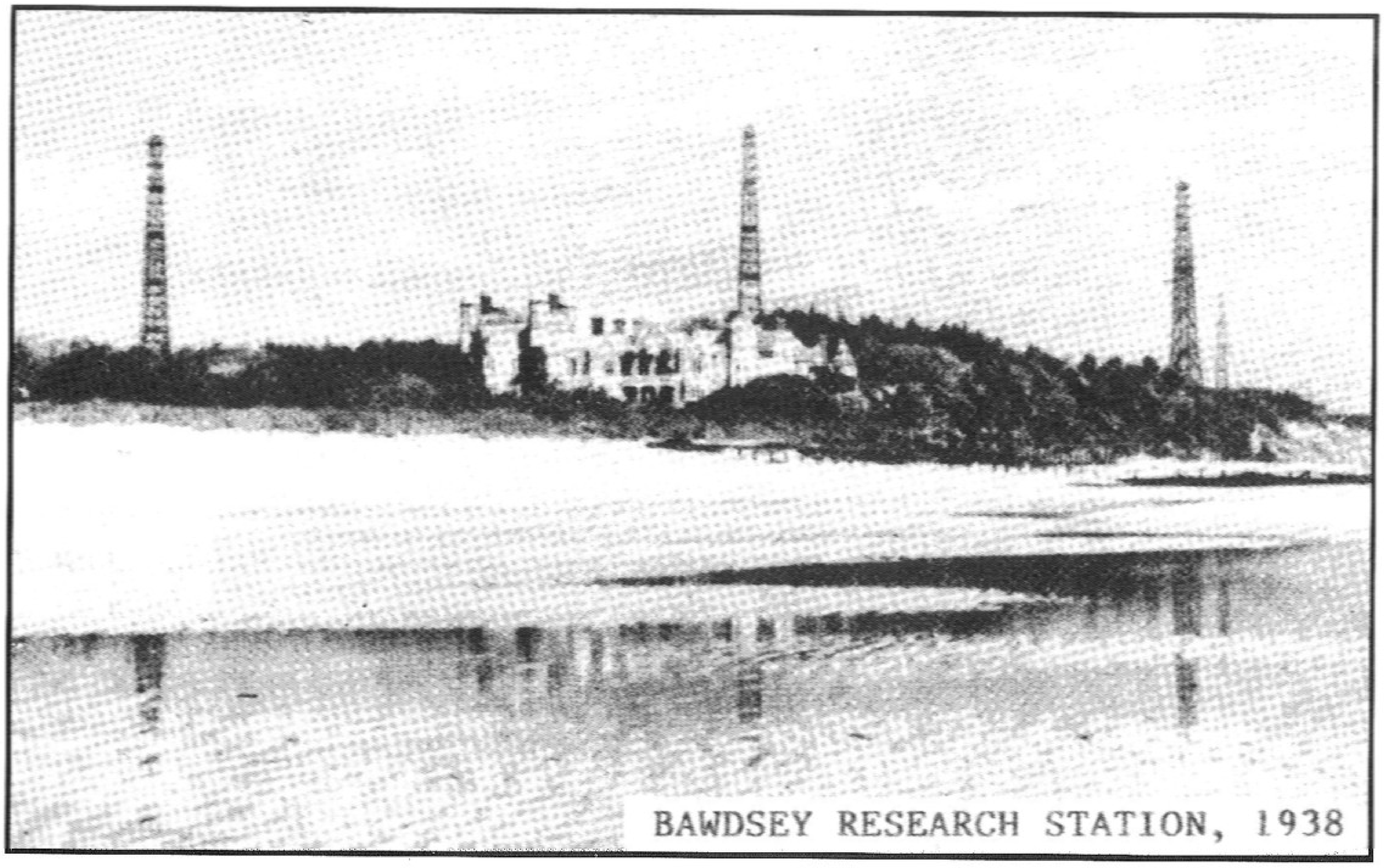
This is one of the first portable television receivers to be manufactured in the UK but does depend on mains for its power. It is a single channel 405 line black and white receiver and came onto the market in 1950/51. There is a provision for radio on the Home, Light and Third programmes.

CHAIN HOME

This display is an attempt to explain the origins and functions of the world's first fully integrated surveillance radar system. The need for the UK to develop an effective defence against enemy air attack was recognised as early as 1934. The Committee for the Scientific Survey of Air Defence was established in late 1934 under the chairmanship of Sir Henry Tizard. This became known as the Tizard Committee. The members quickly decided that, thanks to the work of Sir Robert Watson-Watt and his assistant Arnold Wilkins, the location of aircraft by radio means was feasible. An experimental group was set up at Orfordness in Suffolk and by July 1935 a flight of 3 Hart aircraft was correctly located. By 1936 ranges of detection up to 75 miles were achieved.

In May 1936 research facilities moved to Bawdsey Manor, not far from Orfordness, and the first working CH radar was handed over to its RAF personnel in May 1937.

Other radars were then built along the South Coast to cover potential raids on London and the Home Counties. Quite an elaborate system of integration of the various radars was evolved and information from them was fed to filter rooms. This enabled an overall threat analysis to be made and for fighter aircraft to be scrambled and directed towards the incoming bombers and their escorting fighters.



Bawdsey Research Station in 1938.

1 Air Diagram 5342A

This shows the basic layout of a CH receiver.

2 AP 2911 R

The Radar Supervisors Manual.

3 TRE Document

Copy of original TRE (Telecommunications Research Establishment) document showing the filtering network for an area (14 Group) in Scotland. These notes were intended as guidance for filter room staff.

4 Goniometer

This is just about the only original piece of CH equipment that I have ever seen! This is the device — shown on the AD 5342A — which gives the direction of a located target. It is thought to have originated from the 'buried reserve' at the Rye or Poling CH stations on the South Coast.

BATTLE OF BRITAIN

50 years ago this month the RAF was locked in the famous and crucial battle to prevent German air superiority becoming a fact. Had the German Air Force been victorious then the chances are that operation Sealion, the invasion of the UK, might have been attempted. Had that invasion succeeded then the maps would probably look rather different today.

1 German Target Map and Photograph

This target map and its associated aerial photograph show the location, layout etc of the Plessey factory in Ilford, London. The detail is impressive and, in retrospect, rather frightening. However, one doubts the ability of the enemy bombers to make full use of such information as the opposition to their efforts was impressive by day and not exactly ineffectual by night.

2 Spitfire

Shown also is a drawing of the famous Spitfire fighter which, with the Hurricane, was the main weapon used against enemy fighters and bombers.

3 IFF Mk II

This unit, mounted in allied aircraft, enabled radar plotters to determine if a detected target was friendly or not. The unit was triggered to respond to incoming radar pulses and gave a characteristic response to the radar personnel.

4 TR9 and TR1133

The efficient use of radar information demanded that good communications must exist between ground control staff and the pilots actually in the air. Originally the only W/T set available was the TR9 and its variants. This was, even then, a radio of ancient design and ill suited for the task. Fortunately VHF sets were just becoming available and the first of these, the TR1133, was extensively used. This enabled efficient communications to be maintained. Copies of the TR9 and the TR1133 are shown.

5 Operation Sealion

A considerable effort was made by the German forces to produce intelligence documents for the use of their invading forces participating in the projected operation Sealion. Shown here is a collection of maps, statistical information etc, there being contained within the package a collection of photographs. I particularly like the one shown here – a view of the river Test near Stockbridge and a pair of trout anglers at work! Other photographs, however, might have been of greater military value.

AI (AIRCRAFT INTERCEPTION)

The effective use of our fighter forces, under the most able command of Air Chief Marshal Sir Hugh Dowding, denied the Germans the air superiority that was so desirable to them in 1940. As a result of this reversal the day bombing of the UK gave way to night bombing – the so called Blitz was about to begin.

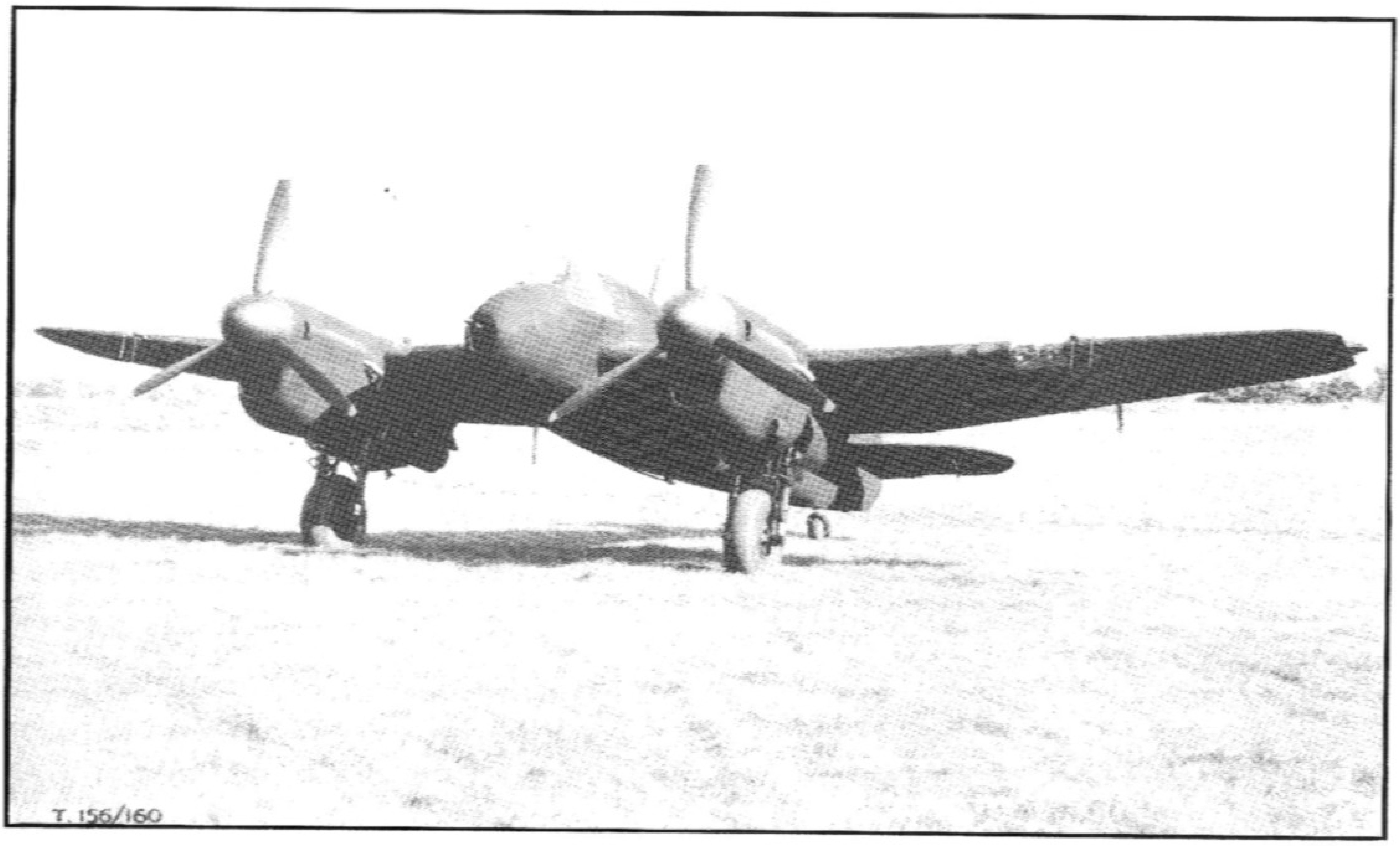
Tracking incoming aircraft by ground radar was continued as before but it was found that night fighters were unlikely to be effective unless fitted with their own shorter range radar. At first only sets working on 190 Mc/s on $1^1/_2$ metres wavelength. This frequency had many disadvantages – multiple aerial systems cluttering the aircraft wings and the cathode ray tube displays tended to be swamped by ground returns at low altitude.

The change to centimetric wavelengths was a great step forward as transmitted energy could be effectively 'beamed' by small diameter parabolic dishes. Whilst there were several UK varieties of centimetric AI (Aircraft Interception) radar the set most used was of American origin the SCR 720 (AI Mark X in UK nomenclature).

Shown here are examples of both types:

1 Indicator Unit Type 48

This indicator has two CRTs, one showing the azimuth of the target and the other the elevation. The example shown here has not yet been restored and is exactly as it was found in a scrapyard some 15 years ago.



AI Mk IV fitted to a Beamfighter. This aircraft has Merlin engines.

2 AI Mk IV Transmitter Aerial

This is the arrow shaped folded dipole aerial located in the nose of the night fighter.

3 AI Mk X (SCR 720)

This set is of American design and manufacture and was imported into the UK in quantity. It operates on a wavelength of 9 cms and a peak output of some 70 kW. The indicator unit uses two CRTs. The aerial scan pattern is helical.

AI X was successfully used during the war and for many years afterwards. Shown here is the transmitter unit and also the indicator.

ASV (AIR TO SURFACE VESSEL)

The war in the Atlantic against the U-boats was both defensive and offensive. The need to defend the hard-pressed convoys to and from the USA became of paramount concern when sinkings of supply vessels reached dangerous levels. The best method of defence was certainly to attack the U-boats ideally by sinking them or at least by keeping them submerged when their operational abilities were greatly lessened.

Regular surveillance from the air became a key factor and especially if the searching aircraft were fitted with radar. Again, these radars were originally operating on about $1^1/_2$ metre wavelengths and not without success. However, the advent of the magnetron valve and hence centimetric wavelengths at high power made a dramatic improvement in the situation. The advent of ASV Mk VI was a tremendous step forward. This was a 200 kW radar carried by Sunderland aircraft, of Coastal Command. This radar was linked to the Leigh Light, a special high power searchlight, which could be switched on at a selected time after first locating the surfaced U-boat. It is a great pity that the depth charges etc available for the attack were not so efficient as was the radar.

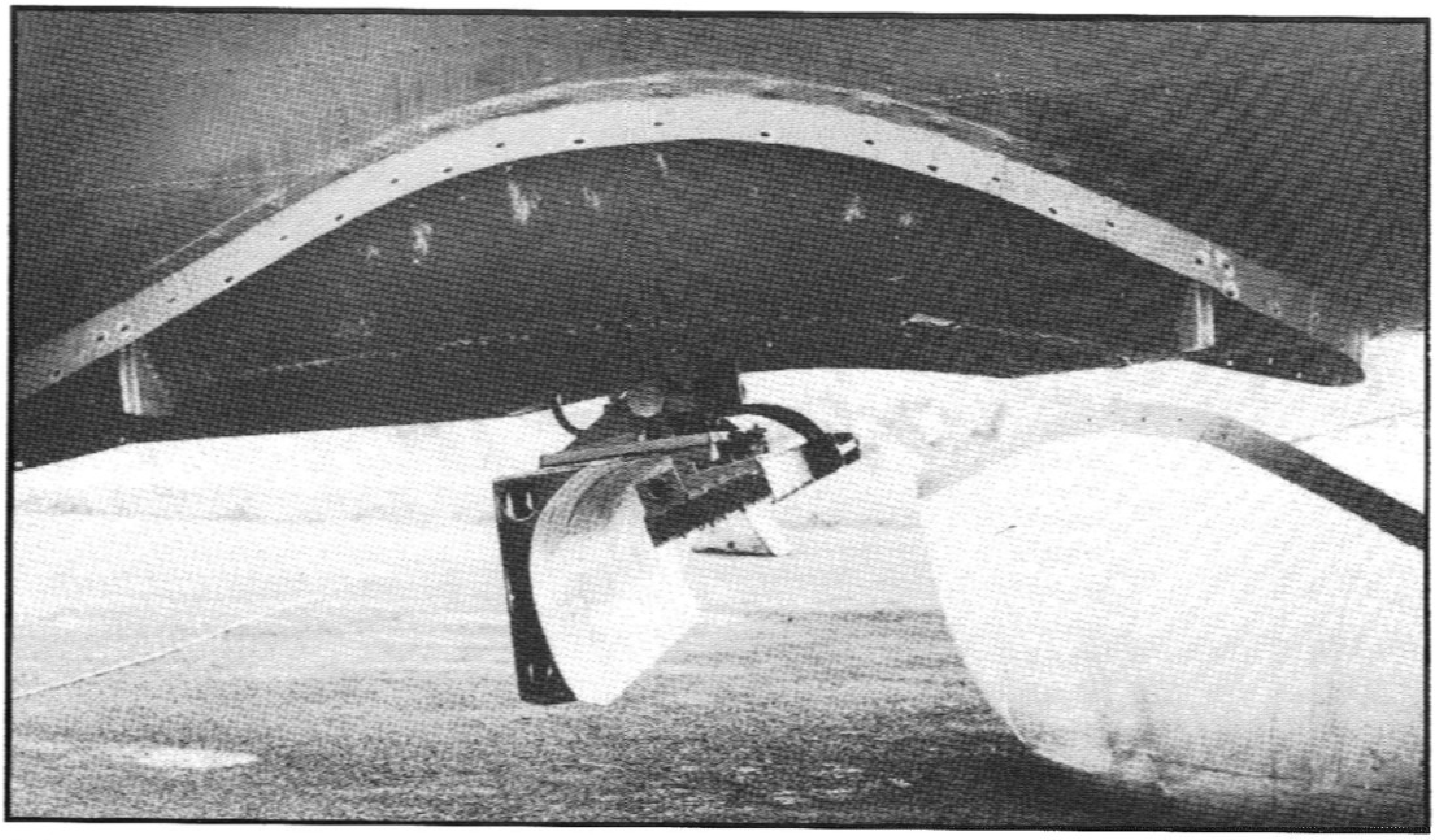
Shown here is the **Scanner Type 68A** associated with the radar and also an unrestored copy of the **Indicator Type 162**. The latter was also used in the H_2S Mk II map drawing radar used by Bomber Command.

H_2S

No display of historical microwave equipment would be complete without some mention of this system, developed at TRE during the war. The group of workers concerned being under the guidance of Bernard Lovell (now Sir Bernard Lovell).

These radar systems were designed to produce radar maps of the ground over which the fitted aircraft were flying. They were thus most useful for navigational purposes but could also be used for blind bombing. The first sets operated on a wavelength of 10 cms but this was soon reduced to 3 cms with a great improvement in definition.

Shown here is the **Indicator Unit Type 184** which was associated with H_2S Mk III.



H_2S scanner mounted on underside of Lancaster bomber. The radome has been removed.

The other item on display is an American unit, titled **RT-63/APS**. These units were brought to this country late in the war when development was proceeding with H_2S Mk VI. The magnetron used as a 3J31 capable of delivering some 60 kW of peak power at a wavelength of $1^1/_4$ cms.

Gee

This is the famous Second World War navigational aid which was largely fitted in aircraft but was also used by ships.

Whilst not strictly a radar device it does make use of the pulse principle. The receiver measures the time intervals of pulses coming from three or four ground stations that are widely separated. These intervals are displayed on a cathode ray tube and by reference to special 'lattice' charts the position of the receiving device is known.

The Gee, or 7000, system enabled aircraft so fitted to know, with accuracy and for the first time, where they were. This meant that bombing became much more accurate and aircraft losses were reduced. The system was fully exploited on D-Day and there is no doubt that the navigational problems involved in the launch of such a vast fleet would have been perhaps impossible without the use of Gee.

Shown here is the **Mark II (Tropical) version** which has been restored to working order by P E Judkins, a trustee and the treasurer of CEM. Alas there are now no Gee transmissions to receive but we hope that the basic scan pattern will show on the indicator unit. The power to run the system is derived from an authentic rotary inverter which is of the correct vintage.

VHF Receivers

This item was on display last year but it is very relevant again as it is the ground part of the VHF transmitters and receivers used to control aircraft during the Battle of Britain.

Shown here in a non-standard rack is the **R1132** which covers the band from 100 Mc/s-124 Mc/s. Also in the rack is a **R1392 receiver** which is more sophisticated in construction, has crystal control and covers the band 100 Mc/s-150 Mc/s. Both receivers are used in conjunction with the T1131 transmitter and are capable of providing communications and direction finding facilities.

It is hoped that one or both receivers will be operational.

Red Steer

This is one of a long series of post-war radars most of which seem to have acquired 'coloured' codenames. This system was a modified form of AI Mk XX and replaced Orange Putter. It was fitted into V bombers (Vulcan etc) and was designed in 1959 or so. It is an X band tail warning radar and part of the ECM (Electronic Countermeasures) rig. It is the largest airborne unit I have seen, this particular copy having rolled off the side of a smouldering heap of rubbish in a scrapyard! I couldn't leave it there as it looked so marvellous. The associated antenna and its radome have appeared more respectably and more recently.

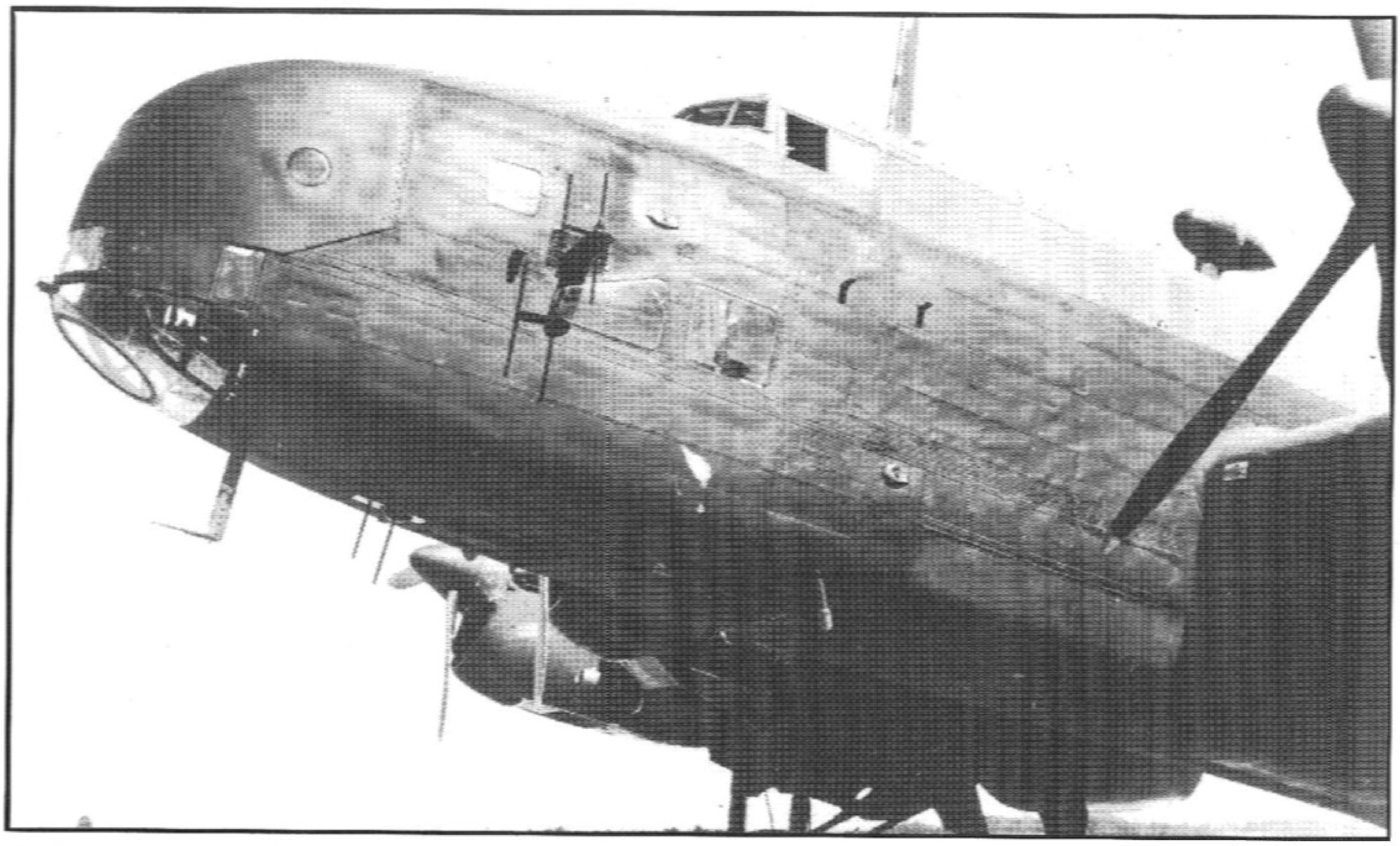
Tail warning radars were used during the Second World War and codenamed Monica. It was, however, discovered that their radiations were more hazardous than helpful and were removed by order of the Bomber Command chief, Air Chief Marshal Sir Arthur Harris.

Rebecca

This system is really a device capable of interrogating a ground based beacon. The transmitter in the aircraft sends out a string of directional coded pulses on a frequency of about 230 Mc/s. This triggers the beacon to reply with a pulse train which is received in the aircraft receiver and displayed on a CRT indicator unit. Because the aerial systems are directional it is possible for the aircraft to determine its distance from and angle to the beacon. It can thus be a useful homing aid to a beacon of known location and can also be used to drop supplies, parachute troops etc in a required location.

The Mark II system is displayed here and is in the middle of a restoration programme which has been undertaken by Richard Trim, a committee member of CEM. We hope that the units will be in operational condition but items of this age do have problems.

Also shown here is a beautiful copy of a **Eureka Mk IIIC beacon** of American



Rebecca II fitted to a Halifax bomber. Receiving aerials beside cockpit and transmitter aerial below the nose.

manufacture and also known as AN/PPN-2. This is capable of acting as a beacon for Rebecca II and is constructed to be dropped by parachute troops. The aerial is incompletely extended.

Australian Radar in World War II

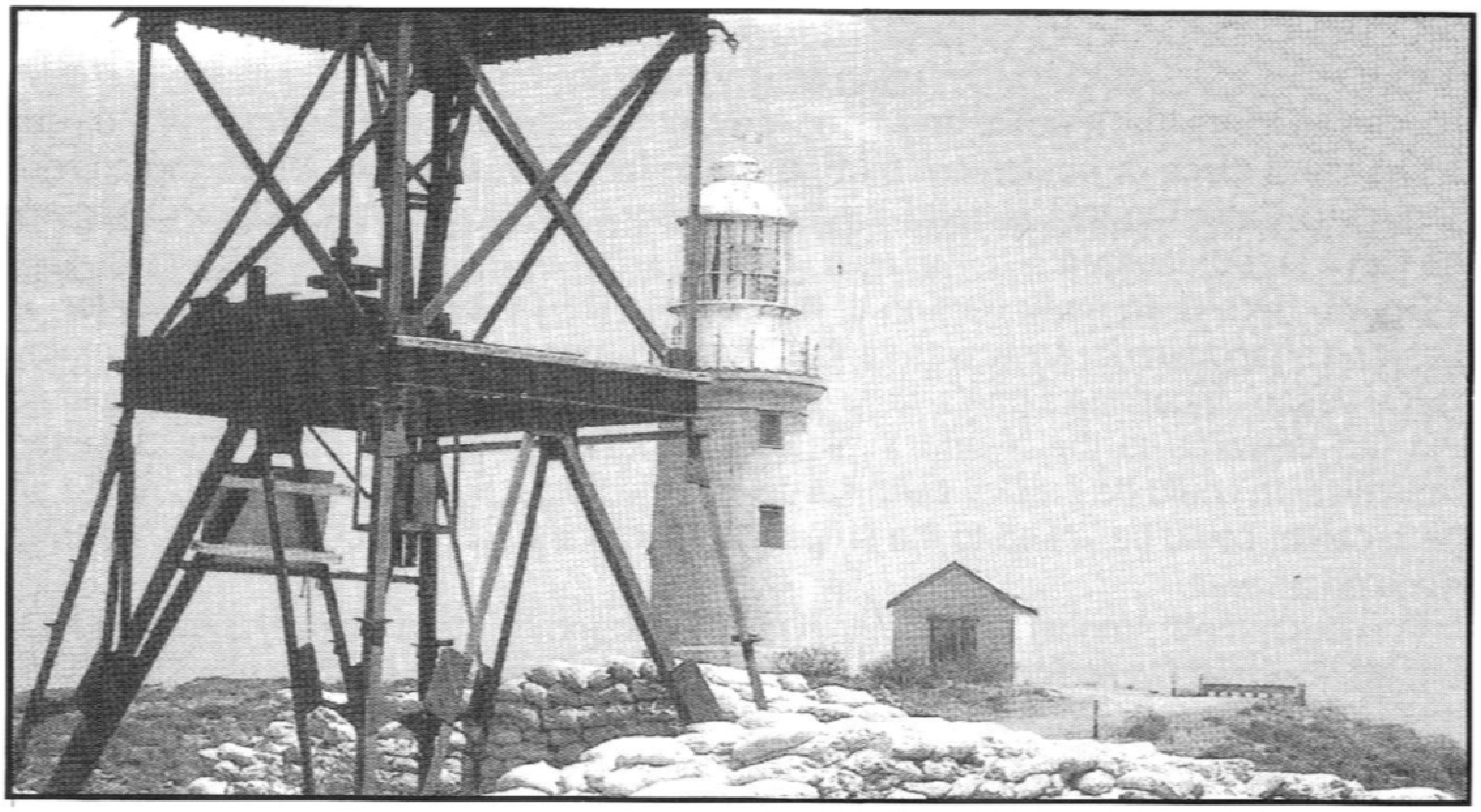
Little attention has been paid to the considerable effort made by the Australians during the last war to produce their own defensive and offensive radars. I was stimulated to explore the scene as I was presented with a postcard showing the remains of a radar station at a place called Exmouth on the Western Coast.

In 1939, at the request of the UK authorities, an Australian physicist was invited to the UK and was shown the new RDF techniques. He then returned home and established the Radio Physics Laboratory under the auspices of the CSIR (Council of Scientific and Industrial Research). Some British equipment was delivered which included RDF and ASV Mark I items. Some personnel from all three services were sent to Britain and trained in RDF and radar.

Progress was initially slow as the organisation to manage a radar development programme did not exist nor were there production facilities. Radio components were not so plentiful as they were in the UK.

However, the whole atmosphere seems to have been changed by the Japanese entry into the war in December 1941. The first air warning radar was put together in a few days using a coastal radar and a modified ASV receiver. The set operated on $1^1/_2$ metres and by changing the pulse width from $1^1/_2$ to 20 microseconds ranges of up to 100 miles were possible! Thus was born the famous AW Mk I radar which became used throughout the Pacific during the whole of the war.

With the advent of troops from the USA into Australia, the air warning radar SCR270



Remains of an AW-1 radar at Station No. 310, Exmouth, Western Australia.

and the gunnery radar SCR268 came as well and were used as models for future development.

Transportable versions of the British Chain Home radars were also imported, the aerial towers being constructed of wood. As the war progressed all the various types of Allied radar found their way to Australia.

The early work, however was essentially Australian and effective. Shown here today are a series of photographs of various radar sites around the coast. I am indebted to the Royal Australian Air Force and to Group Captain Peter Rusbridge in particular for these unique photographs and for the interest taken in the production of this display.

The artefacts shown here are both British but were widely used by the Australian forces in the early part of the war.

1 R1082

This simple battery-powered receiver could cover the bands from 100 Kc/s to 15 Mc/s by the aid of a comprehensive set of coils. The receiver is of pre-1939 design and was used both in the air and as a ground station. Direction finding was possible with the addition of a loop aerial system.

2 R1084

An amazing ground station receiver that could be used either as a TRF or as a superhet. It covered 120 Kc/s-20 Mc/s with the aid of an even more impressive collection of plug-in coils (54 in all I think). In spite of its aged design this was a good receiver in well trained hands. It was much appreciated by Australian operators who probably had a higher opinion of its functions than did their UK counterparts.

Chairman's Choice

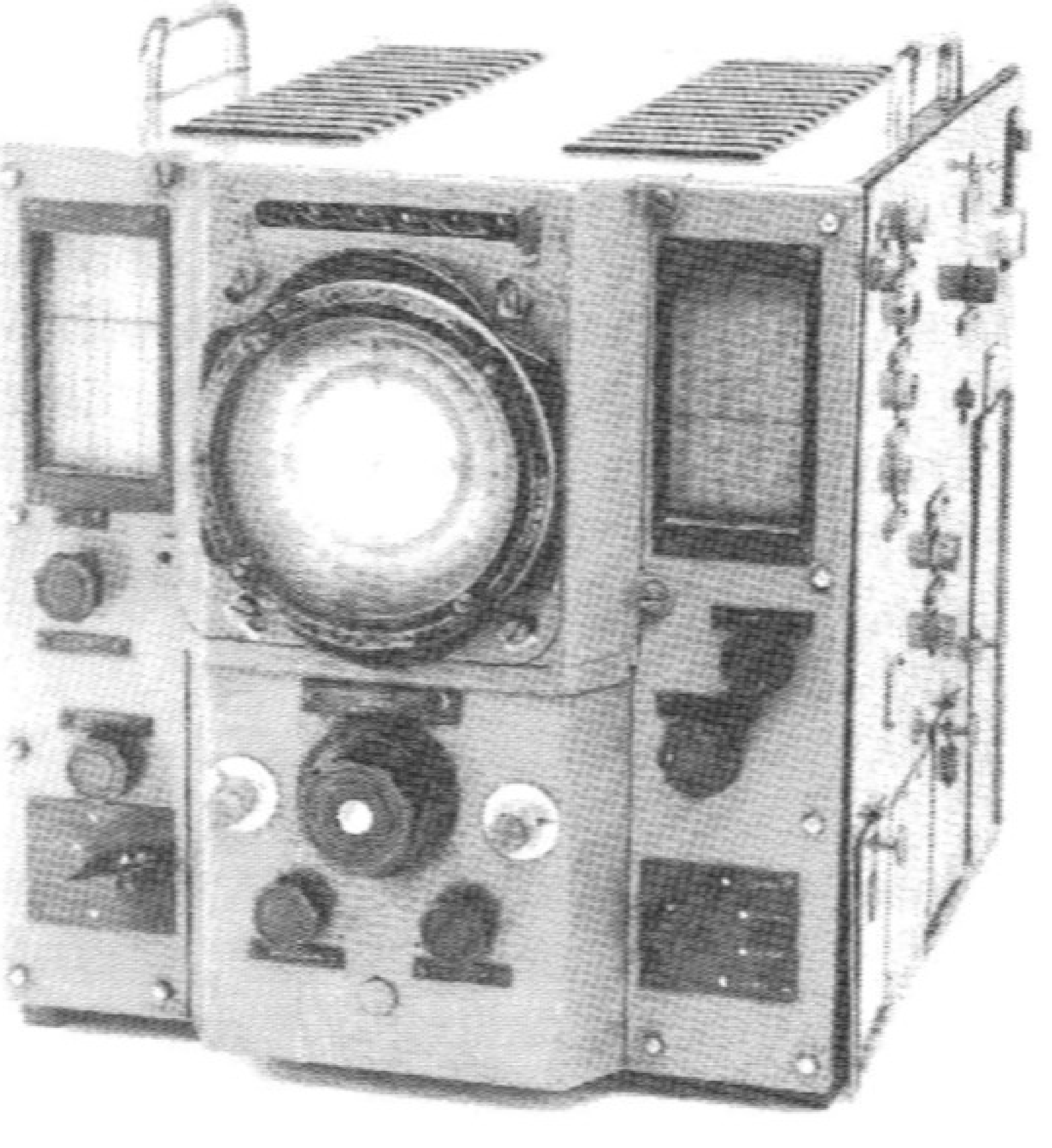
It occurred to me that it would be a good idea for the Conference Chairman of the year to choose a piece of equipment that he would like to see shown. Since the current Chairman, Peter Varnish, is head of naval weapons development at ARE, Portsdown, the Navy is represented.

Shown here is an early version of the famous **HF/DF or 'Huff-Duff' Receiver**. A diamond shaped aerial array was sited at the mast-head of the ship – usually a convoy escort vessel. Incoming signals were fed to the two receivers within the unit, amplified and fed onwards to the X and Y plates of a CRT. The direction of the detected transmission could be quickly seen relative to the ships' head but an azimuth ring on the receiver could be linked to the ships gyro compass and so true magnetic bearing revealed as well.

This equipment, known as the FH4, was developed by the Admiralty Signal School and the Plessey Company over a two year period and was operational in July 1941.

U-boat tactics in the Atlantic had been evolving towards the Wolf-pack concept where U-boats collected together for massed attacks against an allied convoy. This 'coming together' meant that a great deal of wireless transmission to each other and to their bases at Lorient etc was necessary.

These transmissions could be detected by the HF/DF set and would therefore give away the U-boats' position and also their numbers. It is possible that the later extensive use of these receivers and the efficient exploitation of the intelligence so gained was as important as radar in the defeat of the U-boat arm of the German Navy.



FH4 Receiver Serial No. 4.

Finally the Communications and Electronics Museum wishes to thank Roger Marriott and his staff at Microwave Exhibitions and Publishers Ltd for making it possible to display older equipment. The Museum would also like to thank Pascall Electronics Ltd, *Microwave Engineering Europe* and MEPL for funding the production of this brochure to accompany the Historical Exhibition.

HISTORIC EXHIBITION:
RODNEY BURMAN

IT IS now more than two years since the first suggestion was made to incorporate an historic electronics display with the MM '88 Exhibition.

Fortunately, this suggestion was taken up with great enthusiasm by Roger Marriott and his staff and what at first was envisaged as a fairly modest affair has, thanks to the generous provision of space by Microwave Exhibitions and Publishers Ltd, become a major display of historic electronic artefacts.

MM '90 is the third successive microwave show in the UK, and, in the period since the start of MM '88, my own collection has grown significantly to the point where I now have several hundred valves and in the region of one hundred items of historic electronic equipment.

Whilst this collection takes up a considerable amount of space, it pales into insignificance beside the 300 tonnes which has been assembled by Graham Winbolt and the Communications and Electronics Museum. It is thanks to Dr Winbolt that some exceedingly rare and interesting items have been displayed and are to be seen this year.

However, my own more modest collection has provided much interest, particularly from the point of view of restoration and research. Also, from the comments I have heard from visitors to the last two microwave exhibitions, I believe the historic exhibit has generated a considerable amount of interest and evoked a few memories of days gone by.

This year's exhibit displays a range of military electronic equipment dating back to the latter part of World War I, when wireless communication first became of practical value to the armed forces. Because the development of the thermionic valve, from the early triode up to the resonant cavity magnetron, has played such an important part in the progress of military electronics during the two World Wars, the exhibit shows a selection of valves as well as some of the actual equipment that was used. Obviously, by the outbreak of World War II in 1939, electronics covered many more fields than just wireless communication (radar being the most notable) and, consequently, considerable emphasis has been placed on valve development for this application.

So, finally, if any of you reading this catalogue still have pieces of historic electronic hardware or valves tucked away in some forgotten corner, don't leave them to rot or consign them to the rubbish tip. Keep them, renovate them or donate them; after all, they are part of our electronic heritage.

Rodney Burman
Pascall Electronics Ltd

WORLD WAR I

Although Hertz, and subsequently Marconi, demonstrated the technique of wireless communication years before the outbreak of World War I, it was the needs of the military during this period that spurred on the development of the embryonic technology of electronics. By the end of 1918 spark transmitters and crystal receivers were still very much in use, but the improvements taking place in triode valves enabled both transmitters and receivers to be constructed using thermionic devices.

The exhibits in this section all relate to World War I and are representative of British equipment and British, American, German and French valves.

A1 Marconi 'V24': *c*1917. Made for Marconi's W T Co probably by Osram Lamp Works. Anode and grid connections are brought out on opposite sides of the glass tube so as to minimise stray anode/grid capacity and make the valve perform better as a high frequency amplifier.

A2 Marconi 'Q': Details as per A1 except that this valve uses a much larger diameter anode and was specifically recommended for use as a detector.

A3 Air Force 'C': Introduced September 1918. A High Vacuum Triode manufactured by Osram and used in the Aircraft Tuner/Receiver type T10.

A4 De Forest Audion Triode: *c*1908. One of the earliest 3 electrode valves, based on De Forest's triode patent filed in 1907 and granted one year later. Manufactured by H W McCandless & Company in New York. Although not specifically designed as a military valve, spherical audions were used by both US and British signal establishments during World War I.

A5 Fotos French Valve: Manufactured by E C & A Grammont in Lyon from 1915 onwards. The forerunner of the much used 'R' valve and the first valve to be made with what later became the standard 4 pin triode base.

A6 Tuner and Amplifier Short Wave: *c*1917. Manufactured by Robert W Paul, London N11 A crystal or 1 valve regenerative detector receiver covering 100-700 metres. Believed to have been used to receive messages from spotter aircraft for directing artillery fire. Only 100 of these receivers were made and this example (Serial No. 74) is one of only 2 known surviving examples. It was acquired last year in a heavily modified and damaged condition and has needed significant restoration to bring it to its present state.

A7 Transmitter W/T No. 4: Built in May 1917 at the War Department Wireless factory in Soho, London. A spark transmitter designed for airborne use, the tuning was accomplished by tapping the spiral coil on the outside with wavelength being indicated by numbered blocks. The door of the transmitter is fitted with a rubber seal in an attempt to reduce the danger of sparks igniting petrol vapour on the aeroplane. Could have been used to communicate with either of the 2 crystal receivers shown here.

A8 Round Type 'C': 1914-1915. Developed by Captain Round of Marconi and used extensively during World War I. The top pip contains asbestos which, if heated, releases a small amount of gas into the valve thereby controlling the degree of vacuum and hence the valve's performance.

A9 White Valve 1916: Designed in Cambridge under the direction of Sir J J Thomson and later used in the British Signals Experimental Establishment Mk III amplifier.

A10 Long Wave Wavemeter 1918: Manufactured by ATM Co Ltd covers 750-3000 metres (100-400 kHz) in 2 bands. Tuning is by means of a high grade variometer. Unit also has a buzzer for use as a signal source.

A11 Forward Spark 'B' Wavemeter: 1918. Covers 50 to 100 metres (3-6 MHz). Specific points at 65 and 80 metres. Fitted with a carborundum and steel detector driving headphones and a buzzer, so, could be used for tuning transmitters and as signal source for setting up receivers.

A12 Short Wave Mk III Tuner: A 'Short Wave' 100-700 metres crystal receiver for headphone use. Fitted with Perikon and carborundum and steel detectors also output terminals for an external valve amplifier. The buzzer acts as a local signal source for setting up purposes. The Mk III receiver was used as a ground receiver for picking up gun laying target information from spotter aircraft.
Originally a Marconi design, the Mk III was made by several other manufacturers to the Marconi specification. The example shown here is an original Marconi made unit and was probably built about 1916.

A13 VTI: *c*1917. Manufactured by Western Electric for the US Army Signal Corps. Developed from telephone repeater tubes.

A14 VT2: 1917-1918. Manufactured by Western Electric as a small transmitting tube for the US Army Signal Corps. Also used by the US Navy under designation CW 931, from which this example comes.

A15 Siemens Type 'A': 1918. Originally designed as a telephone repeater tube, but pressed into service by the German military.

A16 AEG Type 'A': 1918. Similar to Siemens Type 'A' but manufactured by AEG.

A17 Telefunken EVN 171: Dated November 1917, this valve was much used in German military equipment, especially low frequency amplifiers.

A18 Telefunken EVE 173: *c*1918. In its original box, complete with filament ballast resistor. The copper anode indicates the valve was made in the latter part of 1918 when supplies of nickel (the usual metal) had become exhausted.

A19 Heterodyne Wavemeter: *c*1918. A one valve (R type) oscillator covering 500 to 3000 metres (100 kHz-600 kHz) by means of 2 plug in range blocks. May be used as a signal source or for checking the frequency of a transmitter. The meter, which is

undamped, is used to indicate zero beat when checking transmitters.
A20 WT Set Trench CW Mk III: Manufactured by ATM Co in 1918. A two valve (R type) receiver using a regenerative detector and 1 stage audio amplifier. Covers 260-1550 metres or 350 to 1800 metres, depending on the type of aerial in use! Consequently, needed to be used with either a wavemeter (see A19) or a transmitter for accurate frequency setting.
Folding metal legs kept the equipment above the level of mud, etc, found in the bottom of the trenches. This artefact is the property of Mr John Hallatt, who has kindly loaned it for display at MM '90.

A21 A Radiofotos Grammont TM75: A transmitting triode manufactured in France about 1917 believed to have anode dissapation. An extension of the receiving triode design (A5) for transmitting purposes. A receiving valve with anode and grid connections also bought out to top caps was developed to improve the high frequency performance of the valve.

BETWEEN THE WARS

In the immediate aftermath of World War I, people's thoughts were far from military matters, with the result that technological development, including electronics, proceeded at a much more leisurely pace. In fact, the majority of electronic innovation took place as the result of the growth of public interest in broadcasting.

Ultimately, by the mid 1930's military considerations were once again taking precedence, and items of equipment were being developed specifically for military applications.
The exhibits in this section commence with a selection of military valves dating from 1920, and some late 1930's wireless equipment of British, German and American origin.

B1 Air Force 'D': *c*1919. Manufactured by Osram as a soft valve for detector applications. Used in the Ground Station Detecting Amplifier T-XII.

B2 Russian Triode: *c*1921. This much repaired specimen is identified as being of Russian origin by the Cyrillic symbol stamped on the base shell. It is presumed to have been made in the radio laboratory at Nijni - Novgorod, with military applications in mind.

B3 Moorhead 'G': *c*1919. Copy of the French 'R' valve. Made by Otis B Moorhead in San Francisco under contract to the British Government. Used as an alternative to the BTH 'B'.

B4 VR3B: *c*1925. The Air Ministry equivalent of the DEV, a dull emitter V24. One of the first valves to have a VR (valve receiving) designation. Manufactured by MOV.

B5 VR17: *c*1926. A 2 volt battery triode made by Cossor. Although there does not appear to be a direct commercial equivalent the performance is similar to the Cossor point one series.

B6 VR19: *c*1926. Equivalent to PM2, a 2 volt battery output triode which, although listed as equivalent to a Mullard type Number, is manufactured by Cossor. Unusually for an output valve these examples are metalised.

B7 ARP3: 'Army Receiving Pentode No. 3'. Equivalent to a civilian 9D2. *c*1930. A large RF pentode which, in spite of its size and date of origin, was used in a number of equipments during World War II. This particular example manufactured in Canada by Marconi.

B8 VR28: *c*1928. Equivalent to civilian 220 VSG a variable mu screened grid 2 volt battery valve manufactured by Cossor.

B9 ARP8: *c*1932. Another Cossor valve having civilian part number AC4/Pen. A 4 volt indirectly heated output pentode.

B10 H406D: This example dated 6th December 1934. A 4 volt battery operated screened tetrode made by Valvo for the German military.

B11 RS289: A 4 volt indirectly-heated output pentode made by Telefunken for the German military. Although this example is dated week 32 of 1939, the valve was probably designed in about 1934//35.

B12 ATS 70: Originally introduced about 1928, this valve is a transmitting screened tetrode equivalent to commercial 4282B. Manufactured by Mazda, this valve is marked with a War Department stamp. Later versions have graphite anodes.

B13 TV05-12: *c*1936. A Mullard transmitting VHF (60 MHz) triode with anode and grid brought out to top caps. Fitted rather incongruously with an 8 pin side contact base, this valve carries the Air Ministry reference IOE/130. A pair of these valves could generate 31 watts output at 60 MHz.

B14 RL12P35: 1939. Manufactured by Telefunken, a transmitting pentode used in a number of German World War II ground based and airborne transmitters. Unusual in having 3 top caps connected to plate, suppressor grid and the third is a dummy covering the evacuation pip.

B15 NT36: *c*1935. Naval designation for the DA100, an audio frequency output triode having 100W anode dissipation capability. Now much sought after by Japanese collectors for the construction of 'vintage' hi-fi amplifiers.

B15 UZ42: *c*1936. Japanese manufactured equivalent to the American UX based type 42 output valve. Would be interested to receive a translation of the characters on the paper label.

B17 HX966: *c*1937. Another Japanese valve, equivalent to the American 866A Mercury vapour half wave rectifier. Note the unusual zig-zag filament construction.

B18 DET 1 SW: *c*1928. Manufactured by MOV. A directly heated transmitting triode, probably giving 20-30 watts output. Marked with War Department stamp.

B19 VT47: *c*1935. A directly heated triode having a 20 watt anode dissipation capability. This example carries the Air Ministry designated IOE/10559. Manufacturer unknown.

B20 Torn E_b: German Army receiver 1937. Covers 100 kHz to 7.0 MHz in 8 bands. Band-switching by means of an enormous turret tuner. Displayed with its internal screens removed to show the incredibly elegant mechanical construction which far exceeds the electrical performance obtainable from the 4 valve TRF circuit.

B21 R1082: A 5-valve TRF receiver covering 111 Kc/s to 15 Mc/s by means of 15 pairs of plug-in coils. Originally designed in the mid 1930's, this receiver was used extensively in RAF bombers at the outbreak of World War II. Its standard of construction is fairly primitive when compared with the German Torn E_b receiver which is of the same vintage.

B22 BC322: A dry battery powered VHF (50-65 Mc/s) 2 valve transceiver. Although this particular unit was built in 1942, its design originates from the mid 1930's. The circuit comprises 1 valve oscillator or super-regenerative detector and 1 valve used as a modulator or audio amplifier. Designed by the US Army Signal Corps Laboratories at Fort Monmouth, New Jersey.

B23 R1116: Another mid thirties designed RAF receiver using battery valves and one of the Air Force's standard receivers in 1939. An 8 valve single/double conversion superhet covering 142-1600 kHz and 2.0-20.0 MHz in seven bands. Makes use of permeability tuning and has quite good performance, though hardly ideal for airborne applications.

B24 VT123B: A Bright Emitter triode transmitting valve of fairly basic construction. Marked with Air Ministry stamp and reference number 10A/7258. The 6.30 on the glass is believed to be the filament voltage and anode dissipation. Made by Ediswan *c*1926.

EARLY RADAR

Sir Robert Watson-Watt in England is generally credited with the invention of radar. However, as post-war literature revealed, the use of electromagnetic radiation for detecting ships, aircraft, etc, by means of reflected energy was being investigated in a number of other countries at the same time. Whilst it is undoubtedly true that the British CH system was the first operational radar, work in Germany, France, The Netherlands, Japan, Italy, USSR and the USA was proceeding along similar and, in some cases, more advanced lines.

The majority of the valves and equipment from this era have long since disappeared. However, a few of the surviving examples that relate to metre wave radar are shown here as representative of what was available and used in this early equipment.

The exhibit has been divided by country showing some items that were in use in the UK, Germany and the USA.

Early radar systems generally made use of frequencies below 600 MHz (as low as 25 MHz in the case of CH), mainly because of the difficulty in generating sufficient radio frequency power at the higher frequencies. Consequently, much effort was directed towards improving the high frequency performance of transmitting valves.

C1 CW11 Split Anode Magnetron: Capable of 5 watts output CW at 150 MHz. Manufactured by MOV in about 1937. Valves of this type were used in early experiments to achieve higher power at the higher frequencies needed for radar.

C2 CV53, CV82, CV88, CV90: A range of disc seal triodes developed over the period 1939-1942 with operation at up to 600 MHz in mind. This valves were used in 50 cm naval radar and in the GCI Radar Type 16.

C3 CV55: A conduction cooled pulsed triode for operation up to 500 MHz. *c*1940. This valve, under the development No E1190, was fitted with the same successful oxide coated cathode assembly as used in the E1189 prototype resonant cavity magnetron.

C4 CV15: External anode triode pulsed oscillator for 1.5 metre (200 MHz) radar. *c*1940.

C5 CV178: Similar to CV55 (C3) but with slightly different mounting holes.

C6 3B/250A: STC/Western Electric. *c*1937. Also known as a Samuel Valve. Used in 1938 in an experimental AI radar operating at 30 cms.

C7 NT99/CV92: Transmitting triode for pulsed oscillator applications up to 600 MHz. A pair of these valves could generate up to 100 kW peak at 600 MHz. *c*1942.

C8 A pair of VT90 'Micropup' triodes. Developed through a combined GEC/Admiralty programme, these valves were made in large numbers during World War II in the UK, Canada and the USA. A typical application was the transmitter for 1.5 metre ASV when in a self-squegging oscillator circuit a pair of these valves generated 7.5 kW output for 2.5 micro-seconds at 176 MHz. Both the VT90 and the NT99 (C7) were designed for forced air cooling. *c*1941.

C9 CV58. CV1507: Detector diode and spark gap widely used in 1.5 metre and 50 cm radar. *c*1941.

C10 NT41A: Silica Envelope Transmitting Triode developed by HM Signal School. Valves similar to this type were used in the transmitters of early naval radars, eg type 79Y (43 MHz) and 281 (90 MHz). *c*1941.

C11 R3132B: Complete receiver unit for ASV Mk II (200 MHz). The unit contains a superhet receiver, detector and video amplifier, a motor driven aerial switch for alternately connecting the left and right hand aerials to the receiver. Also the receiver power supply and an 1800V supply for the indicator unit. ASV Mk II was probably produced in greater numbers than any other radar system during World War II with something in excess of 10,000 equipments being manufactured. *c*1942.

C12 Transmitter T3074: A radar transmitter covering 185 to 205 MHz. Believed to be from an early AI radar. Uses a pair of VT90 'Micropup' triodes in a push-pull oscillator. The AI application is supported by the fact that the oscillator is anode modulated, the frequency range matches that of metric air interception radar and the oscillator. The AI application is supported by the fact that the oscillator has a delay line in the grid circuit which helps to sharpen the trailing edge of the transmitted pulse, thereby improving the minimum range performance of the radar.

C13 LD1, LD2, LD5, LD15: A selection of German World War II high frequency triodes showing the completely different type of construction from the USA/UK valves for similar applications. 1941-1944.

C14 TS60/14: Manufactured by Gema in Germany. *c*1942. A high power all glass triode using 'ship in a bottle' construction. Application and performance not known, but note the heater current rating of 75A.

C15 TS1: Manufactured by Gema in Germany. *c*1940. Output approximately 7.5 watts CW at 500 MHz. The 'doorknob' design is believed to have originated at Philips, and as well as being made in Germany the valve was also copied in the USA by Western Electric and Tung-Sol (VT191, 316A) (C24) and in Japan.

C16 TS1a: A 'mirror image' of the TS1 with anode and grid leads reversed to facilitate the design of push-pull oscillators.

C17 RD12T$_f$: Manufactured by Lorenz in Germany from 1939 onwards. Have also seen examples from Telefunken. This valve probably represents one of the best performance UHF triodes of its time. A pair in push-pull generated 50 kW pulse at 53.6 cms, when used in the Fu MG39L/40L KURPLALZ/KURMARK fire control radar. A pair of these valves was also used in the transmitter of the FuG200 HOHENTWELL German ASV radar operating on 550 MHz.

C18 LS180: Manufactured by Telefunken in Germany from 1940 onwards. This valve was the transmitter valve from the 'Wurzburg' flak control radar. One of these valves (a slightly earlier version than the one shown here) was taken with equipment captured during the Bruneval raid in February 1942.

C19 TS41: By Gema Germany from 1937 onwards. Two of these valves were used in the transmitter of the 'Freya' early warning radar, generating 15-20 kW pulse at 125 MHz.

C20 TS6: Another valve by Gema Germany. *c*1938. A pair of these valves generated 15 kW pulse at 375 MHz and was used in the transmitter of the German SEETAKT radar. First evidence of this radar was seen from its antenna on the Graf Spee after she was scuttled in Montevideo harbour in December 1939.

C21 Acorn Valves: A selection of Acorn valves that were originally introduced by RCA in 1934. Though capable of operation up to 500 MHz, they were extremely fragile which prevented their wider use. As the display shows, versions were made in the UK, Germany and Japan.

C22 VT128: Giant Acorn. In reality, an 'orbital beam hexode'. An electron beam multiplier valve designed as a high gain high frequency amplifier. Used as the second RF stage in the BC404-C receiver at 106 MHz. This version formed part of the SCR270 radar which actually detected the Japanese aircraft on their way to attack Pearl Harbour. *c*1939.

C23 832A: *c*1938. A Transmitting Double Beam Tetrode which, surprisingly, was used as the first RF stage in the SCR270 receiver. A valve of this size was needed to handle the transmitter pulse breakthrough without damage!

C24 8025A: USA. *c*1942. A triode with thoriated tungsten filament designed for parallel line oscillator circuits up to 500 MHz. Up to 35W output CW.

C25 316A: USA. *c*1941. This example manufactured by Tung-Sol. Similar to Gema TS1 (C14). Used in the early American IFF set type ABA-1.

C26 15E: Eimac *c*1938. A ring circuit using 6 of these valves was capable of generating 50 kW pulse at 500 MHz.

C27 VT127: A high power glass triode manufactured by Eimac USA. *c*1937. 315 W CW output at 150 MHz. May have been used in early radar transmitters up to 200 MHz.

C28 100Th: Another Eimac transmitting triode. *c*1936. Although originally designed for amateur transmitting service, a ring of 6 of these valves was used in the US radar type CXAM.

CENTIMETRIC RADAR, ELINT AND ECM AND COMMUNICATIONS

This section has been divided into three areas. Centimetric Radar, ELINT and ECM and Communications.

All the items on display were used by either the UK, Canada, the USA or Germany and Japan during World War II.

The Centimetric Radar section shows a selection of valves, in particular, early magnetrons and klystrons, the development of which enabled centimetric radar to become a practical reality.

ELINT and ECM shows a German and an American ELINT receiver of the period and a number of valves associated with these and other receivers, and also jammers developed at that time.

The Communications section incorporates a number of transmitting valves and an American and a Canadian heterodyne wavemetre. Also on open display are a number of receivers, the majority of which are operational.

CENTIMETRIC RADAR

DM1 3D/E1189: 1940/1941. Made in Canada by Northern Electric for Research Enterprises Ltd. Shown with its label from the outer packing, which shows the tie-up between 3D and E1189. E1189 was the GEC development number allocated to the first sealed resonant cavity magnetron suitable for use with a permanent magnet and this valve is a copy of the 8 resonator example taken to America by the Tizard mission in September 1940. Power approximately 10kW, pulse at 9.1cms, efficiency 15-20 per cent.

DM2 Open 3C: A frequency variant of the 3D showing 8 resonator anode block and absence of strapping, which was not introduced until late 1941.

DM3 CV56B: *c*1942. One of the first production strapped 10cms magnetrons, used mainly for naval radar.

DM4 Permanent magnet used with early 10cms magnetrons field strength approximately 1050 Oersteds *c*1942.

DM5 CV2111: *c*1944. A British designed 14 resonator X band 3cms magnetron.

DM6 Raytheon 2J50: American 3cms (X band) cavity magnetron used extensively in airborne radar in the latter part of World War II.

DM7 CV160: *c*1943. A high power 10 cms magnetron used in the Gun laying Radar AA No. 3 MK IV.

DM9 CV1482: *c*1943. Open 10 cms magnetron showing strapped anode assembly.

DM10 CV64: *c*1942. The RAF Standard 10 cms magnetron used in H_2S, ASV, etc. It is believed that the German LMS 10 (DM11) was copied from one of these.

DM11 LMS10: The German copy of the British 10 cms cavity magnetron. Copied from a magnetron in H_2S equipment recovered from a crashed British bomber shot down over Rotterdam in 1943. Used in "Egerland" 10 cms air defence radar, one of which was completed just before the cessation of hostilities, and also the Berlin night fighter AI radar.

DM12 Unidentified German World War II resonant cavity magnetron with 12 slot type resonators. Believed to be intended for 3 cms operation. Probably an experimental type, never used in actual equipment due to the cessation of hostilities.

DE1 Tuning unit type 207b: *c*1943. Contains a CV67 klystron and power supply. Used as the local oscillator in H_2S MK III and some versions of ASV.

DK1 CV116: *c*1942. A British designed 3 cms reflex klystron for local oscillator applications.

DK2 CV129: *c*1943. A British designed 3 cms reflex klystron with provision for frequency adjustments by cavity deformation.

DK3 CV238: *c*1943. 3 cms reflex klystron with external cavity.

DK4 723/B; 2K25: Probably the most used local oscillator source for magnetron powered X band radar. Can be tuned both electrically and mechanically. Manufactured by many companies throughout the world, including the USSR from 1942 onwards.

DK5 Early Meil Tube: *c*1942. Microwave oscillator performance not known. Manufactured by STC.

DK6 DV27: *c*1942/1943. Wide range electronically tunable 10 cms oscillator. Manufactured by STC.

DK7 WL417A: *c*1942. Westinghouse, USA. Mechanically tuned reflex klystron with flexible copper bellows between top and bottom of tube. Used as the local oscillator in the SCR584 radar.

DK8 2K28: *c*1944. Octal based external cavity reflex klystron. Manufactured by Raytheon.

DK9 707B: *c*1945. Octal based external cavity reflex klystron manufactured by Raytheon for local oscillator applications. 110MW output 1200-3750MHz.

DK10 CV150: *c*1944 A transmitting klystron for S band made by EMI. Performance not known.

DK11 CV323: 3 cms reflex klystron with complicated mechanical tuning arrangement.

DK12 CV36: *c*1941. 10 cms reflex klystron, known as a "Sutton" tube after the head of HM Signal School, Bristol, where the valve was designed. Used as the local oscillator for naval radar type 271.

DK13 CV67: *c*1942. Similar to CV36. Used as local oscillator in ASV MK III, H_2S Mk II and various other 10 cms radar.

DK14 CV158. *c*1942. Another variant of the "Sutton" tube.

DS1 CV115: Small resonant spark gap T/R Cell probably used at 3 cms. *c*1943.

DS2 LG76: Telefunken copy of the CV43 'Soft Sutton Tube' (DS7). Developed by Germany as part of the exercise to copy the H_2S equipment recovered from crashed British bombers.

DS3 721A: *c*1943. American made gaseous T/R cell for use with external cavity at 10 cms.

DS4 CV458: *c*1944. UK made X band T/R cell for direct insertion into waveguide.

DS5 GL471A: *c*1943. Made by GE USA. A spark gap type T/R cell.

DS6 CV360: *c*1944. A neon tube waveguide power indicator. The tip of the tube is inserted into the waveguide and the height of the glow is an indication of the relative power of the transmitter.

DS7 CV43: 1941. The original gaseous T/R cell for 10 cms operation also known as a 'Soft Sutton Tube'. One of the tubes is shown with its external heater assembly which was needed to keep its performance constant at varying ambient temperatures.

DS8 CV293: *c*1943. Similar to the CV43 but mounted in resonant cavity with waveguide aperture.

DS9 CV85: Trigatron spark gap modulator valve. *c*1942. The CV85 was used in the modulator type 64, part of ASV Mk III and H_2S Mk II.

DS10 CV486: Trigatron spark gap modulator valve. *c*1942.

DS11 Air Blast Spark Gap. *c*1944. Used in the modulator of the AA No. 3 Mk IV Radar. Works on the same principle as the CV85 but uses air blown across the electrodes to keep them cool and extinguish the spark.

DS12 715B: *c*1944. Manufactured by Raytheon, USA. A tetrode hard modulator valve with peak anode current of 20 amps and a typical anode voltage of 20 kV.

DS13 CV57: *c*1941. MOV manufactured tetrode hard modulator valve. 11 kV max. anode voltage. All appear to have been made with chromium plated bases, an unnecessary luxury in time of war.

ELINT AND ECM

DT1 APR4Y: The ultimate development of the standard USAAF ELINT receiver used throughout World War II for the detection of German and Japanese radars. Covered from 38-3000 MHz using 4 plug in tuning heads. The particular one shown here covers 74-320 MHz and uses acorn valves and a 'butterfly' tuned circuit. The receiver main frame contains a 30 MHz IF amplifier with approximately 90 dB of gain, FM and AM detectors, audio and video amplifiers, and a 400 Hz power supply.
The tuning units may be manually scanned or motor driven between pre-set limits. The APR4Y shown here was manufactured by Webster Electronics of Chicago in the early 1950's and the TN17 tuning unit, which carries an Air Ministry reference No. T181, dates back to 1945.
This equipment was used by the RAF up until the mid 1960's.

DT2 Fu MB4: Also known as 'Samos' A VHF/UHF search receiver covering 90-470

MHz in 4 switched bands. Uses an intricate turret and tuning mechanism with tuned double diode mixer and triode local oscillator. Because the IF is only 2.5 MHz, image rejection is very poor, but frequency accuracy is surprisingly good at ±0.5 per cent. Fitted with AM and FM detectors and an internal 100 MHz oscillator for calibration/ checking. Designed to be used in both a search and direction finding mode. Unfortunately, this example is missing its 20 micro-amp tuning/level meter, and the main tuning knob is not original. Otherwise, the receiver works within its originally published specification. Manufactured in 1944 by Rohde and Schwarz.

DT3 703A: A 'Doorknob' triode capable of operation up to 1500 MHz. Used as the local oscillator valve in the TN18 and TN19 tuning units of APR-4. This example made in 1944 by Tung-Sol, USA.

DT4 RD12Ga: *c*1943. An all glass high frequency double diode used as the mixer in the 'Samos' receiver. Also used as a mixer and detector up into the microwave region. Manufactured by Lorenz.

DF5 EF13: RF pentode by Telefunken. The standard German all metal valve, used as the IF and AF amplifier in the 'Samos' receiver. Introduced 1937/38, this example *c*1943.

DT6 RD2Md2: *c*1944. A four gap interdigital anode magnetron by Telefunken used as the 9 cms local oscillator for the 'Korfu' microwave search receiver used to detect centimetric ASV and H_2S transmissions.

DT7 CV52: *c*1942. A high frequency triode by MOV used as the local oscillator in the British UHF ELINT receiver. AB3 type R1294 covering 500-3000 MHz.

DT8 MD10/2000: *c*1944. An all glass multi-segment split anode magnetron manufactured by Brown Boveri. Filament rating 4.55A at 1.6 volts. Presumed to have been developed with some kind of jamming application in mind.

DT9 8012: *c*1944. A UHF triode with thoriated tungsten filament manufactured by RCA. A pair of these were used in the APQ9 (Carpet III) radar jammer giving about 20 watts output between 475 and 585 MHz.

DT10 388A: *c*1942. The original Western Electric 'doorknob' triode. A pair of these valves was used in the APT2 (Carpet) radar jammer producing 5 watts output from 450-720 MHz.

DT11 5J29: *c*1943. High power split anode liquid cooled magnetron. Manufactured by GE USA for use in the APT4 (Broadloom) and TDY-1 radar jammers. Capable of delivering 150 watts CW output over 450-780 MHz. Filament current in the region of 30 amps.

DT12 5J30. A lower frequency version of the 5J29, used to extend the lower frequency range of the jammer down to 116 MHz where the internal hairpin of the 5J29 would have appeared as a short circuit. How the coolant was supposed to circulate is not clear. Introduced 1943/44. This example made in the mid 1950's. The TDY-1 Naval version of these jammers continued in service use up until the early 1960's.

COMMUNICATIONS

This section concentrates on transmitting valves and equipment used during World War II for communications.
All the equipment shown in this section has been restored to full working order and some of the receivers in the open display are powered to enable visitors to the exhibition to tune them and assess their performance.

DC1 LM7: *c*1939. Heterodyne frequency meter covering 195 kHz to 20 MHz by reference to an internal 1 MHz crystal oscillator. Accuracy better than ±0.01 per cent of frequency using the calibration chart and vernier scale. Built by Bendix Corporation to the highest mechanical standards (the main tuning capacitor is gold plated). Used as the communications frequency standard on board US Navy ships.

DC2 807: By RCA, the best known of the 800 series transmitting valves. There are at least 20 variants of this valve and it is still manufactured in the Peoples Republic of China. A beam tetrode with 25 watt anode dissipation and full power rating to 60 MHz. Much loved by the radio amateur and used in many American and British Military equipments. Introduced in 1936.

DC3 NT46R: *c*1941. A silica envelope transmitting triode developed at HM Signal School for Navy transmitters. An indication of the power output of this valve can be seen from the filament rating which is 15.5 volts at 39.0 amps. Made by MOV.

DC4 3E29: *c*1944. A VHF double beam tetrode capable of delivering up to 83 watts CW output at 200 MHz under class C conditions. Equivalent to RCA 829B introduced in about 1944.

DC5 DET12: High frequency triode with thoriated tungsten filament and graphite anode. Made by MOV and in the USA from 1939 onwards. A pair of these valves was used in the output stage of the RAF T1131 VHF ground to air transmitter giving about 60 watts output from 100-150 MHz.

DC6 RL12P50A: A pentode capable of 40 watts anode dissipation and output of 85 watts at 25 MHz. Anode and suppressor grid brought out to top caps. This example is marked 'KRIEGSMARINE' and dated week 46 of 1941. Manufactured by Telefunken.

DC7 815: Introduced 1937. An early VHF double beam tetrode on an octal base. Capable of 56 watts output at 125 MHz.

DC8 VT61A: A double triode mounted on a B5 base. Capable of 16 watts output at 250 MHz. Used as a neutralised push-pull Class B amplifier delivering about 2 watts in the T1136 portion of the TR1133 the first RAF VHF airborne transceiver which was used extensively during the Battle of Britain, 50 years ago.

DC9 UV203: *c*1941. A Japanese power triode with a 30-40 watt anode dissipation. Probably used as a modulator valve in communications transmitters.

DC10 VT104/PT15. An RF pentode, a pair of which are used in the output stage of the T1154 RAF transmitter. Made by MOV and rated at 60 watts output at 20 MHz. Introduced around 1935.

DC11 813: *c*1937. Another well known transmitting beam tetrode having a power dissipation of 100 W on its graphite anode. Used as the output valve in the Canadian No. 52 set transmitter and many other medium to high power transmitters.

DC12 860: A power screened tetrode of unusual shape. 100 watts anode dissipation. Capable of 165 watts output in Class C at 30 MHz. Originally introduced by RCA in 1932/33, this example is Westinghouse manufactured.

DC13 RT323: *c*1940. A Japanese manufactured power triode with external anode radiator. Similar in appearance to RCA 827R, which has 800 watt anode dissipation and can be used to 110 MHz.

DC14 RS282: A 100 watt anode dissipation triode manufactured by Telefunken. Unusual construction with grid and cathode connections brought out to side arms. This example is dated week 18 of 1940 and carries a 'WEHRMACHT' marking and an eagle and swastika.

DC15 RS291: *c*1940. A screened tetrode transmitting valve of 110 watt anode dissipation. Manufactured by Telefunken, this example is undated.

DC16 304H: *c*1941. Heintz & Kaufman 'Gammatron'. A triode capable of 1220 watts CW out put @ 175 MHz. Constructed by combining 4 lower power valves within a single envelope. A variant of this valve with the tuned circuit inside the envelope generated 250 kW pulse @ 600 MHz and was used in the TPS 3 radar.

DC17 DET16/CV1363: A triode for operation at up to 30 MHz. Output power in the region of 250 watts. Manufactured by MOV. Introduced *c*1938.

DC18 RS329g: A high power triode rated at up to 1200 watts output at 75 MHz. Filament rating 23 volts at 14 amps. Made by Telefunken, this example is dated week 30 of 1940.

DC19 RS214g: Another high power triode giving 440 watts at 15 MHz. This example marked 'KRIEGSMARINE' and dated week 8 of 1940.

DC20 PB2/500: *c*1941. A power pentode with anode and suppressor grid brought out to top connectors. Maximum output 600 watts at 60 MHz. Manufactured by Philips.

DC21 TE149: Canadian Crystal Calibrated Heterodyne Wavemeter. Manufactured by RCA Victor Co. Ltd, Montreal. The crystal frequency is 1 MHz, but the variable oscillator is unusual in that it uses a variable inductor as the tuning element. Accuracy is ±0.02 per cent, and after fitting batteries and carrying out some minor remedial mechanical work the wavemeter was found to operate within its original specification. The equipment is shown with its original transit case, spares box and operating manual (dated December 1941). This unit also carried an original inspection label dated September 1 1944.

DC22 Canadian No. 52 Set Remote Receiver: A superhet receiver covering 1.75-16 MHz in 2 bands. The receiver is identical with the one forming part of the WS 52 complete installation. The WS 52 was intended for use as a base or mobile station and also contained a powerful (more than 100 W) sender. The remote receiver is provided with a separate mains or 12 volt power supply, which can be seen behind the unit. Some considerable work was required to restore this receiver as the metalisation on the ceramic trimmer capacitors in the coil pack had failed necessitating replacement with air spaced parts before the receiver could be aligned correctly. Built 1944.

DC23 Command receiver, transmitter and modulator: Just 3 examples of a complete range of models available to cover 190 kHz to 9.1 MHz on the receive side and 2.1 to 9.1 MHz on the transmit side. The units shown here are the **BC 455B receiver** covering 6-9.1 MHz and the **BC 458A transmitter** covering 5.3-7 MHz. Behind is the modulator and transmitter power supply **type BC 456B.** The equipment was normally installed in aircraft, the receivers being in racks of 2 or 3 and remotely controlled by means of the special control box coupled to the tuning drive via a Bowden cable. The transmitters were normally installed in racks of 2. The receiver unit, although not fitted in its correct rack, has been connected to a 24 volts DC supply and is also coupled to a remote control unit enabling it to be demonstrated. The date of this equipment is 1943/44.

DC24 R1155E: The famous bomber command receiver. This model covers 75 kHz to 500 kHz, 600 kHz-1.5 MHz and 3.0 MHz-18.5 MHz. It is a 7 valve superhet with 3 additional valves being provided for the DF function. Although normally powered from the aircraft DC supply via a rotary convertor, this unit has been provided with a mains supply to enable it to be demonstrated. *c*1943.

DC25 Portable Transmitter and Receiver Type 3 Mk II. Better known as the 'B2' spy set. A crystal controlled CW 2 valve transmitter and superhet receiver covering 3.0 to 16.0 MHz. The equip;ment shown here is packed in the watertight cases that were designed for parachute drops. Also with the transmitter and receiver is the combination power pack suitable for AC mains or 6 volts DC operation and the spares box containing transmitter tank coils, spare valves, etc. If used in populated areas the equipment was usually fitted into a fibre suitcase, whilst if it was going to be used in the field it was normally kept in the 2 watertight boxes. The equipment was made and used in considerable numbers by the SOE and guerilla forces during the latter part of World War II.

DC26 FuG 10 EK: A German airborne superhet receiver covering 5.3 to 10.0 MHz. Originally designed by Lorenz in 1938, the equipment is interesting in that all 11 valves are of the same type (RV12P2000). The design makes extensive use of magnesium alloy castings and is very small considering the date of design and its performance. The receiver also has the facility for mechanically setting 4 pre-set frequencies.

Although this receiver has been restored to full working order, it has not been possible to demonstrate it here due to the lack of a suitable power connector.

DC27 HRO M: Another well known receiver manufactured by the American National Company of Malden, Massachusetts. Covers 50 kHz to 30 MHz by means of 9 plug in coil sets. Many of these receivers were used by the Allied monitoring service during World War II and it was also issued in a naval version. This particular version uses 6.3 volt UX based valves, although the original design used valves with 2.5 volt heaters and there was a subsequent model using octal valves which apparently did not perform as well as the 'M'. The power supply in use here is UK made specifically for the HRO series. A particular feature of the receiver is the HRO tuning dial which has an effective scale length of 12 feet and a resolution of 1 division in 500. Built *c*1943.

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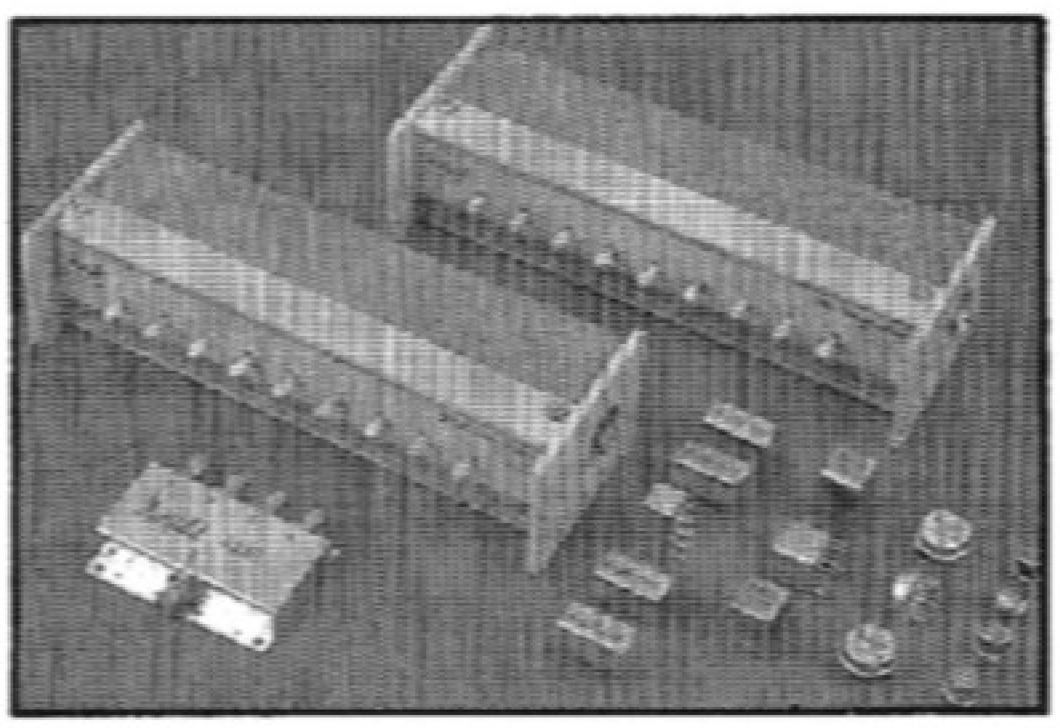

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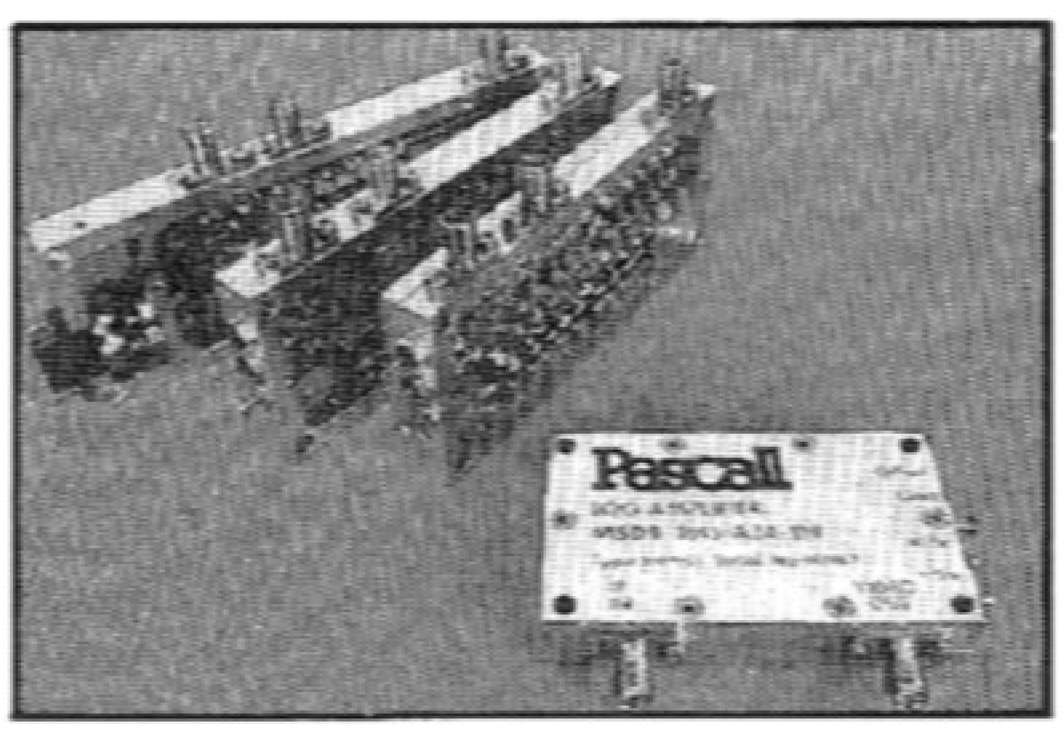

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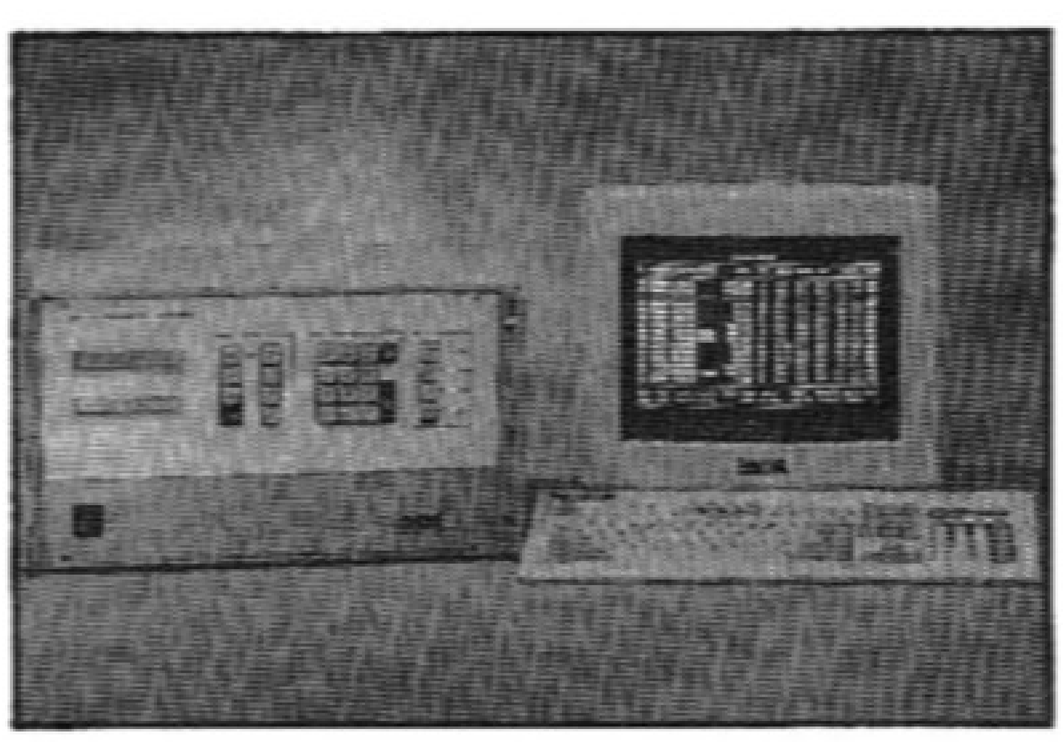

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