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MINISTRY OF AVIATION

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

BOSCOMBE DOWN

WHIRLWIND MARK 10 XN 126

TRIALS OF MONOPOLE AND WIRE AERIALS
WITH ANTENNA COUPLERS 180L AND 490T [C]
FOR USE WITH COLLINS 618T HF

PRESENTED BY

S. A. DEAN
NAVIGATION AND RADIO DIVISION

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22 OCT 1965

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(7) ~~Whirlwind Mark 10 XN 126.~~

~~Trials of Monopole and Wire Aerials~~
~~with Antenna Couplers 180L and 490T~~ (8)
~~for use with Collins 618T HF~~ [C].

~~Presented by~~

(10) S. A. Dean,
[redacted]

A. & A.E.E. Ref: ANR/T/03 T.I. No. NR49/65
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Summary

Results are given of comparative flight trials on two possible aerial systems for Collins 618T HF radio equipment in a Whirlwind 10 aircraft, these two having already been selected as best after ground tests not reported here.

It is concluded that a monopole aerial, together with Antenna Coupler 490T-1A, is the best of the systems proposed and is likely to be operationally satisfactory provided that steps are taken to overcome the tuning failures and the burning of the selector switch.

This report is issued with the authority of

eef (1) J R Bird.

Air Commodore,
Commandant, A. & A.E.E.

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/1. Introduction

1. Introduction

Trials Requirement Serial No. 16 was initiated by DLRD(A)/AL.10 under reference DE.907/06 dated June 1965 with the object of improving the efficiency of the HF installation in Whirlwind Mk. 10 aircraft of FEAF.

Whirlwind XN 126 was fitted at 60 MU Dishforth with RARI 3034 which comprised two separate aerial systems, (monopole and wire), and alternative Antenna Couplers (180L and 490T).

The aircraft arrived at Boscombe Down on 18th August 1965 and was returned to Dishforth on 27th August. In this very limited period 11 flights were carried out with an aggregate flying time of 13 hours 30 mins.

2. Radio Reports

2.1 Previous Reports Issued

Letter report issued to AL.10B/B 30th July 1964 reference ANR/T/02/SAD.

2.2 Included in this Report

Ground and flight tests of monopole aerial, wire aerial, and 490T-1A aerial tuning unit on Whirlwind XN 126.

2.3 Tasks to Follow

None programmed.

3. Aims of the Trial

Whirlwind Mk. 10 aircraft of FEAF were fitted with Collins 618T HF under SRIM 2967 during early 1964, but the performance of that installation was below acceptable standards. In consequence work to determine an aerial system which would satisfy the operational need was put in hand. Measurements of the following system parameters were made:

(a) Frequency coverage

(b) Radiation patterns

(c) Operation at short range (0 to 50 miles)

(d) Operation at medium range (400 miles)

(e) Operation at long range (1000 miles)

4. Description of New Items of Equipment

4.1 Monopole Aerial 437R-1

The monopole aerial is a tunable helical coil mounted in a fibreglass casing for attachment to the outside of an aircraft fuselage. It is a radiating element which presents to the tuner a load comparable to the frequency selected but having a roof wire of only 10 feet long. Without the monopole an aerial of such short length would necessitate the load being contained within the ATU: this would result in a reduction of effective radiated power. The monopole characteristics are as follows:-

/Frequency

Frequency range	- 2 to 30 mc/s
Input RF power	- 200 watts average, 600 watts peak.
Input impedance	- Compatible with 490T-1A antenna coupler.
Size	- 5 feet long, 15 ins. wide, $6\frac{1}{2}$ ins. deep, aerofoil configuration.
Weight	- 23 lbs.
Tuning time	- $2\frac{1}{2}$ seconds maximum.
Ambient temperature	- Operating -55°C to +71°C Non-operating -62°C to +85°C.
SWR	- 1.3 to 1

4.2 Antenna Coupler 490T-1A (ATU)

Antenna Coupler 490T-1A was developed to cater for the increasing number of aircraft installations which cannot be fitted with long aerials. The minimum aerial length specified for the 180L tuner is 45 feet, the 490T reduces this to 25 feet. Additional advantages have been incorporated, one being a reduction of the tuning time from 15-30 seconds to approximately 3 seconds, which means that, on retuning, radio silence is broken for a very much shorter period. Another change is that if a tuning point is reached where the Standing Wave Ratio (SWR) is higher than a predetermined figure (approximately 1.3 to 1) the system rejects the setting and no transmission can be made. This could be a questionable advantage in that a transmission with a bad SWR may sometimes be better than no transmission at all.

It should be noted that, due to peculiarities of switching, the 180L ATU cannot be used with the monopole aerial.

The 490T general specification is:

Weight	- 19.7 lbs.
Size	- 1-ATR short. 10 1/8" wide 7 5/8" high 12 5/8" long.
Temperature	- -55°C to +71°C operating. -62°C to +85°C non-operating.
Altitude	- Sea Level to 30,000 feet operating
Frequency	- 2 to 30 mc/s.
Input impedance	- 50 ohms
Tuning accuracy	- 1.3 to 1 SWR when tune power is 70 to 200 watts.
Tuning time	- 3 seconds typical, 5 seconds maximum.

5. Aircraft Installation

Whilst the aircraft was at Dishforth for the installation of SRIM 3034 several aerial systems were tried and some rejected because they did not improve on the original "V" wire installed under SRIM 2967. The results of these tests are attached in Appendix I. On the 12th July 1965 a meeting was held

/at

at Dishforth where it was decided that the two aerials to be fitted for the Boscombe Down trials would be the grounded twin wire and the helical monopole. The ATU fit would be the 490T with provision for changing to the 180L should the necessity arise.

The 490T ATU was mounted in one of two positions in the baggage compartment at the rear of the cabin. On the port side connection was made to the monopole aerial and on the starboard side to the wire aerial. The remainder of the installation was unchanged from that fitted by SRIM 2967, the transmitter-receiver being positioned on the upper shelf in the forward radio bay.

It was also agreed at the 12th July meeting that on the completion of the A. & A.E.E. trials SRIM 3034 would be cancelled and a new SRIM initiated to fit the finally approved installation.

6. Trials

6.1 Frequency Coverage

The frequency coverage of each of the aerials was obtained with the use of an in-line wattmeter connected in series with the aerial feeder. The instrument indicated forward (incident) and reverse (reflected) power from which the SWR can be calculated. At the same time the field Strength of each transmission was measured at a distance of approximately one mile on the Stoddart NM20-B. Part of this test was curtailed in order that the aircraft could meet its scheduled return date. The results obtained are tabulated in Annex A with a graph of the field strength measurements in Figure 1.

The deviations of the A. & A.E.E. tests from those at Dishforth (Appendix I) are that the power measurements were lower with the A. & A.E.E. tests and that the monopole did not tune at 11.5 mc/s. The difference in power levels was not relevant to the tests and was therefore not pursued.

The factors which arise from the combined tests are that:

(a) The field strength levels were comparable for the two aerials,

(b) The monopole would not tune above 14.5 mc/s.,

(c) The wire aerial burns out the ATU at frequencies between 18.5 and 20 mc/s.

Investigations into the electrical characteristics of the wire aerial with an RF bridge showed a smooth transition of reactance through the frequency band in question, and aerial configurations had already been tried which, although unsatisfactory in other respects, did not burn the ATU.

In normal circumstances factors (b) and (c) would have meant that the installation was unacceptable for trials, but the aircraft time schedule did not allow for a protracted investigation or for the acquisition of another ATU.

6.2 Radiation Patterns

Radiation pattern measurements were made by RAE (Cove Radio) with the Whirlwind flying at 4000 feet over Boscombe Down. The Cove report is reproduced at Appendix II but the polar diagrams are embodied in the main Report at Figures 2 to 7 inclusive. The Figures are incomplete as a set for several reasons, one being that the 2835 Kc/s horizontal aerial at Cove was down for repair, also the wire aerial in the Whirlwind would not tune at 8975 Kc/s and the monopole would not tune at 15036 Kc/s. The facts which emerge are:

/(a)

(a) At 2835 and 5685 Kc/s the vertical component of the monopole is greater than that of the wire.

(b) At 2835 and 5685 Kc/s the vertical patterns are poor for the wire aerial.

(c) At 5685 Kc/s (and, by extrapolation, at 2835 Kc/s) the wire is a predominately horizontal aerial.

(d) At 5685 and 8975 Kc/s the vertical and horizontal components of the monopole are comparable.

(e) At 15036 Kc/s the wire aerial has assumed the characteristics of the monopole aerial.

The conclusions that can be drawn from the comments are that at the lower frequencies the monopole has the better characteristics, and at the higher frequencies the two aerials are comparable.

The above measurements were carried out using amplitude modulation as a necessity, and it is relevant to include the aircrew comments on the reception qualities.

Monopole	2835 Kc/s	very good - loud and clear
	5685 Kc/s	very good - loud and clear
	8975 Kc/s	not good - weak with rotor modulation
	15036 Kc/s	aerial would not tune
Wire	2835 Kc/s	not so good as the monopole
	5685 Kc/s	not so good as the monopole
	8975 Kc/s	aerial would not tune
	15036 Kc/s	good.

6.3 Short Range Tests

Short range tests were carried out by working to Cove Radio where measurements were made of the field strength of each transmission over varying distances up to 50 nautical miles. The results and comments of the ground station are contained in the Cove report at Appendix II, and the comments of the Whirlwind observer at Annex B.

In Appendix II the percentage average of satisfactory calls is 98.6 for the monopole and 82.2 for the wire. In Annex B if 5/5 signals are considered to be 100% operation then the averages for the airborne reception were 91% for the monopole and 71% for the wire. In this subjective assessment both the ground and airborne operators have agreed that the monopole had a communication advantage over the wire aerial. The difference is mostly apparent with amplitude modulation where the lower power will show up any weaknesses of the systems. It will be seen that when using the wire aerial and amplitude modulation there is little chance of establishing communication beyond 30 nautical miles.

/6.4

6,4 Medium Range Tests

The medium range tests were carried out with the Whirlwind in the locality of Boscombe Down, working to RNAS Lossiemouth, a distance of approximately 400 nautical miles. The frequencies used were 3932 and 6709 Kc/s, both upper sideband. A summary of the results is as follows:

Frequency	Lossiemouth receiving		Whirlwind receiving	
	Monopole	Wire	Monopole	Wire
3932 Kc/s	2/4	5/3	4/3	2/3
6709 Kc/s	5/5	2/3	5/5	3/4

On the wire aerial both stations reported distortion, which, from the Cove report, appeared to be caused by rotor modulation. In three of the four pairs of the above results the monopole was the better of the two systems.

6.5 Long Range Tests

Long range tests were carried out by working with the Transport Command network in accordance with their Point-to-Point Operating Procedure reference C.133571/60/D. of Tels.(Air) dated June 1964. This document left no freedom of choice for selection of frequencies which would guarantee two-way communication, but as the trial was to be a comparison between aerials the situation was accepted. The periods chosen were to start at 0900 and 1900 hours local times and the frequencies allocated for these were 11,272 and 4717 Kc/s respectively. Each station on the net was called in turn using first the monopole and then the wire aerial. Of these calls only one was successful, this was to Malta using the monopole aerial when signals were reported weak but readable. At the same time Cyprus also reported having heard the aircraft call but it was weak and unreadable. The frequency was 11,272 Kc/s. No success was obtained from the wire aerial during either period.

6.6 ATU Comparison

Direct comparison between the 180L and 490T ATUs were made on two aerials during the Dishforth trials (Appendix I). A further comparison was made by A. & A.E.E. on a Wessex Mk. 5 at the RN Aircraft Repair Yard, Fleetlands, with the results at Annex C. From the results of these two trials it will be seen that the 490T did not altogether meet the manufacturer's specification. The burning at 18 to 20 mc/s on one particular aerial may possibly be due to peculiarities of that aerial but this could not be substantiated. The failure to tune at certain frequencies on both wire and monopole aerials points to a fault in the ATU. Investigation as far as possible was carried out in the limited time available but the problems were not resolved. They have been referred back to the Collins Radio Company.

It should be noted that the 490T was designed to reject a tuning point if it was above an SWR of 1.3. This could be a questionable advantage in that with that condition no transmission can be made with the 490T but the 180L will radiate, though with reduced efficiency.

It was demonstrated that, in general, the 490T ATU had the better tuning capabilities, i.e., it was faster in action and was more accurate in its frequency matching. However, its performance was degraded by inability to match at some frequencies, and by the burning of the selector switch.

7. Conclusions

All the communication tests show that the best results were obtained when using the monopole aerial and the 490T ATU. The radiation pattern tests also point to the advantages of the monopole in the lower part of the frequency range. The tests do not, however, eliminate the wire aerial from consideration, as at some frequencies there was little to choose between them from the communication aspect.

For a given aerial system there is some gain in changing to the 490T ATU in order to take advantage of the better frequency matching and the faster tuning time. A decision to do this must be conditional on the Firm finding and rectifying the cause of the drop-out at some frequencies and the burn-out on the wire aerial.

If the weight and aerodynamic penalties can be accepted, the best HF aerial system for the Whirlwind Mk. 10 aircraft of FEAF is the monopole and the 490T ATU. The alternative is the twin wire, 20 ft. long, spaced 6" between wires, but still using the 490T ATU. The penalty with the wire aerial will be difficult communication on the lower frequencies and a more rigid approach to the ground aerial configuration. By this it is meant that, at some frequencies the wire aerial is predominately horizontally polarised and therefore the best signals will be obtained with a horizontal aerial on the ground. The monopole is not so critical in its polarisation.

8. Recommendations

8.1 It is recommended that Whirlwind Mk. 10 aircraft of FEAF be fitted with HF aerial systems comprising Monopole Antenna 437R-1 and Aerial Coupler 490T-1A.

8.2 If weight and aerodynamic qualities preclude the use of the monopole aerial then the 20 ft. twin wire coupled with the 490T-1A ATU may prove to be acceptable, but poor communication will be encountered at some frequencies. If the wire aerial is selected then attention must be given to the type of aerial in use on the ground.

8.3 It is recommended that Collins Radio be committed to show evidence that the 490T ATU will not normally have the faults experienced on both the Dishforth and A. & A.E.E. tests.

Circulation List

D.R.N. A/H	1 Copy	
D.L.R.D.A.	1 "	
A.L. 10	2 Copies	1 for Action
A.D.H.	2 "	(for information of D.P.O.)
R.N.(Q)	1 Copy	
R.D.T. 3	1 "	
T.I.L.	50 Copies	
R.A.E. Farnborough	6 "	
R.A.E. Bedford	2 "	
R.T.O. Westlands	2 "	

Appendix I

Whirlwind Mk. 10 Antenna Study

1. Introduction

In order to achieve more efficient HF radiation from a Whirlwind Mk. 10 helicopter a number of antenna systems have been experimented with and as much data as possible obtained in the time available.

2. Programme

The object has been to install two HF Antenna systems prior to a full scale evaluation programme as follows:-

(a) Install a Collins 490T-1A antenna tuner together with a 437R-1 Helical Monopole antenna and its optimum length of top loading wire.

(b) Install the best possible wire antenna together with either a 490T-1A or 180L-3A antenna tuner.

3. Conditions of Test

The same 618T-3 transceiver and 714E-3 control unit were used throughout all tuning and relative field strength measurements.

(a) Tuning checks were carried out using a standard 28 volt D.C. power supply unit with the Whirlwind helicopter located outside the hangar and as far as possible from any metal objects. A Collins feedthru Wattmeter was used for forward and reflected power measurements, forward power being read to the nearest 10 watts. The scale of the wattmeter was calibrated to 500 watts forward power and 60 watts reflected power. The A.M. facility was used for all tuning checks.

(b) Relative signal strength measurements were taken on the 437R-1 Helical Monopole system and the best two wire antennas. A bench installation was set up in the radio shop having a vertical antenna, long wire of approximately 45 feet attached to the side of the hangar. The helicopter was located approximately $\frac{3}{4}$ mile from this point and measurements taken as per check list 8. The C.W. transmit facility was used for these tests.

4. Wire Antenna Systems

Configurations of wire antenna together with the 490T-1A and 180L-3A antenna tuners were experimented with as follows:-

(a) An open ended long wire antenna together with a 180L-3A tuner as detailed in check list 1. This followed closely the original SRIM 2967C and confirmed the known shortcomings of this combination as indicated by the data obtained.

(b) An open ended long wire antenna together with a 490T-1A tuner as detailed in check list 2. This indicated a marked improvement in tuning and stability, particularly between 2-15 Mc/s. The gaps in tuning range cannot be accounted for at this stage. (See Note 1).

(c) A grounded end long wire antenna together with a 490T-1A tuner as detailed in check list 4. This proved less satisfactory than the open ended wire and again with gaps in the tuning range (See Note 1). A failure in the series varicoil of the 490T-1A occurred at 19.5 Mc/s. The 180L-3A was not checked on this antenna system since it is already known to be incapable of adequately tuning it.

/(d)

(d) A grounded end twin wire system together with a 180L-3A tuner as detailed in check list 5. This combination proved very unsatisfactory, having gaps in the tuning range and very poor V.S.W.R. figures on a large number of frequencies, which would in low radiated power and poor serviceability of equipment.

(e) A grounded end twin wire system together with a 490T-1A tuner as detailed in check list 6. This combination proved to be the most satisfactory system, giving good tuning and V.S.W.R. over the full frequency range except for 19.5 Mc/s. Here again a tuner failure occurred in the series varicoil of the 490T-1A (See Note 1).

(f) An open ended twin wire together with the 490T-1A tuner as detailed on check list 7. This was a limited check between 16-30 Mc/s to see whether the 19.5 Mc/s problem could be overcome.

Note 1

In order to investigate the gaps occurring at certain points in the tuning range, particularly in conjunction with the 490T-1A tuner it would be necessary to check the antenna systems with a RF bridge at these points. The results could then be checked against tuning capability graphs already available for the 490T-1A.

5. The Monopole Antenna

The 437R-1 Helical Monopole Antenna (Engineering Prototype Model) together with the 490T-1A was experimented with to determine the optimum length of "top" loading wire required. This proved to be 10 feet in length and tuning and V.S.W.R. figures are detailed in check list 3. Excellent tuning and V.S.W.R. was achieved between 2-14.6 Mc/s but between 14.6 to 20.5 Mc/s the system went to fault condition. Shortening the "top" loading introduced difficulties in the 2 Mc/s region and extending it above 15 feet caused tuning difficulties at other frequencies. In the interest of efficiently radiated vertically polarised signals 10 feet is therefore the optimum length.

6. Radiation Efficiency

Three systems including the monopole were selected as being the most promising for tuning and V.S.W.R. and relative signal strength measurements were taken on them as stated under paragraph (3) and listed in check list 8. It is emphasised that these tests are relative and were introduced to give guidance as to which wire system might prove to be the more satisfactory.

7. Equipment Failure

Three instances of 490T-1A antenna tuner failure occurred.

All failures concerned a RF voltage breakdown of the same insulator drive shaft of the series varicoil module.

All failures occurred at a frequency of 19.5 Mc/s.

All failures occurred on grounded end antenna systems.

/The

The problem is being investigated at present but there is no evidence of this having occurred elsewhere. Grounded end antennas have been energised on other aircraft without this failure. It is suspected that this is a problem associated only with the Whirlwind and may be some form of shunt resonance associated with the tail boom. Again it is stressed that a RF bridge must be used to check these antennas to ascertain the values of resistance and reactance presented before any explanation can be presented.

Addendum

(Authors Note: RF bridge tests were carried out at Boscombe Down. The resistance and reactance figures changed smoothly through the frequency in question.)

Annex to
Appendix I

Check List No. 1

RF Tuner type 180L-3A. Serial No. 1805
Aerial - "U" type, wire length 45' 6" fed from end on starboard side of aircraft.
Open ended on 17" masts.

Frequency mc/s	Forward power watts	Refltd power watts	SWR	Remarks	Frequency mc/s	Forward power watts	Refltd power watts	SWR	Remarks
2.0	Time delay cut-out				13.0	150	10	1.70	unstable
2.25	200	18	1.86		13.5	150	1	1.18	
2.5	Time delay cut-out				14.0	150	1	1.18	
2.75	110	9	1.80		14.5	160	1	1.17	
3.0	110	1	1.21		15.0	150	1	1.18	
3.25	160	3	1.32		15.5	120	2	1.30	
3.5	150	1	1.18		16.0	140	1	1.18	
3.75	180	3	1.30		16.5	130	1	1.19	
4.0	170	3	1.31		17.0	120	1	1.20	
4.25	150	2	1.26		17.5	130	1	1.19	
4.5	130	1	1.19	unstable	18.0	170	1	1.17	unstable
4.75	130	1	1.19		18.5	170	1	1.17	unstable
5.0	130	1	1.19		19.0	220	25	2.02	
5.25	140	1	1.18		19.5	350	60	2.41	
5.5	120	1	1.20		20.0	180	10	1.62	
5.75	150	1	1.18		20.5	130	1	1.19	unstable
6.0	160	2	1.25		21.0	150	1	1.18	
6.25	120	1	1.20		21.5	150	1	1.18	
6.5	150	1	1.18		22.0	130	1	1.19	unstable
6.75	160	1	1.17	2 tries	22.5	160	1	1.17	unstable
7.0	120	2	1.30		23.0	180	8	1.52	unstable
7.5	130	1	1.19	3 tries	23.5	110	1	1.21	
8.0	150	1	1.18	2 tries	24.0	110	1	1.21	
8.5	130	1	1.19		24.5	300	22	1.74	
9.0	120	1	1.20		25.0	Time delay cut-out			
9.5	130	1	1.19		25.5	Above equipment specification			
10.0	120	1	1.20		26.0	"	"		"
10.5	140	1	1.18		27.0	"	"		"
11.0	130	1	1.19	3 tries	28.0	"	"		"
11.5	120	1	1.20	unstable	29.0	"	"		"
12.0	160	2	1.25		29.9	"	"		"
12.5	160	1	1.17						

Annex to
Appendix I

Check List No. 2.

RF Tuner type 490T-1A. Serial No. 2.
Aerial - "U" type, wire length 45' 6" fed from end on starboard side of aircraft.
Open ended on 17" masts.

Frequency mc/s	Forward power watts	Refltd power watts	Remarks	Frequency mc/s	Forward power watts	Refltd power watts	Remarks
2.0	130	0		13.0	140	0	
2.25	130	0		13.5	150	0	
2.5	130	0		14.0	140	0	
2.75	130	0		14.5	140	0	
3.0	130	0		15.0	130	0	
3.25	130	0		15.5	Fault between 15.02 to 15.76		
3.5	130	0		16.0	150	0	
3.75	130	0		16.5	150	0	
4.0	140	0		17.0	150	0	
4.25	140	0		17.5	140	0	
4.5	140	0		18.0	140	0	
4.75	140	0		18.5	150	0	
5.0	140	0		19.0	150	0	
5.25	130	0		19.5	150	0	
5.5	130	0		20.0	150	0	
5.75	130	0		20.5	160	0	
6.0	140	0		21.0	160	0	
6.25	140	0		21.5	170	1	
6.5	140	0		22.0	170	1	
6.75	150	0		22.5	Fault between 22.3 to 23.7		
7.0	150	0		23.0	" " " " "		
7.5	150	0		23.5	" " " " "		
8.0	150	0		24.0			
8.5	150	0		24.5	130	0	
9.0	150	0		25.0	150	0	
9.5	150	0		25.5	150	0	
10.0	150	0		26.0	150	0	
10.5	150	0		27.0	150	0	
11.0	150	0		28.0	120	0	
11.5	140	0		29.0	130	0	
12.0	140	0		29.5			
12.5	140	0		29.99	Fault		

Annex to
Appendix I

Check List No. 3

RF Tuner type 490T-1A. Serial No. 2
Aerial - Helical monopole 437R-1. Top loading wire 10 feet.

Frequency mc/s	Forward power watts	Refltd power watts	Remarks	Frequency mc/s	Forward power watts	Refltd power watts	Remarks
2.0	150	0		13.0	150	0	
2.25	140	0		13.5	150	0	
2.5	130	0		14.0	150	0	
2.75	130	0		14.5	150	0	
3.0	130	0		15.0	Fault between 14.8 to 20.9		
3.25	130	0		15.5	" " " " "		
3.5	130	0		16.0	" " " " "		
3.75	130	0		16.5	" " " " "		
4.0	130	0		17.0	" " " " "		
4.25	140	0		17.5	" " " " "		
4.5	140	0		18.0	" " " " "		
4.75	130	0		18.5	" " " " "		
5.0	130	0		19.0	" " " " "		
5.25	140	0		19.5	" " " " "		
5.5	140	0		20.0	" " " " "		
5.75	140	0		20.5	" " " " "		
6.0	130	0		21.0	150		
6.25	140	0		21.5	150		
6.5	140	0		22.0	150		
6.75	140	0		22.5	150		
7.0	140	0		23.0	150		
7.5	150	0		23.5	150		
8.0	140	0		24.0	150		
8.5	140	0		24.5	150		
9.0	140	0		25.0	150		
9.5	140	0		25.5	150		
10.0	140	0		26.0	Fault above 25.8		
10.5	150	0		26.5	" " "		
11.0	140	0		27.0	" " "		
11.5	140	0		28.0	" " "		
12.0	150	0		29.0	" " "		
12.5	150	0		29.9	" " "		

Annex to
Appendix I

Check List No. 4

RF Tuner type 490T-1A. Serial No. 2.
Aerial - "U" type, wire length 45' 6" fed from end on starboard side of aircraft.
On 17" masts. Port side end grounded.

Frequency mc/s	Forward power watts	Refltd power watts	Remarks	Frequency mc/s	Forward power watts	Refltd power watts	Remarks
2.0	130	0		13.0	130	0	
2.25				13.5			
2.5				14.0	130	0	
2.75				14.5			
3.0	130	0		15.0	130	0	
3.25				15.5			
3.5				16.0	130	0	
3.75				16.5			
4.0	130	0		17.0	130	0	
4.25				17.5			
4.5				18.0	140	0	
4.75				18.5			Tuner failure
5.0	140	0		19.0	170	1	
5.25				19.5			Tuner failure
5.5				20.0	140	0	
5.75				20.5	160	0	
6.0	150	0		21.0	160	0	
6.25				21.5	150	0	
6.5				22.0	150	0	
6.75				22.5	150	0	
7.0	130	0		23.0	160	0	
7.5				23.5	140	0	
8.0	130	0		24.0	140	1	
8.5				24.5	120	2	
9.0	130	0		25.0	130	0	
9.5				25.5	130	0	
10.0	130	0		26.0			Fault
10.5				27.0			Fault
11.0			Fault	28.0	150	0	
11.5				29.0	140	0	
12.0	140	0		29.99	140	0	
12.5							

Annex to
Appendix I

Check List No. 5

RF Tuner type 180L-3A. Serial No. 1805.
Aerial - Two wires on starboard side 20 feet long spaced 6". Common feed at forward end, and both grounded at far end.

Frequency mc/s	Forward power watts	Refltd power watts	SWR	Remarks	Frequency mc/s	Forward power watts	Refltd power watts	SWR	Remarks
2.0	100	5	1.58		13.0	170	1	1.17	
2.25	120	2	1.30		13.5	170	2	1.24	
2.5	120	15	2.12		14.0	150	1	1.18	
2.75	Time delay cut-out				14.5	170	1	1.17	
3.0	"	"	"	"	15.0	170	1	1.17	
3.25	"	"	"	"	15.5	140	1	1.18	
3.5	130	1	1.19		16.0	150	1	1.18	
3.75	170	5	1.42		16.5	140	1	1.18	
4.0	180	2	1.24		17.0	140	1	1.18	
4.25	180	5	1.40		17.5	170	2	1.24	
4.5	140	2	1.27		18.0	Time delay cut-out			
4.75	170	1	1.17		18.5	180	3	1.30	
5.0	170	1	1.17		19.0	220	25	2.02	
5.25	140	1	1.18		19.5	170	2	1.24	
5.5	170	1	1.17		20.0	190	3	1.29	
5.75	170	1	1.17		20.5	150	3	1.33	
6.0	170	1	1.17		21.0	170	2	1.24	
6.25	150	1	1.18		21.5	150	2	1.26	
6.5	170	1	1.20		22.0	280	60+	3.1+	
6.75	150	1	1.18		22.5	170	2	1.24	
7.0	150	1	1.18		23.0	300	60+	3.1+	
7.5	Time delay cut-out				23.5	270	60+	3.1+	
8.0	"	"	"	"	24.0	280	60+	3.1+	
8.5	110	1	1.21		24.5	140	25	2.46	
9.0	110	1	1.21		25.0	Time delay cut-out			
9.5	120	1	1.20		25.5	Above equipment specification			
10.0	120	1	1.20		26.0	"	"		"
10.5	130	1	1.19		27.0	"	"		"
11.0	160	1	1.17		28.0	"	"		"
11.5	170	1	1.17		29.0	"	"		"
12.0	170	1	1.17		29.99	"	"		"
12.5	170	1	1.17						

Annex to
Appendix I

Check List No. 6

RF Tuner type 490T-1A. Serial No. 2.
Aerial - Two wires on starboard sides 20 feet long spaced 6". Common feed at forward end, and both grounded at far end.

Frequency mc/s	Forward power watts	Refltd power watts	Remarks	Frequency mc/s	Forward power watts	Refltd power watts	Remarks
2.0	140	0		13.0	140	0	
2.25	140	0		13.5	140	0	
2.5	130	0		14.0	140	0	
2.75	130	0		14.5	140	0	
3.0	130	0		15.0	140	0	
3.25	130	0		15.5	140	0	
3.5	130	0		16.0	130	0	
3.75	130	0		16.5	130	0	
4.0	140	0		17.0	130	0	
4.25	130	0		17.5	130	0	
4.5	130	0		18.0	130	0	
4.75	130	0		18.5	140	0	
5.0	130	0		19.0			Fault
5.25	130	0		19.5			Tuner failure
5.5	130	0		20.0	140	0	
5.75	130	0		20.5	140	0	
6.0	130	0		21.0	140	0	
6.25	130	0		21.5	140	0	
6.5	140	0		22.0	150	0	
6.75	130	0		22.5	140	0	
7.0	130	0		23.0	140	0	
7.5	130	0		23.5	140	0	
8.0	130	0		24.0	140	0	
8.5	130	0		24.5	140	0	
9.0	130	0		25.0	140	0	
9.5	130	0		25.5	130	0	
10.0	130	0		26.0	130	0	
10.5	130	0		27.0	140	0	
11.0	130	0		28.0	130	0	
11.5	130	0		29.0	140	0	
12.0	140	0		29.99	180	3	
12.5	140	0					

Annex to
Appendix I

Check List No. 7

RF Tuner type 490T-1A. Serial No. 2.
Aerial - Two wires on starboard side, 20 feet long spaced 6". Common feed at forward end, common but not grounded at far end.

Frequency mc/s	Forward power watts	Refltd power watts	Remarks	Frequency mc/s	Forward power watts	Refltd power watts	Remarks
2.0				13.0			
2.25				13.5			
2.5				14.0			
2.75				14.5			
3.0				15.0			
3.25				15.5			
3.5				16.0	130	0	
3.75				16.5	140	0	
4.0				17.0	130	0	
4.25				17.5	130	0	
4.5				18.0	130	0	
4.75				18.5	140	0	
5.0				19.0	140	0	
5.25				19.5	140	0	
5.5				20.0	140	0	
5.75				20.5	140	0	
6.0				21.0	140	0	
6.25				21.5	140	0	
6.5				22.0	140	0	
6.75				22.5	140	0	
7.0				23.0	150	1	
7.5				23.5	150	2	
8.0				24.0	120	2	
8.5				24.5	130	0	
9.0				25.0	130	0	
9.5				25.5			Fault
10.0				26.0			Fault
10.5				27.0			Fault
11.0				28.0			Fault
11.5				29.0	160	1	
12.0				29.99	130	0	
12.5							

Annex to
Appendix I

Check List No. 8

Relative signal strength measurements

Comparative figures taken using:-

(a) 490T-1A tuner with 437R-1 monopole aerial

(b) 490T-1A tuner with 20 ft. twin aerial, grounded end

(c) 490T-1A tuner with 48 ft. long wire aerial

Frequency kc/s	Monopole (Check List 3)		Twin wire (Check List 6)		Long wire (Check List 2)	
	AGC volts	Input micro-volts	AGC volts	Input micro-volts	AGC volts	Input micro-volts
2025	9.0	700	7.5	375	7.0	250
2835	9.0	700	8.5	500	7.25	300
4717	11.5	2000	10.5	1300	10.5	1300
5685	11.25	1800	10.75	1500	10.75	1500
6709	10.5	1300	10.0	1000	10.75	1500
8975	10.25	1150	11.25	1800	10.25	1150
11272	9.5	850	10.5	1300	10.5	1300
15036	-	-	9.5	850	7.5	375
23265	-	-	5.0	60	-	-

Note 1. The AGC volts were negative. They were measured with an Avo model 8 on the 30 volt range, connected to J5 of the AM/Audio module of the 618T-3 trans-receiver.

Note 2. The Input microvolts are approximate values representing the equivalent voltage at the receiver input terminal.

Appendix II

Cove test report No. 23/65

HF Radio trials on Whirlwind Mk. 10, XN 126

1. Introduction

This section was requested by the Navigation and Radio Division, A. & A.E.E., to assist in their radio acceptance trials of Collins 618T with wire and monopole aerials fitted to the Whirlwind Mk. 10 (A. & A.E.E. radio trials test instruction NR 49/65 refers).

2. Object of trial

(i) To obtain the HF polar diagrams for vertical and horizontal polarisation in the aximuth plane in flight, using the "orbit" method on 2835, 5685, 8975 and 15,036 Kc/s; both monopole and wire aerials to be measured.

(ii) To carry out a 50 mile range test of R/T communication on a track through Boscombe Down to Cove Radio Station (Farnborough), keeping continuous communication and using both S.S.B. and A.M.; both aerials to be tested.

3. Aircraft installation

Transmitter/receiver: Collins 618T

Aerials: (i) Monopole type 437R-1
(ii) Wire.

A.T.U.: Both aerials used in conjunction with an A.T.U. type 490T-1A, positioned on port or starboard side depending on aerial in use.

4. Ground installation

Transmitter: TA 127. 300 watts AM.
600 watts p.e.p. on SSB.

Receiver: RA 17, modified for signal strength measurements and used with Adaptor type RA 63 for S.S.B. reception.

Aerials: (i) Rhode and Schwartz w/b bicone type HA 47/4 for communications reception.

(ii) Bicone type HA 47/4 and quadrants for signal strength measurements.

5. Flight arrangements

(i) Polar diagrams -

A circular course was flown, centred over Boscombe Down, at a height of 4,000 feet. Air speed was chosen to give a minimum diameter to the circle. The aircraft turned in 10° steps levelling and holding each heading for a few seconds. Carrier wave was transmitted on A.M. throughout the turn, the navigator indicating the heading every 10°. Signal strength was measured at Cove simultaneously on vertically and horizontally polarised aerials. After completion of the orbits at the required frequencies the aircraft landed while the aerial system was changed to the alternative arrangement; the second sortie being flown shortly afterwards.

/(ii)

(ii) 50 Mile Range Tests -

The aircraft flew on a track through Boscombe Down to Cove Radio Station. Although the height required for this exercise was 4,000 ft., weather conditions did not permit this altitude and these tests had to be carried out at heights between 400 and 1,500 feet. Transmissions were made alternately on A.M. and S.S.B., signal strength being measured on A.M. Separate sorties were flown for each aerial on 2835 and 5685 Kc/s.

6. Flight Results

The results are shown in the attached graphs and polar diagrams. The latter have angular corrections applied and bearings are relative to the aircraft nose. They are plotted to a dB scale relative to 1.0 µV, signal strength values being the equivalent voltage obtained at the receiver aerial input after calibration with a signal generator type CT 452. On 2835 Kc/s, no horizontal measurements were made as a suitable aerial was not available. Polar diagrams for the wire aerial on 897 Kc/s and the monopole on 15,036 Kc/s have not been measured due to a failure of the A.T.U. to tune correctly on these channels; in both cases the aircraft reported 2 failure lights. During the monopole polar diagram on 897 Kc/s a rotor modulation effect was noted, this probably takes place as a result of radiation from the rotor blades producing phase modulation. In fact, there is also some amplitude modulation which was observed on the signal strength meters. The aircraft reported there was some difficulty in copying the ground station R/T at this time because of distortion. As flying time was restricted S.S.B. was not checked under these conditions but it is likely that the S.S.B. will be vulnerable to the phase modulation. Rotor modulation was not observed on the other frequencies used for the trials.

The graphs showing the results of the 50 mile range test indicate measured signal strength in dB relative to 1.0 µV and also the ground operator's assessment of strength and readability in QSA/QRK numbers. They are defined in ACP 131(A) to the following scale:-

Signal Strength	Readability
1 - Scarcely perceptible	1 - Unreadable
2 - Weak	2 - Readable now and then
3 - Fairly good	3 - Readable with difficulty
4 - Good	4 - Readable
5 - Very good	5 - Perfectly readable

It will be noted that the operator's assessment of strength/readability is not always in agreement with the measured signal strength. However, an aural assessment must invariably be based on prevailing signal to noise (atmospheric, man-made and interference from other stations) and therefore it is more likely to indicate the results that may be obtained under operational conditions. The specific short-range HF R/T requirement is understood to be two-way communication from 0-50 NMS. Using the ground installation detailed in para. 4 it was only possible to obtain completely satisfactory communication on both 2835 and 5685 Kc/s by using S.S.B. and the monopole aerial.

The following table gives a summary of the readability of calls and shows the percentage of satisfactory calls, based on QRK 3 as the minimum value of acceptable communication.

/Table

Percentage of Readability, Air to Ground (QRK)												
Freq.	System	No. of calls	Monopole			%	No. of Satisfactory Calls	Wire			% Satis-factory
			3-5	2	1			3-5	2	1	
2835 (	AM	18	17	1	-	94.5	15	6	3	6	40
(	SSB	17	17	-	-	100	18	16	2	-	88.8
5685 (	AM	14	14	-	-	100	14	14	-	-	100
(	SSB	18	18	-	-	100	18	18	-	-	100

(SIGNED)

P.R. BURKITT

Annex A

Measured at Boscombe Down

Frequency mc/s	Monopole aerial		Wire aerial	
	Inc. power watts	Field strength mic. volts/m	Inc. power watts	Field strength mic. volts/m
2.0	94	1010	87	
2.5	104	1600	96	800
3.0	90	1400	90	
3.5	100	1700	96	2400
4.0	100	2000	92	
4.5	100	800	98	900
5.0	94	1800	98	
5.5	104	3200	110	2200
6.0	104	6000	103	
6.5	104	8000	104	6000
7.0	100	12000	96	
7.5	104	16000	104	16000
8.0	100	11000	92	
8.5	106	5000		
9.0	104	10000	98	
9.5	102	1400		
10.0	100	4000	106	
10.5	104			
11.0	104	1400	100	
11.5	Not tuning		106	1200
12.0	100	2000	110	
12.5	108	3600		
13.0	102	4000	110	
13.5	106			
14.0	104	5000	108	
14.5	Not tuning			
15.0	"		104	
16.0	"		106	
17.0	"		103	
17.5	"		94	3000
18.0	"		100	
19.0	"		Not to be used	
20.0	"		ATU burnt out	
21.5	"		104	1400
23.5	"		108	1400
25.0	"		110	4500

Note: With the 490T ATU the reflected power is invariably zero.

Annex B

Short range tests - Aircrew report

Note: The aircrew assessment of strength and readability is based on the QSA/QRK numbers as follows:

Signal strength (QSA)	Readability (QRK)
1. Scarcely perceptible.	1. Unreadable.
2. Weak.	2. Readable now and then.
3. Fairly good.	3. Readable with difficulty.
4. Good.	4. Readable.
5. Very good.	5. Perfectly readable.

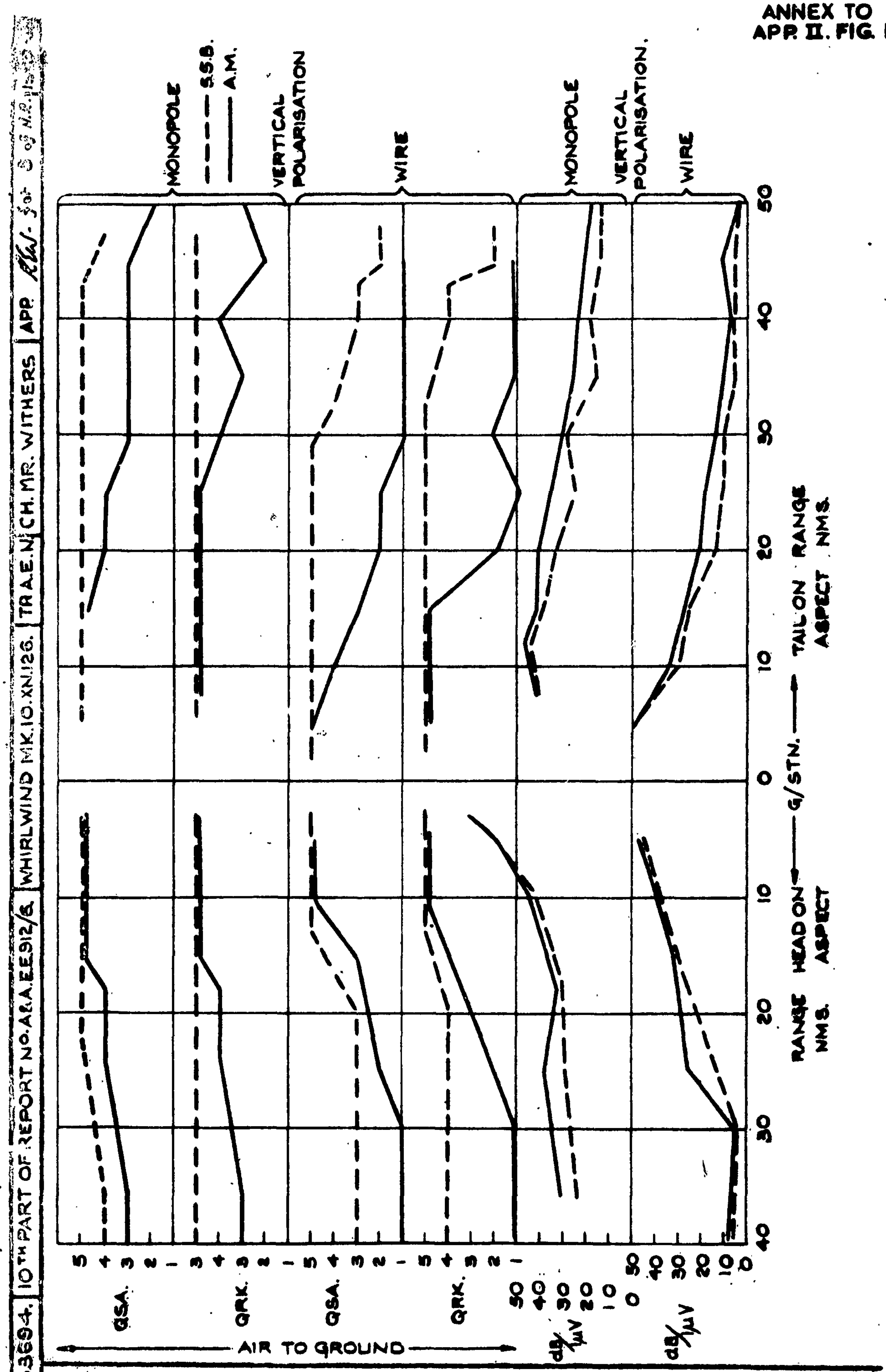
Distance (n.m.)	SSB				Amp. Mod.			
	2835 Kc/s		5685 Kc/s		2835 Kc/s		5685 Kc/s	
	Monopole	Wire	Monopole	Wire	Monopole	Wire	Monopole	Wire
Inbound								
50		5/5	4/4					1/2
47½				3/3				
45	5/5	4/3			5/5	2/2		3/1
42½	5/5	5/3		3/3				
40					3/3			3/1
37½				4/4				
35			5/5			0/0	5/5	4/1
32½				5/4				
30	3/4						5/5	4/2
27½		4/3	5/5	5/4	2/3			
25	5/5				3/3	3/2	5/5	5/4
22½	5/5	4/4	5/5	5/4				
20							5/5	5/4
17½			5/5	5/4		0/0		
15	5/5				5/4	4/3	5/5	5/4
12½	5/5	5/5	5/5	5/4				
10					5/5	5/5	5/5	5/4
7½	5/5	5/5	5/5	5/4				
5					5/5	5/5	5/5	5/5
Outbound								
5	5/4		5/5	5/4		5/5		5/5
7½		5/5	5/5	5/4	5/5		5/5	
10	5/5					4/4	5/5	5/4
12½		5/5	5/5	5/4	5/5			
15	5/5				5/5	4/3	5/5	5/4
17½	5/5	4/5	5/5	5/4				
20					3/5	4/2	5/5	4/4
22½	5/5	4/5	5/5	5/4				
25					5/4	4/2	5/5	4/4
27½	5/5		5/5					
30					4/3	2/1		4/4
32½	5/5	4/5	5/4	4/4			5/4	
35					4/3	2/1	4/4	5/4
37½	5/5	4/4	4/4	4/3				
40					4/3	0/0	4/4	5/4
42½	5/5	5/3	3/4	4/3				5/4
45		5/2			4/1	0/0	2/1	
47½	5/5	4/2	3/4	3/1				
50		5/2			4/3		3/4	5/4

Annex C

Calibrations of 618T in Wessex Mk. 5 XS 514

Frequency mc/s	180L-3A/1493			490T-1/146	
	Inc.power	Ref.power	SWR	Inc.power	Ref.power
2.0	100	2.5	1.38	114	0
2.5	90	2.0	1.35	106	0
3.0	110	1.0	1.21	116	0
3.5	108	0	1.00	118	0
4.0	96	0	1.00	120	0
4.5	112	0	1.00	118	0
5.0	92	0.5	1.16	116	0
5.5	95	0.5	1.16	119	0
6.0	82	0.5	1.17	102	0
6.5	94	0.5	1.16	Not	tuning
7.0	85	0.5	1.17	"	"
7.5	84	1.0	1.24	"	"
8.0	86	1.0	1.24	114	0
8.5	95	0.5	1.16	106	0
9.0	92	0.5	1.16	109	0
9.5	104	0.5	1.15	108	0
10.0	94	7.5	1.79	114	0
10.5	155	1.5	1.22	118	3
11.0	108	0	1.00	117	0
11.5	114	0.5	1.14	114	0
12.0	140	2.5	1.31	110	0
12.5	150	14.0	1.88	108	0
13.0	106	0	1.00	112	0
13.5	118	1.0	1.20	106	0
14.0	100	0	1.00	110	0
14.5	108	1.0	1.21	108	0
15.0	100	0.5	1.15	Not	tuning
15.5	91	2.0	1.35	"	"
16.0	119	2.0	1.30	"	"
16.5	104	2.0	1.32	"	"
17.0	107	0.5	1.15	"	"
17.5	130	3.0	1.36	"	"
18.0	94	1.5	1.29	"	"
18.5	100	2.0	1.33	"	"
19.0	88	1.5	1.30	"	"
19.5	98	4.0	1.51	115	0
20.0	105	1.5	1.27	Not	tuning
20.5	130	1.5	1.24	"	"
21.0	114	1.0	1.21	119	0.5
21.5	135	1.5	1.24	111	0.5
22.0	94	0	1.00	106	0.5
22.5	140	4.0	1.41	103	1.0
23.0	130	6.0	1.55	102	0.5
23.5	120	12.0	1.93	102	1.0
24.0	135	20.0	2.25	100	0.5
24.5	58	19.0	3.68	98	1.0
25.0	97	0.5	1.15	98	0.5
25.5	127	24.0	2.54	96	1.0
26.0	85	1.0	1.24	95	0.5
26.5	110	16.0	2.23	100	0
27.0	116	7.5	1.68	100	0.5
27.5	76	5.0	1.69	100	0
28.0	54	14.0	3.07	96	0.5
28.5	100	23.5	2.88	Not	tuning
29.0	300	260.0	27.96	"	"
29.5	310	250.0	18.61	"	"

ANNEX TO
APP. II. FIG. I.



2835 KC/S.

ANNEX TO
APP. II FIG. 2.

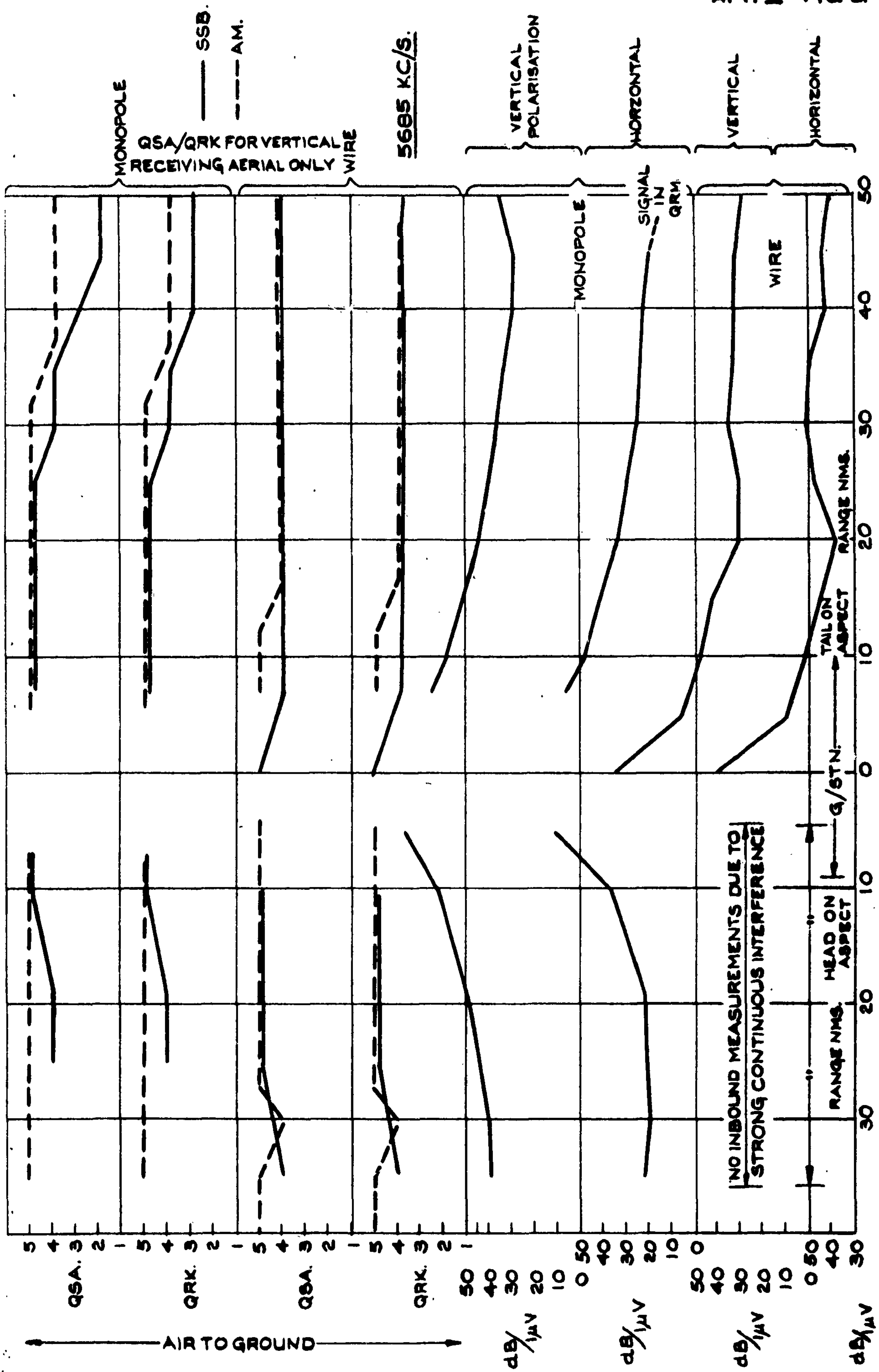
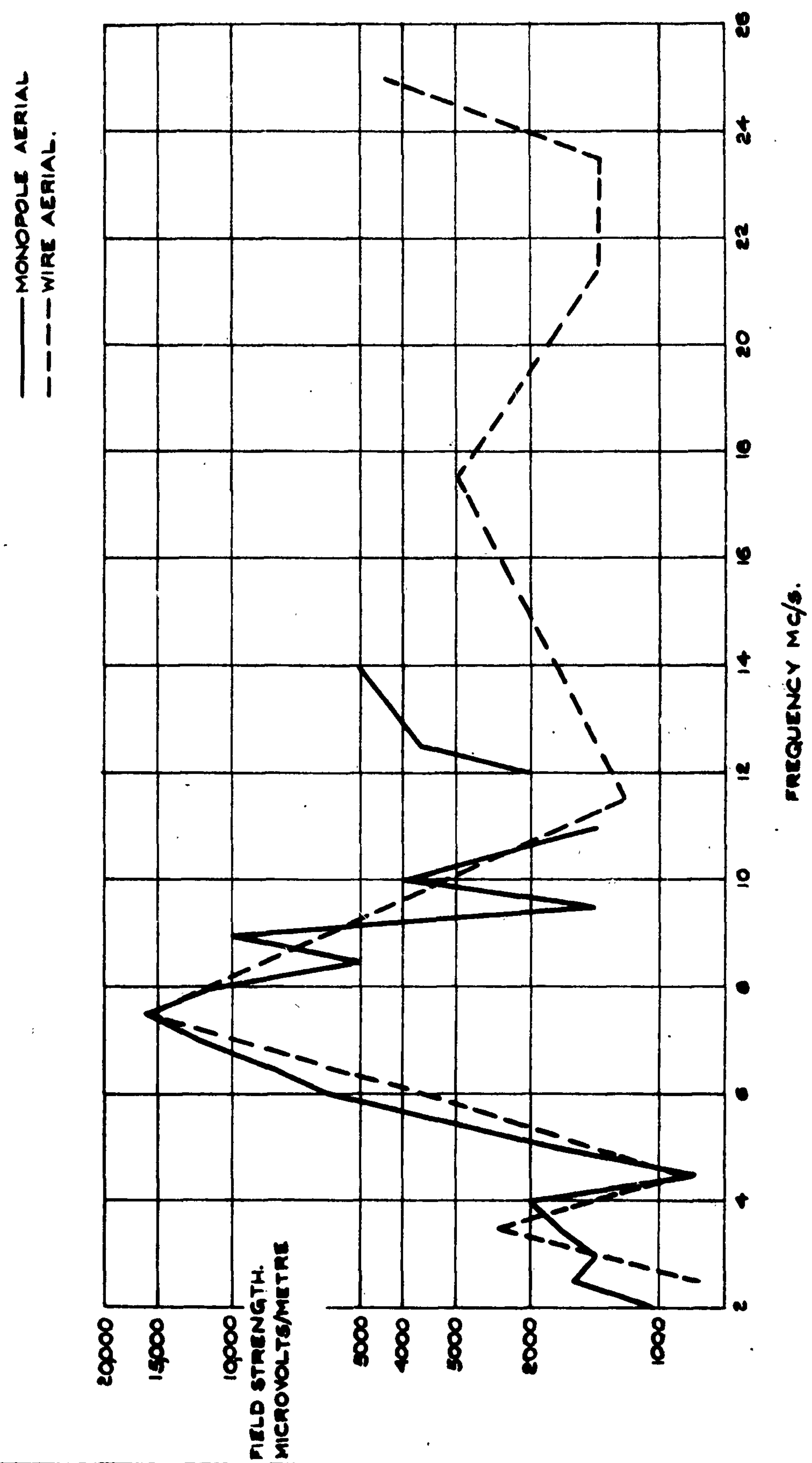


FIG. I.

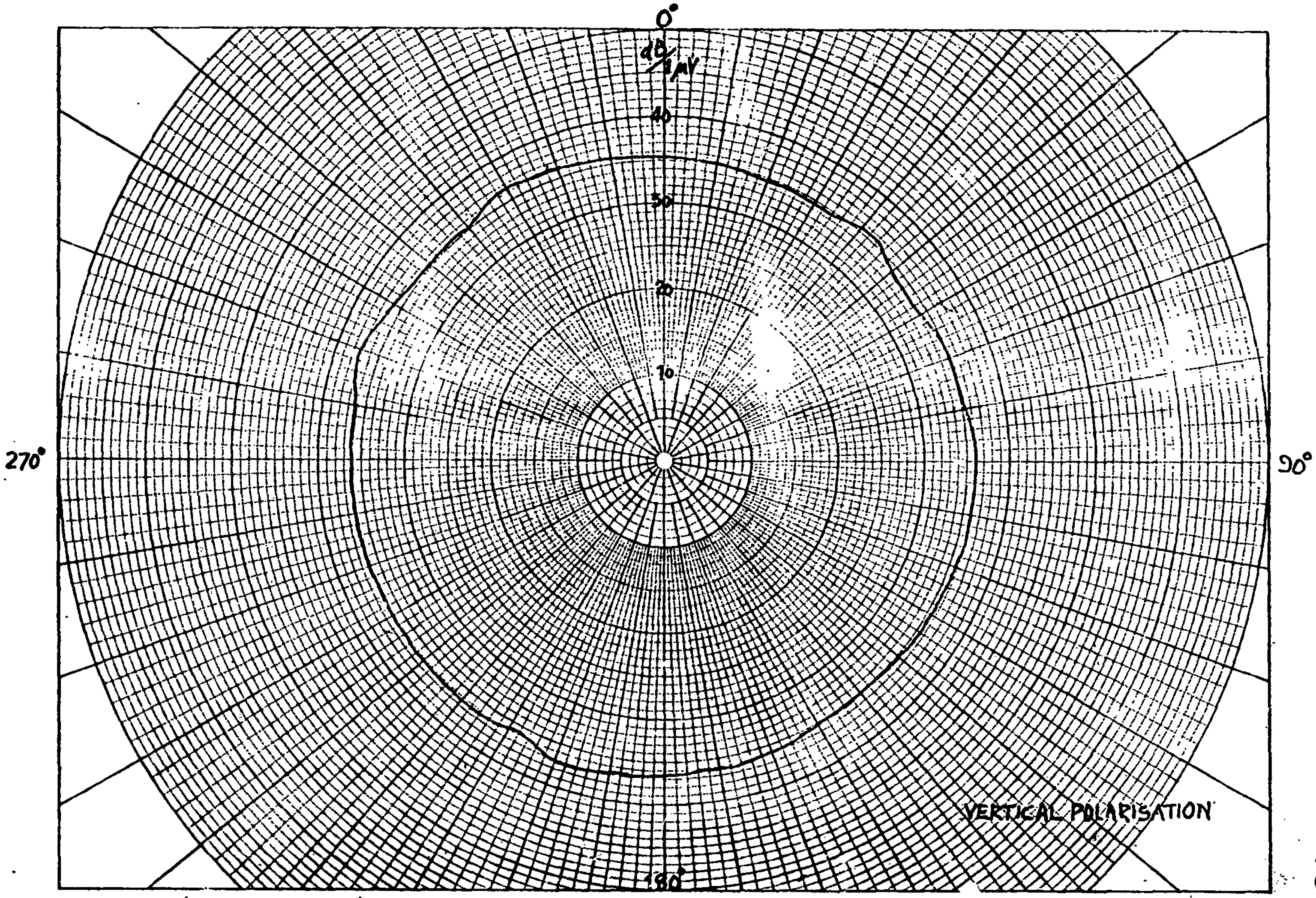


SK.B.3687. | 10TH. PART OF REPORT No. A&A.E.E. 812/6. | WHIRLWIND MK.10. XN.126. | TR A.E.N. | CH. MR. WITHERS | APP. RLW. for S of N.R. | 13.10.65

COLLINS 618 T. HF.
FIELD STRENGTH Vs FREQUENCY MEASURED AT ONE MILE.

SK. B. 3688.

DATA SHEET NO. 13 POLAR CO-ORDINATE

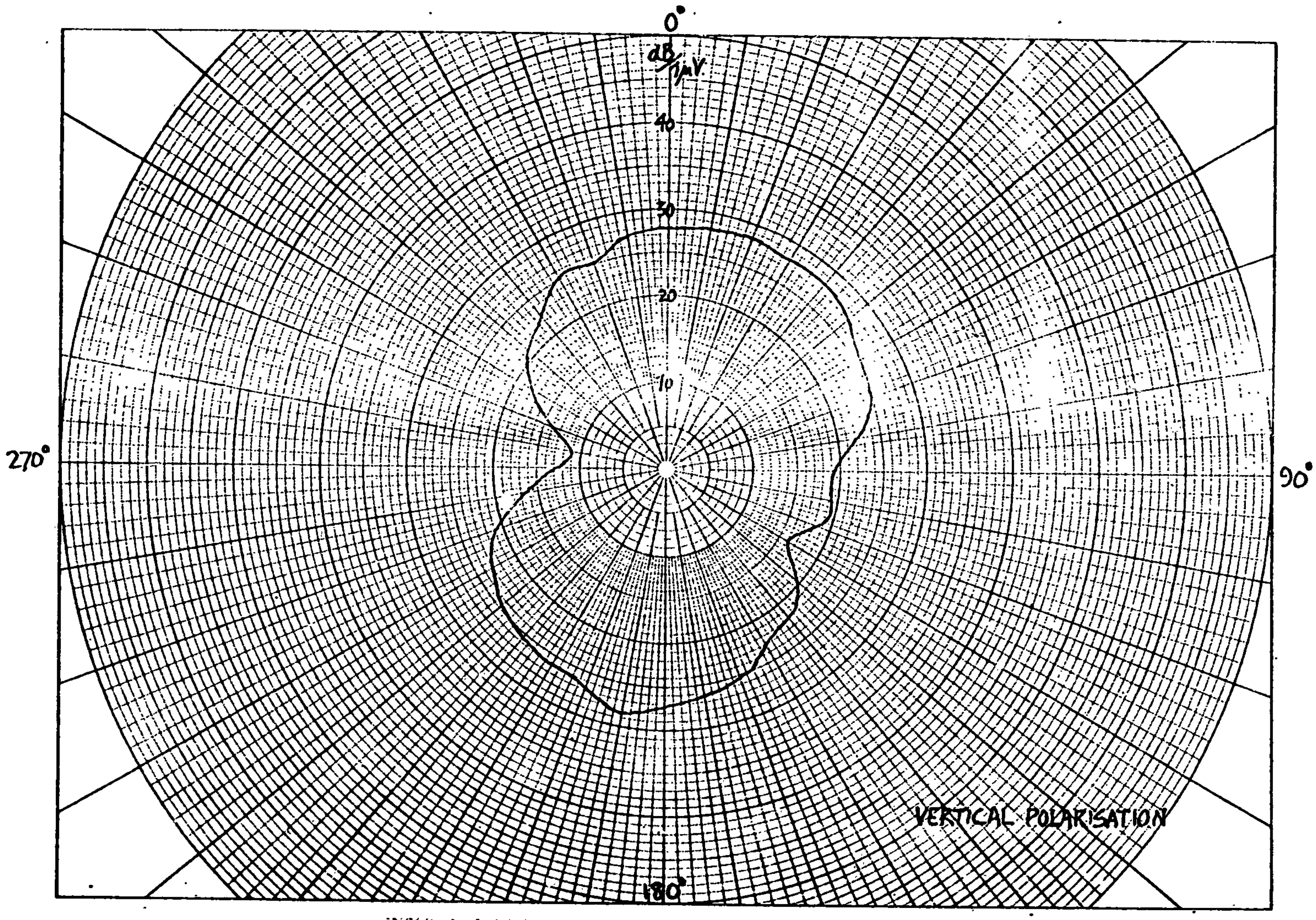


WHIRLWIND MK 10 MONOPOLE Æ. 2835 KC/S.

FIG. 2.

SK. B. 3689.

DATA SHEET No. 13 POLAR CO-ORDINATE

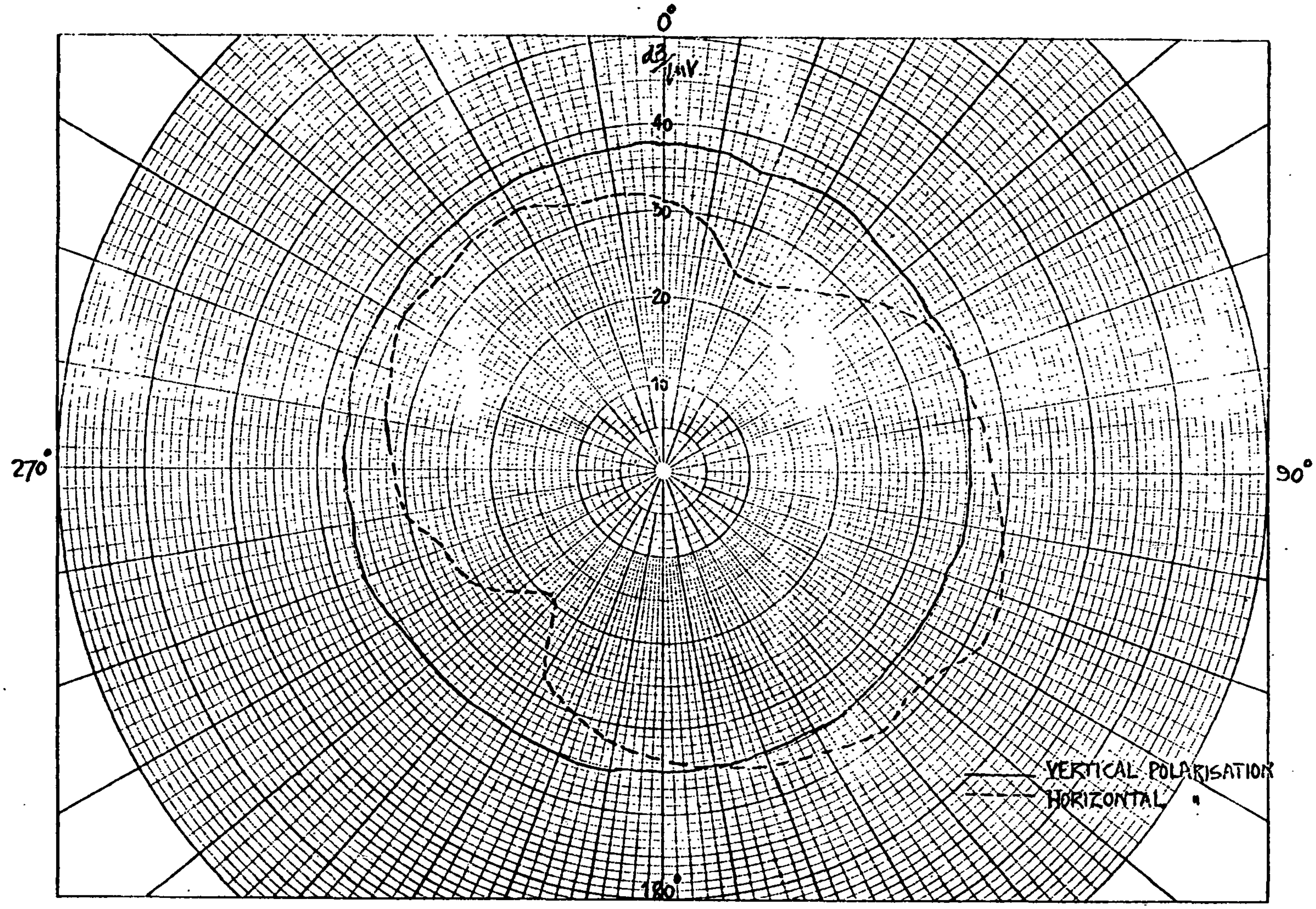


WHIRLWIND MK 10 WIRE Æ. 2835 KC/S.

FIG. 3.

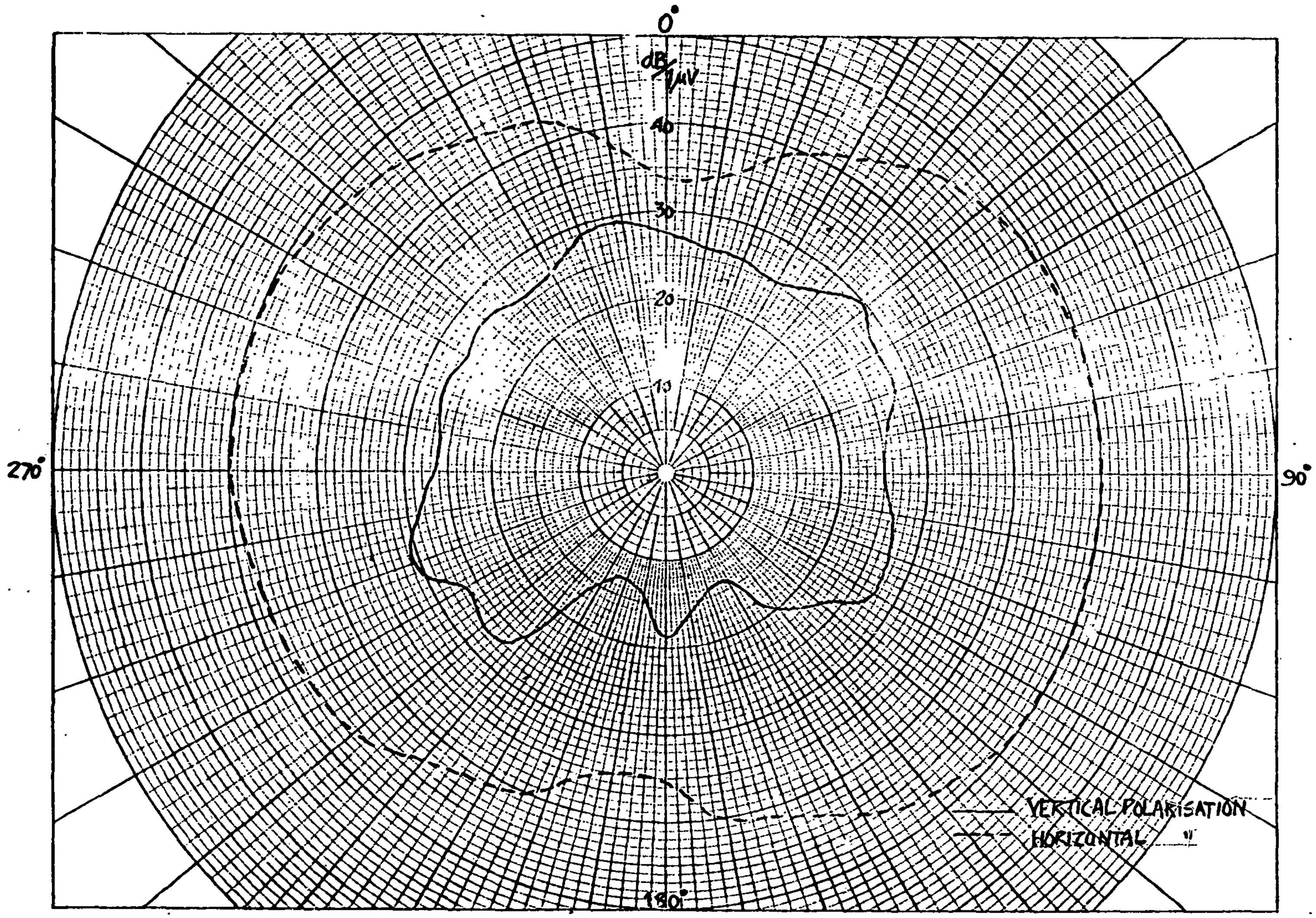
SK.B. 3690.

Data Sheet No. 13 Polar Co-ordinate



WHIRLWIND MK 10 MONOPOLE Æ. 5685 KC/S.

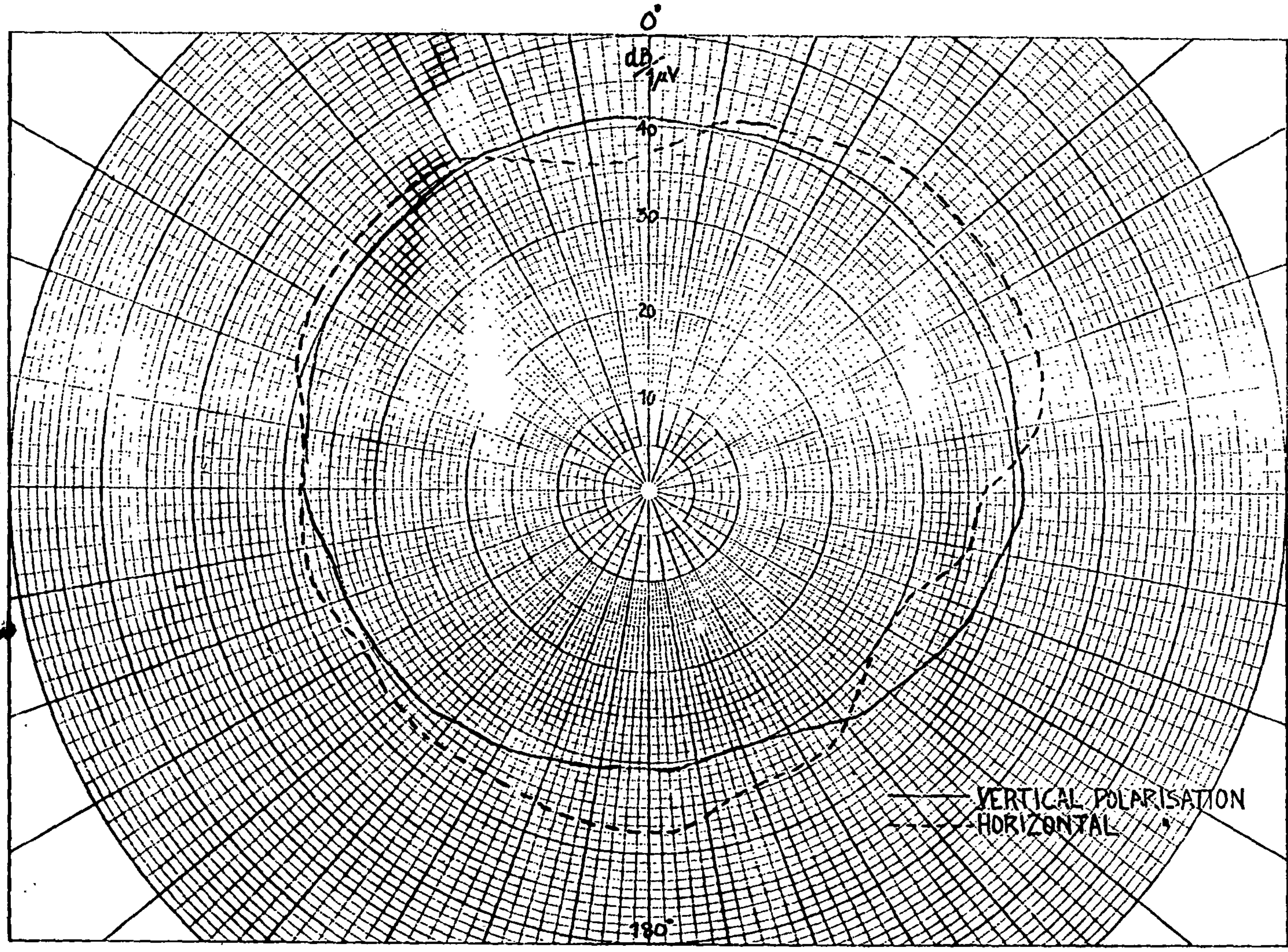
FIG. 4.



WHIRLWIND MK 10 WIRE Æ. 5685 KC/S.

FIG. 5.

Data Sheet No. 13 Polar Co-ordinate

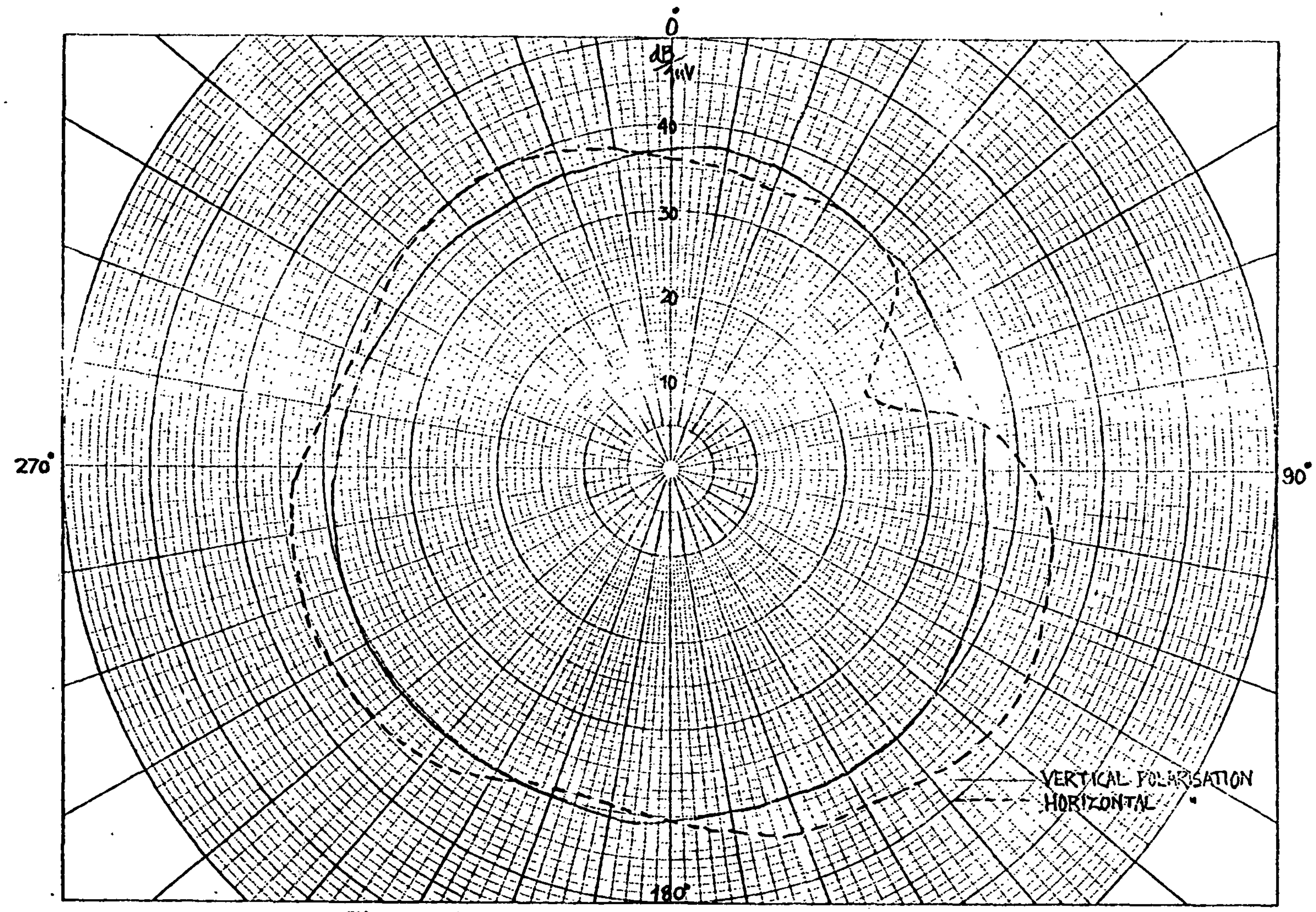


WHIRLWIND MK.10 MONOPOLE Æ. 8975 KC/S.

FIG. 6.

SK.B. 3693

Data Sheet No. 13 Polar Coordinate



WHIRLWIND MK.10 WIRE Æ. 15,036 KC/S.

FIG. 7.

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It is concluded that a monopole aerial, together with Antenna Coupler 490T-1A, is the best of the systems proposed and is likely to be operationally satisfactory provided that steps are taken to overcome the tuning failures and the burning of the selector switch.

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