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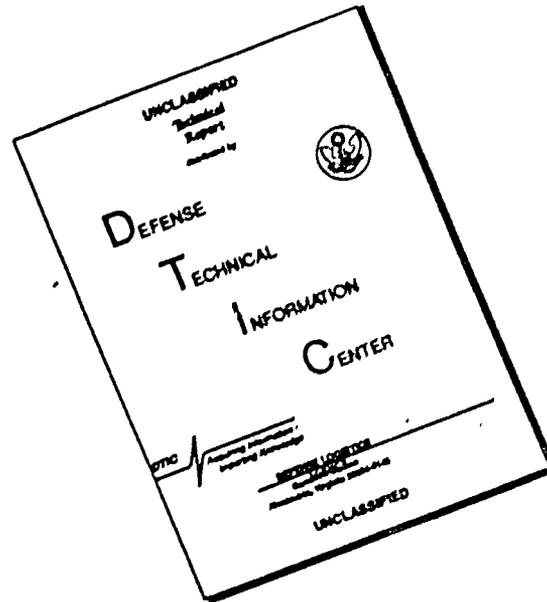
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## Armed Services Technical Information Agency

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A.R.L./R.1/E.301.

AIRCRAFT DETECTION BY INTRA-RED TELESCOPE.

AT ABINGDON R.A.F. STATION, NOVEMBER 5th AND 8th, 1940.

References:-

Copy!

- (1) A.R.L. letter to S.R.E. Dept. E.300, September 9th, 1940.
- (2) R.A.E. Note. Inst/S.605/AM/23. (Inst.447).
- (3) R.A.E. Note. Inst/S.605/AM/23. (Inst.451. October 16th, 1940.)
- (4) Notes of Meeting to discuss the Application of E.M.I. Electron Telescope held in D.S.R's room, Admiralty, on Wednesday, October 23rd, 1940.

Introduction.

Consequent on the decisions of the Conference held at S.R.E. Department (Admiralty) on October 23rd, 1940, a meeting was held at A.R.L. between representatives of R.A.E. and A.R.L. when it was decided to carry out controlled trials at Abingdon Aerodrome. Dr. McGee of E.M.I. and Mr. E.W. Chivers of A.D.E.E. were informed of the proposed trial. Direct arrangements were also made with Captain Hope of A.A. Command, Watford, to provide a G.L. Set and operators.

Equipment and Scheme.

Arrangements were made by R.A.E. to provide and fly a Whitley Bomber at night over the Aerodrome at a series of heights. It was hoped that other types of aircraft might also be available but permission to fly captured enemy craft at night was not obtained. R/T communication between ground and aircraft was arranged at Abingdon.

At the observing position on the ground were set up four E.M.I. electron telescopes each fitted with a different optical system as follows:- (A) Dallmeyer 6" focus Super Anastigmat lens F/1.9 and 1 1/8" eyepiece, Field about 10°; (B) 12" Mangin Mirror with small aluminised plane mirror set up in a Cassegranian arrangement, Field about 8°; (C) 12" Mangin Mirror with "bent telescope" set up in Newtonian arrangement, Field about 8°, and (D) 36" Front aluminised parabolic Mirror, Field 4°. Observers were detailed to make simultaneous observations with these different systems.

The G.L. Station was located about 50 yards from the observing point and it supplied information as follows:- bearing angles by Magslip transmission, elevation angles and range by telephone. Observing systems B, C, and D were provided with roughly graduated circles but A was arranged to be held in the hand and trained in a direction roughly parallel to the others.

The procedure of the trial was for each observer to record the instant when he detected the image of the plane in the electron telescope and to follow it until recording the instant when he finally lost it. From information given by the G.L. set this was hoped to provide the maximum slant ranges.

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For/

For the measurement of exhaust manifold temperature A.R.L. provided a photographer's exposuremeter modified for the purpose and calibrated against an 'Inconel' surface. The instrument could be used down to 450° and was easy to handle during flight. R.A.E. personnel offered to use the instrument during tests.

Account of Trials.

The party consisting as follows assembled at Abingdon on Saturday, November 2nd, a date chosen for absence of moonlight:-

Dr. B.G. Hill.	}	A.R.L.
Mr. C.W. Luxford.		
Dr. E. Lee.		
Dr. A. Elliott.		
Mr. W.R. Merton.		
Mr. L.E. Mayes.	}	R.A.E.
Squadron Ldr. A.N. Combe.		
Mr. A.A. Hall.		
Dr. G.L. Pickard.	}	A.D.E.B.
Mr. E.W. Chivers.		
Dr. McGee.		Mesrs. E.M.I.
Squadron Ldr. Hannafin.		Abingdon R.A.F. Station.
2nd Lieut. P. Blair.		A.A. Command., R.A.F. Station.

The equipment was set up the same evening but the weather became too bad to carry out the proposed trial. This unsuitable weather persisted until Tuesday, November 5th, when it was possible to arrange a low flying trial. As a result of this experience it was decided to reduce the number of observing systems and to make certain modifications in the electrical supplies; a further trial was carried out on November 8th. During these trials it was only possible to obtain a Whitley Bomber as no other types were available.

Nov. 5th, 1940.

The weather was overcast with clouds at 1500 - 2000 feet. Sixteen runs were made by the Whitley all at 1500 feet but the pilot reported the plane in cloud at times even at this height. In addition two observations were recorded on unidentified aircraft (suspected enemy) which flew in the vicinity and on a course which presented a broadside view only. They were located and their ranges given by the G.L. set. During the flights R.A.E. officers flew and measured the exhaust temperatures.

Trouble was experienced with the electrical supply to the E.M.I. telescopes due to the prevalence of excessive moisture and the breakdown of one of the power packs and, therefore, it was found possible to use only two of the four systems on this occasion, namely (B) and (D). The results are set out below:-

Run/

Run	System (B)		System (D)	
	Slant range (yards)		Slant range (yards)	
	Pick up	Lost	Pick up	Lost
1		4,500	-	4,200
2		3,000	-	-
3		4,500	-	-
4		2,500	-	-
5		3,400	-	-
6	3,400	-	-	-
7		2,800	-	-
8	-	-	-	-
9		2,900	-	-
10		3,400	-	-
11		4,200	-	-
12		5,200	-	4,500
13	-	-	-	5,200
14		-	-	5,000
15		3,200	-	4,200
16		2,500	-	-
"Stray" (1)	5,000	3,300	-	-
"Stray" (2)	5,500	7,400	-	-
		6,000	-	-

On many occasions information from the G.L. was received late so that when found the target was well within range and at times it was lost due to training difficulties with the improvised apparatus. As the information required is the practical limiting range of the system those observations which have no significance in this respect are not recorded. A hyphen, however, indicates a definite failure to see the target.

It was apparent from these trials that System (L) (36" Mirror) gave no important range increase to offset its weight and bulk. Also its smaller field of view is not large enough to cover the latitude of elevation errors given by the G.L. (about 5 degrees in elevation - but much less in bearing). It was, therefore, decided to eliminate System (D) before the next trial. The electrical difficulties produced by the damp conditions were obviated to a great extent by the improvisation of a power pack giving a more generous output.

Nov. 8th, 1940.

The moon was now two days past first quarter. At the commencement of the trials the sky was very clear, later it became slightly cloudy but the clouds were above the plane until the last few runs were made. Wratten filter No.87 was used throughout to suppress the moonlight background. This was found very desirable. Systems (A), (B) and (C) were set up and operated but system (C) failed to give any results. It was not possible to find the reason for this during the trial but it is probable that excessive moisture had condensed on the surfaces and it is also likely that the cover glass of the 36" searchlight in which a mounting had been improvised was seriously distorting the image. The trial, therefore, reduced to a measure of the performance of systems (A) and (B). The observations on (A) were made by Dr. McGee and those on (B) by Mr. Merton.

Run/

Run	Height (ft)	System (A)		System (B)	
		Blind range (yards)	Level	Blind range (yards)	Level
1	4,500		7,500		
2	4,500		7,500		(Power gear failed)
3	8,000		8,000		7,800
4	8,000		8,500	4,500	
5	12,000		7,800	7,200	
6	12,000	11,000		17,300	
7	16,000	8,500	8,500		6,000 (visual)

It will be seen that the two systems give very similar performances. It seems that good optical definition is of greater importance than had been expected as system (B) possesses about ten times the light grasp of system (A). Dr. McGee was, however, using his test tube with his lens and some allowance should be made for this.

Measurement of Engine Exhaust temperatures.

The measurements were made during the runs by observation from the cockpit using the optical pyrometer specially calibrated for the temperature range 450°-600°C. Observations were made on the central lobe unless otherwise stated. The results may be taken as having a probable error of ±5°C.

Height (ft)	Conditions of flight	Air temp.	Exhaust temp.
4000 - 8000	climb	-1°C	530°C
	level	-1°C	(530°C lobe 525°C stubs 800°C hot spot)
8000 - 12000	climb (High Speed supercharger clutched in at 8000 ft.)	-8°C	530°C starb. 550°C port
12,000	level	-8°C	555°C starb. 545°C port 525°C front lobe 555°C central lobe 540°C rear lobe
12000 - 16000	climb		555°C starb. 575°C port
16,000	level	-16°C	565°C starb. 555°C port
Glide at 600ft/min. descent			Exhaust black

Discussion of Results.

It has been shown possible to detect and follow with optical accuracy a Whitley bomber using the radiation from its hot exhaust manifolds at ranges where it is invisible to the eye either unaided or provided with optical assistance. (This Whitley was fitted with Merlin Rolls Royce Engines).

The ranges, while encouraging, are not great enough to ensure detection at all flying heights but they are of the right order and may possibly be somewhat improved by optical means. It is not known whether greater sensitivity is achievable by modifications of the electron telescope but it is not considered likely that the extreme limit has been reached.

It is not known whether enemy aircraft engines attain similar temperatures but the observations made on two unidentified aircraft on November 5th and previous observations reported by R.A.E. (Dept. Note Inst.451) afford evidence that the exhaust temperatures are not very different.

If the apparatus is to be used in conjunction with G.L. sets a field of view of about  $10^\circ$  is desirable to cover the probable errors in elevation given by the G.L.

Proposed future action.

It is considered that this should be twofold and simultaneous. The optical system should be improved to give high definition as well as large light grasp and observations should be carried out at a suitable G.L. Station on enemy aircraft using the equipment at present available.

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A.R.L.  
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