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TACTICAL TRIALS METEOR III
COMPARISON WITH TEMPEST V

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TACTICAL TRIALS - METEOR III
COMPARISON WITH TEMPEST V

INTRODUCTION

1. In accordance with instructions received from Headquarters Fighter Command, Tactical Trials have been completed on the Meteor III, including the use of Dive Brakes and a comparison with the Tempest V.

2. Three Meteor III aircraft were used for these trials, Nos. EE.446, EE.428, EE.281. All these aircraft are standard production types, and were completely equipped and fully armed.

3. Official performance figures, obtained from the Ministry of Aircraft Production, R.D.T.I. are used for the tables of Radius of Action (included in Appendix "B").

4. As the Meteor is the first jet fighter to undergo trials at the C.F.E. a summary of the typical characteristics of the type is given in Appendix "D".

5. This report is based on the Meteor III as received by this Unit; it is understood however that action is already in hand on the points raised in the Recommendations marked with an asterisk.

6. It is understood that the use of the Meteor modified for Fighter Reconnaissance is being considered; this modified aircraft is outside the scope of this report and is considered to require a separate trial.

PART I

DESCRIPTION

Role

7. The Meteor III is a short range single seater interceptor fighter. With the addition of the 180 gallon drop tank, a larger range is possible. (Appendix "C"). Photographs giving six views of the type are at Appendix "A" and "B".

8. To date the Meteor III has not been equipped to carry any external stores, i.e. R/P or bomb load.

Airframe

9. The airframe is of normal metal construction, with the tail-plane mounted on the fin to be clear of the jet blast. The Pilot is seated in front alongside the guns which are in the fuselage, the fuel tanks are also in the fuselage.

10. Normal split flaps are fitted, strong enough to be put down to 20° at 225 m.p.h. to assist in slowing up, and to be fully deflected at 150 m.p.h. The air brakes extend from the middle of the chord of the stub wing between the fuselage and engine and are slotted plates. They are stressed to be used at all speeds, and are operated hydraulically to two positions only, fully extended or retracted.

/11. ....

11. The tricycle undercarriage is hydraulically operated from a pump on the starboard engine, with a hand pump in the cockpit and an hydraulic accumulator for emergency use. The accumulator will give one extension of the undercarriage or flaps.

12. Owing to the nosewheel, the aircraft has a low resistance on the ground and wheel brakes are needed to slow up. No emergency brake system is fitted to provide for brake failure through break down or operational damage.

Engines

13. The aircraft is powered by two Rolls Royce Derwent I turbine jets. The characteristic power output, fuel consumption, and surging is dealt with in Appendix "D".

14. The true level speed is nearly the same at all altitudes at which the turbines will maintain full r.p.m. as their thrust decreases with altitude in nearly the same degree as the drag of the aircraft.

Fuel Capacity

15. The fuel capacity is 330 gallons internally carried in one main fuselage tank which is divided into two compartments, the front one feeding the port engine and the rear one the starboard engine.

16. The ventral drop tank of 180 gallons can also be carried, the fuel being transferred to the main tanks by air pressure from the blower on the engine.

17. The two compartments of the main tanks can be inter-connected by a balance cock when the fuel will settle to the same level in the two tanks. This does not enable the two engines to be run off one tank.

18. The fuel used is Kerosene, under the nomenclature of A.V./Turbine, Ref. No. 34A/179 into which is mixed 1% of lubricating oil to Spec. D.E.D. 2472/B/0, key letter X, Ref. No. 34A/32. Special care should be taken to use an approved filter nozzle owing to the small working clearances of the injection pump mechanism and the consequent need to avoid the presence of small particles.

19. The oil used is Intava 7106 or Wakefield Perfecto, extra light, Ref. No. 34A/200. The oil tank capacity is 2¾ gallons and normal consumption is 1 pint per engine per hour at cruising r.p.m. and 1½ pints per engine per hour at maximum r.p.m.

Auxiliary Power

20. Electric power is supplied by a generator fitted on the port engine and a 40 ampere hour accumulator. The services operated are:- engine fuel pumps, compass, radio, gun firing, gyro gunsight, fuel gauges, I.F.F., cockpit lighting and cockpit warning lights.

21. A test has shown that the radio will operate for a period of about 12 minutes after the port engine has stopped or the generator has failed, after which communication ceases. If an unsuccessful attempt to restart the engine is made with the restart button, the radio and other services will begin to fail immediately.

22. The hydraulic pump is driven by the starboard engine and serves undercarriage retraction, flap operation, and air brakes. An hydraulic accumulator will give an emergency extension of the undercarriage, and a

/cockpit ....

cockpit hand pump is also fitted which lowers the undercarriage 130 strokes and raises it in 150. Flaps are lowered in 52 strokes and are raised in 42 strokes.

23. A vacuum pump for instrument operation is fitted to each engine, with a vacuum transfer cock on the right of the pilot.

24. The pneumatic system which operates the brakes and cocks the guns is fed by air bottles which have to be refilled on the ground. (No engine driven compressor is fitted). The connection is in the port wheel bay.

Guns

25. The aircraft carried four Mk. II^{x} 20 m.m. Hispano Guns, two on each side of the cabin. They are mounted on diaphragms built out from the main webs. The fuselage structure is protected by metal blast tubes.

Ammunition

26. Ammunition is carried in four 150 round tanks mounted in pairs one above the other in the magazine bay. A rounds counter is fitted to the port side of the cockpit.

Gun Firing Control

27. The guns, which are fired electrically, are controlled by a wobble type button on the control column. When the flap is open the gun circuit is live and depressing any part of the finger plate fires all four guns and operates the camera.

28. If the guns are wired for selective firing, only two guns fire when the top of the finger plate is pressed, pressure on the bottom firing the other two. All four guns fire when the centre of the finger plate is pressed. The camera operates in all cases, but its harmonisation is disturbed by firing the guns.

29. A micro-switch is fitted to ensure that the gun circuit is broken when the undercarriage is down.

Gun Heating

30. The guns are heated by hot air, from a muff fitted round the port jet pipe, being blown on to the underside of the gun bodies. No control is provided.

Gunsight

31. The first two aircraft employed on the trial were equipped with the Projector Type 1, Mk. 1. The sight, which reflects on the windscreen, is fitted to a mounting which is attached to the windscreen base. The gunsight dimmer switch is on the instrument panel and the master switch on the starboard switch panel.

32. In the latter stages of the trials, Meteors, fitted with the Gyro Gunsight Mk. IID were used. This is mounted on a casting attached to brackets which are secured to the cockpit coaming. Both the master switch and the selector dimmer are mounted on the starboard switch panel.

/Camera ....

Camera

33. A G.45 Camera, mounted in the fuselage nose fairing, operates with the guns through the wobble button, or can be operated independently by depressing the camera finger plate, which is visible when the safety flap is closed over the gun finger plate. An exposure and footage indicator is fitted on the port side of the cabin. The camera master switch is on the starboard switch panel.

Harmonisation

34. The diagram used in the early stages of the trial (See Appendix "E", Fig. 3a) was provided by O.R.S., Fighter Command. It was found impossible to bring the port lower gun on to its harmonising spot owing to fouling of the cocking cylinder with the attachments of the case ejection chute of the gun above. To provide adequate clearance for the prevention of short recoil stoppages, the port lower gun was aligned on a spot 10" inboard of the position detailed in the O.R.S. diagram. Point harmonisation was later adopted, the diagram used being given in Appendix "E", Fig. 3b.

Armour

35. 7 m.m. armour plate is fitted to the nose wheel and seat bulkheads. The windscreen panels and the rear view panels in the seat bulkhead are of armoured glass. The top skin forward of the windscreen is of 10 SWG light alloy with 4 m.m. armour deflector plates fitted on the underside.

36. The rear nose wheel doors and the main webs forming the sides of the cabin are of 10 SWG light alloy to act as deflector panels. Other 10 SWG light alloy deflector panels are fitted to the outer structure at the sides of the cabin.

Ancillary Equipment

37. A TR.1143A V.H.F. set is fitted with the control box in front slightly above the throttle lever.

38. I.F.F. is fitted and a G.45 camera gun. No provision is made for reconnaissance camera.

39. A fire extinguisher is fitted to each engine. They are operated manually by pressing the two red buttons situated on the right hand side of the instrument panel next to the hood jettison handle.

Cockpit Layout

40. Appendix "G" "Visibility from Cockpit" shows the field of view, distortion of view through the perspex, and accessibility for cleaning the perspex.

41. The flying instruments are clearly visible on the Standard Blind Flying Panel. All the engine instruments are, however, partly or entirely obscured by the control column and the right arm of the pilot. This applies especially to the oil pressure gauges, burner pressures and jet temperatures.

42. The flying instrument panel is illuminated at night, but there is no light for engine instruments and flap indicator etc. (See Paras. 107 - 114).

43. The seat and rudder pedals have an adequate range of movement. The rudder pedals are independently adjusted. The throttles and air brake levers are grouped conveniently on the left hand side of the cockpit. The flap and undercarriage levers are placed side by side on the left hand side of the instrument panel. Their juxtaposition is considered a disadvantage especially at night. There is no safety catch for the undercarriage lever in the cockpit, but there is a ø mechanism to prevent the retraction of the wheels when the undercarriage legs are compressed with the weight of the aircraft. There is no method of retracting the undercarriage in emergency on the ground.

> øNote. A case has occurred of the undercarriage being retracted on the ground in spite of this mechanism.

44. The new design of crank for operating the sliding hood is weak and frequently bends and is likely to fail in normal use.

45. The map holder is of inadequate size and is situated underneath the throttle box, and a map has to be bent somewhat to get it in. There is no luggage compartment.

46. A control for a warm air supply is fitted but not working, the effect of selecting "warm" now being only to limit the supply of cold air.

Weights and Loadings.

47. The full loaded all up weight is 12,614 lbs., and the corresponding wing loading is 34 lbs/sq.ft. The wing loading of the Tempest V used in the comparative trials is 38 lbs/sq.ft.

48. Carrying a full ventral tank, the all up weight is 14,343 lbs.

49. The maximum landing weight permitted is 12,000 lbs. This is reached with a clean aircraft when 250 gallons of fuel remain. If the ventral tank has not been jettisoned it is reached when 216 gallons remain.

Centre of Gravity.

50. The design range of the centre of gravity is from 27.9% of the standard mean chord to 34.1% standard mean chord. In all cases the centre of gravity lies within this range. The most extreme position reached is for an aircraft with no ventral tank with all its ammunition expended when the centre of gravity is at 33.0% standard mean chord. The effect of the ventral tank is to move the centre of gravity forward .2% standard mean chord when empty and .4% when full.

Servicing and Maintenance.

51. Servicing and maintenance has been carried out in accordance with A.P. 2210 A and C, Vol. 2, Part 2. These instructions have proved satisfactory. It is important that the starter battery is always fully charged, as the peak demand is approximately 850 amps., and it is essential that the battery operator keeps the button depressed for the whole 30 secs. of the starting cycle.

52. On the limited experience of this unit, the following times for typical servicing jobs have been found and are shown compared with similar jobs on a Tempest:-

/Over....

	Tempest	Meteor
Mainplane Change	115 man hours	20 man hours
Engine Change	105 " " ex crate (75 man hours with components fitted)	48 " "
Minor Inspections	105 man hours	70 " "
Daily Inspections		
Fitter	1.30 " "	.45 " "
Rigger	1.00 " "	.45 " "
Instruments	.10 " "	.10 " "
Electrical	.30 " "	.30 " "
Wireless	.05 " "	.05 " "
Armament	.30 " "	.30 " "
Refuelling (Oil and Fuel)	.15 " "	.20 " "
Rearming	.10 " " (2 Airmen)	.15 " " (4 Airmen)

(a) A delay of up to twenty minutes is caused in the daily inspection in removing and replacing the intake grill owing to the complication of the fastening.

(b) But in general it will be seen that the Meteor is much easier to service than the Tempest.

53. Arrangements have to be made for mixing the small proportion of lubricating oil with the fuel, and special filtering equipment is necessary when refuelling owing to the fine clearances in the fuel injection mechanism.

FLYING LIMITATIONS

54. (i) The maximum permissible speed on the Meteor III, imposed for structural considerations is 500 I.A.S.

(ii) The critical Mach. number on the Meteor III is .74. (This is additional to the 500 m.p.h. I.A.S. restriction mentioned above). Therefore, it can be seen that at low altitude the structural limitation is the deciding maximum and at altitude it is the Mach. number limitation.

(iii) Intentional spinning is prohibited.

(iv) The undercarriage or flaps should not be lowered above 155 m.p.h. I.A.S.; if the undercarriage is down the aircraft should not be flown above 225 m.p.h. I.A.S.

/(v) ....

(v) Aerobatics must not be performed at an all-up weight in excess of 12,300 lbs.

(vi) The aircraft should not be landed at an all-up weight above 12,000 lbs.

(vii) The operational limitations are:-

	r.p.m.	Jet Pipe Temp.	Time Limit
Take-off	16,400/16,600	680	5 mins.
Climbing	16,000	650	30 "
Combat	16,400	680	5 "
Cruising	15,400	600	

Compass Deviation

55. The Meteor III is equipped with a Pioneer Magnesyn Remote Indicating Compass, the repeater for which is situated in the pilot's cockpit. There is at present no provision for a magnetic stand-by compass. Detailed investigations have been carried out on this compass by A. & A.E.E. and are published in the 7th part of their Report No. 817 The deviation observed in these investigations was always within the limits of ± 2.4°.

PART II

PERFORMANCE

Handling on the Ground

Starting and Scrambling

56. The starting up is extremely easy and can be completed in approximately 56 secs. This, coupled with the fact that no warming up is necessary is of considerable advantage for a rapid "scramble", and a formation of Meteors could get off the ground nearly as quickly as a formation of any conventional single engine fighters, and more rapidly than a formation of twin-engined fighters.

57. A number of test "scrambles" have been carried out, with the pilot strapped in the cockpit, helmet on, R/T plugged in, starter control plugged in, one airman standing by, brakes on, and no chocks. The time was taken from the moment the high pressure cock was turned on, till the aircraft became airborne, and included starting up both motors, taxying 75 yards, turning on to the runway, and taking off.

58. Two types of take-off technique were used. First, the jet engine procedure of turning on to the runway, and opening up the throttles fully on the brakes to check the max. r.p.m. and jet pipe temperatures. This type of "scramble" takes 2 minutes, 40 secs. Secondly, the conventional take-off was done, which can be used for an emergency where no checks of r.p.m. or jet pipe temperature are done on the runway, and this reduced the time to scramble to 2 minutes, 5¼ seconds.

/59. ....

59. The view for taxying on the ground is satisfactory, although the field of view permitted by the airframe structure is reduced by the gyro gunsight. In the air, the view all round is good, except for the reduced outlook forwards and downwards. Both wing tips can be seen from the cockpit.

60. Differential use of the throttles enables gradual turns to be made, but for medium and rapid turns, brakes have to be used. This, combined with the fact that there is no engine driven compressor on the aeroplane, is of a great disadvantage if long distances have to be covered on the ground before taking off. (It is understood, however, that on the Meteor IV aircraft an engine-driven compressor is being incorporated).

61. At the rearmost limit of the C.G. position there is a slight tendency for the nose-wheel to lift off the ground at fast taxying speeds, but at all normal C.G. positions the aircraft has a pleasantly solid feel on the ground.

Handling in the Air

62. The handling trials were done at normal service loadings.

Take-Off

63. To take-off, both the elevator and rudder trimming tabs need to be set at "Neutral". The engines are normally run up to a maximum r.p.m. against the brakes (16,500 + or - 100 r.p.m.), to ascertain whether full power is available, to check that the jet pipe temperature is not exceeding the maximum and that burner pressure is normal. One third flap can be used to shorten the take-off run. When the brakes are released the aircraft accelerates fairly slowly, with no tendency to swing. Using one-third flap with no wind the aircraft becomes airborne in about 650 yards, at approximately 105 m.p.h.

Landing

64. The Meteor III is a very straightforward and easy aircraft to land. Pilots do not find any difficulty in familiarising themselves with the tricycle undercarriage landing procedure, and the brakes are good.

65. Even with the flaps down, the gliding angle is rather shallow and the speed without the use of dive brakes decreases very slowly. A normal gliding approach is recommended, flaps and wheels down, under 150 m.p.h., last turn in at 140 m.p.h. and the final approach at 115 m.p.h.

66. Pilots should aim to touch down approximately 20 yards up the runway, so as to keep the angle of the approach right, and obviate the tendency to undershoot. If an undershoot is experienced, the throttles should be opened early to extend the glide owing to the poor acceleration of the Turbines at low speeds. A flat approach is definitely not suggested, as this will place the aircraft in such an attitude as to produce a nose-up and tail-down landing with a possibility of damaging the tail plane.

67. Landings have been made in cross winds without difficulty, the maximum being a wind of 30 m.p.h. at right angles to the runway. The Meteor is considered suitable for single runway operation.

/Flying Controls ....

Flying Controls

68. Rudder. The rudder is heavy, but effective. Owing, however, to the fact that use of the rudder tends to increase the snaking at medium and high speeds, this effectiveness is not an advantage.

69. Ailerons. The response to aileron movement is good but the stick force necessary to produce any particular movement is much heavier than on any modern fighter.

70. Elevator. The elevators are light and effective. Elevator and rudder trimmers are fitted. These are effective, especially above approximately 300 m.p.h., and provide adequate trim throughout the speed range. There is no change of trim on "unstick" or when the undercarriage is retracted, and the slight tendency to sink when the flaps are raised can easily be corrected by elevators.

General Handling

71. On the whole, the aircraft is pleasant to fly in calm weather. At the lower end of the speed range the slightly greater care which has to be paid to control movements suggests that the measure of longitudinal stability decreases with speed. Above 250 m.p.h., however, the balance between stability and elevator stick force for manoeuvring is pleasant. At no time does the aircraft tighten in turns.

72. Due to the characteristics of the jet engine, the initial acceleration during take-off is moderate, and the climb is poor when airborne until the climbing speed is reached after which the best rate of climb is obtained at a comparatively high air speed and small angle of climb. The slow acceleration occurs at low speeds in all circumstances.

73. The great disadvantage of the Meteor III from a tactical and general flying viewpoint is the heaviness of the ailerons throughout the speed range. At medium and high speeds evasive action and even moderate turns are very tiring.

74. It is considered that the upright seating position and the low rudder pedals are a distinct disadvantage in combating the effects of "G".

75. The almost complete absence of change of trim on a typical fighter sortie relieves the pilot a great deal.

76. Under "bumpy" weather conditions the aircraft becomes directionally unstable, the instability manifesting itself as moderate to bad "snaking". The only cure for this is to throttle back and reduce speed, the use of rudder only aggravates it.

Search and Sighting View

77. The view forwards and to both sides is excellent. To the rear, however, immediately behind the pilot's head, the metal armour-plate greatly restricts the view. Further, considerable distortion is noted when objects are viewed through the rear canopy. (See Appendix "G", Figs. 10a & 10b).

Low Flying

78. The Meteor III is a pleasant aircraft for low flying, having an excellent all-round view except that the original view forward and down is partly blocked by the Gyro Gunsight.

/Aerobatics ....

Aerobatics

79. The Meteor III would be an excellent aircraft for all aerobatic manoeuvres if the ailerons were not so heavy. It has the advantage that the turbines do not cut under conditions of negative "G" as provision is made for 15 seconds inverted flight.

Formation Flying

80. Owing to the poor acceleration and deceleration of the Meteor aircraft, a little difficulty may be found to begin with in keeping a steady position. The normal fault is over-correction with the throttles, but, with practice, this can be overcome. At speeds above 300 I.A.S. formation becomes simple, because the power of the engine increases, and it will be found that in the region of 350 I.A.S. any response to the throttle compares favourably with that of the conventional fighter.

81. For formation take-offs, the use of 16,000 r.p.m. by the Leader is recommended, thus allowing 400 r.p.m. for the rest of the section, to use for correction.

82. The Leader should hold his aircraft on the ground longer than for a normal independent take-off, to enable the rest of the section to gain more speed before becoming airborne.

83. For formation flying, 15,000 r.p.m. allows sufficient reserve for keeping station and gives a suitable speed (See Para. 81).

84. Formation landings are quite straightforward. Owing to the slow throttle response at low speeds it is essential for the Leader to give clear signals when he wants the wheels and flaps lowered.

Operational Ceiling and handling at altitude

85. The height at which rate of climb fell below 1,000 ft. per minute was 31,000 ft. The handling qualities of the Meteor III at altitude are similar to lower down. Care must be taken to see that the burner pressure does not fall below 10 lbs/sq. in. As height is gained the r.p.m. have to be reduced to avoid surging. (For surging behaviour see Appendix "D").

Instrument Flying and Bad Weather Flying

86. All the blind flying instruments are visible to a pilot flying with his seat in the normal position. At high speeds or in bumpy weather, the snaking is enough to cause a considerable deflection of the rate of turn indicator, so that a mean position of the needle has to be judged.

87. Bad weather flying without rain is easy, but even the slightest shower cuts down visibility to a minimum through the front windscreen and side panels to such an extent that it is impossible to differentiate between sky and ground.

88. The G.G.S. installation apart from its adverse psychological effect of a large object immediately in front of a pilot's eye does not interfere with instrument flying but it reduces the view over the nose from 16° to 9° when the aircraft is in the cruising attitude.

Pilot's Comfort

89. Various opinions have been formed for and against the upright seating position in this aircraft, but owing to its limited duration the

/fatigue ....

fatigue question has not been decided. It is considered, however, that if the back of the seat was mounted on Springs like the Tempest V's the pilot's comfort would be increased. The aircraft is uncomfortably cold especially at medium and high altitudes, as no cockpit heating is fitted, in addition when either hot or cold air is selected the pilot is subjected to cold draughts around the face and feet.

Compressibility

90. The following tables show the effects of compressibility, and those speeds above which these effects will manifest themselves at various heights; the limiting speed is reached in a 15° dive. Providing the angle of dive is not very steep, ample warning is given of the approach of compressibility phenomena (see below) and also the forward load required on the control column to maintain the dive becomes very uncomfortable. This tendency for the nose to rise as compressibility is approached is a good characteristic of the Meteor III. Compressibility phenomenons which have been met are:-

I.A.S.	Altitude	Mach. No.	Remarks
500	4,000 ft. - 5,000 ft.	.68	Severe snaking combined with lateral oscillation, controls still effective.
510	5,500 ft. - 6,000 ft.	.72	Violent snaking and lateral oscillation. Stick nearly solid but still effective; nose up tendency.
528	6,000 ft.	.73	Violent "juddering" (vibration up and down), stick also vibrating badly and entirely ineffective and solid. On throttling back controls became effective again after a short pause.

91. Directly the first indication of compressibility is experienced, the engines should be throttled back and the aircraft eased gently out of the dive. Use of excessive "G" in recovery will aggravate the compressibility effects and bring on "juddering" at the lower Mach. number than under steady flight conditions.

92. Marked differences are apparent between individual aircraft resulting in differences of as much as 30 m.p.h. in the critical Mach. number due to dirty aerofoil sections, dents in cowls, etc.

93. The limiting speeds given in A.P. Handling Notes for Meteor III are:-

20,000 ft.	400 m.p.h. I.A.S.
25,000 ft.	360 m.p.h. "
30,000 ft.	325 m.p.h. "
35,000 ft.	290 m.p.h. "

In war conditions, a pilot would have difficulty in remembering these figures and in watching the necessary instruments.

/Spinning ....

Spinning

94. Spinning Trials have been carried out by the Gloster Aircraft Company, and the following is a summary of their experiences, with the centre of gravity, being moved progressively aft:-

95. "With the centre of gravity at 30.2% aerodynamic mean chord spinning characteristics are quite normal. The aircraft was spun in both directions at 15,000 ft. and the recovery was accomplished in each case after two turns by 10,000 ft. This was repeated from 20,000 ft. and, in each case, control was regained by 15,000 ft. after two turns".

96. "With the centre of gravity at 32.7% aerodynamic mean chord, however, spinning characteristics of the Meteor III appear to be more unpleasant. During the spin severe elevator buffeting takes place and the stick moves approximately 2" to 4" and considerable force is necessary to hold it steady. Buffeting also takes place around the centre section during the recovery".

97. The rearmost C.G. position that can be reached under operational conditions, occurs when the ammunition has all been used and the front fuel tank has been emptied. The C.G. position is then 33.0% of aerodynamic mean chord. This can only occur when the pilot is flying on the port engine and fails to open the interconnecting cock.

98. There is a tendency for the machine to go into a spin in the opposite direction if control movements are not positive and corrections made quickly.

99. It is essential when the centre of gravity is aft of its normal position to move the control column well forward and to use full opposite rudder for the recovery, and to centralise the rudder rapidly as the spin stops, in order to avoid spinning in the opposite direction.

100. The Meteor III has not been cleared for practice spinning but, if the foregoing instructions are followed, the pilot should have no difficulty in recovering from an accidental spin.

Single Engined Flight

101. Single engine flying on the Meteor III presents no difficulties. The property of a normal propeller-engined twin aircraft to roll immediately an engine cuts is reduced on the Meteor.

102. The following approximate figures have been found from trials made at this Establishment - N.B: In all cases the "dead engine" was stopped, not merely throttled back.

(i) At 5,000 ft. - Starboard engine stopped
Wheels and flaps up

15,400 r.p.m. straight and level 250 I.A.S.
16,500 r.p.m. " " " 284 I.A.S.

16,000 r.p.m. climbing at 225 I.A.S. 450 ft/mins.
16,500 r.p.m. " " " " 600 "

(ii) Port engine stopped
Undercarriage down, flaps up

16,500 r.p.m. straight and level 168 I.A.S.
16,500 r.p.m. climbing at 150 I.A.S. 80 ft/min.

/At 16,500 r.p.m. ....

At 16,500 r.p.m. with undercarriage and flaps down the aircraft does not maintain height. At 120 I.A.S. it loses height at approximately 100 ft/min. The minimum speed to control the aircraft and maintain height with the undercarriage down and quarter flap is 125/130 I.A.S. At this speed full opposite rudder is needed.

Restarting in Flight.

103. Owing to the action of the present barostat control, very low r.p.m. occur when throttling back at altitude and the fire may go out, and this also occurs if there is a momentary failure of fuel supply. In these circumstances restarting is uncertain. Turbines have been stopped on thirteen occasions at this unit, and have been restarted on all occasions but one. But this result has been achieved by experienced pilots making repeated attempts while flying on the other engine, the total number of attempts to restart by approved methods amounting to about forty for these twelve restarts.

104. To avoid the burners going out at high altitude it is essential that when throttling back, the movement of the throttles is done slowly, so as to allow the engine r.p.m. to keep pace with the throttle movements, as it is found that the r.p.m. drop off very slowly. The r.p.m. must not be allowed to drop below 10,000.

Ditching.

105. It would appear from the photographs in Appendix "H" of the model tests carried out by R.A.E. Farnborough, to asses the probable ditching behaviour of the Meteor that no trouble should be experienced in ditching this aircraft in calm weather.

Night Flying.

Cockpit Layout.

106. A normal blind flying panel is fitted with fluorescent instruments. The present lighting consists of two UV lamps; two red cockpit lights for backing up the UB lamps; a single red lamp in the rear port side of the cockpit; and an emergency red light for use in the event of a general lighting failure.

107. Owing to both UV lamps being positioned too far aft in the cockpit, unnecessary light causes obstructions to fluoresce, between the lamps and the panel, especially such objects as the air conditioning pipe on the port side and the perspex side panel forward of the sliding hood. Further, with this positioning of the lighting, the lower engine instruments and fuel contents gauges are barely illuminated, thus making their reading difficult.

108. During the trials a more satisfactory solution was found by re-positioning most of the lights in the following manner:-

(i) Port UV Lamp moved approximately 4 inches forward and dropped slightly.

(ii) Starboard UV lamp approximately 10 inches forward and positioned below the hood winding mechanism.

(iii) The two backing-up red lights have been depressed to illuminate a larger expanse of the blind flying panel.

/(iv)....

(iv) The single red light has been positioned to illuminate the elevator and rudder trimmer tab indicators.

(v) The emergency red light has been more centrally placed.

Taxying

109. The forward view is exceptionally good as is usual on majority of tricycle undercarriage aircraft. The undercarriage indicator lights cause reflections on the perspex, but this is not serious.

Take-Off

110. Perfectly straightforward, even on instruments. It is necessary to use a flash-lamp to check take-off revs. and flap setting.

General Handling

111. As for day, except the reflection on the windscreen and panels which becomes rather annoying and confusing.

Jet Glare

112. Jet glare is not apparent from the Pilot's point of view. Tests have been carried out using a Mk. X A.I. aircraft as an airborne range finder, to determine ranges and angles off at which jet glare can be seen from behind. On an average of four runs at a height of 5,000 ft. the range at which jet glare could be seen by the intercepting fighter was five plus miles, the glow was visible within a cone of 60°. (Another trial has been carried out on a Meteor III fitted with Welland engines. Reference A. & A.E.E. Report 817,a, Part III).

Approach and Landing

113. A normal approach and landing can be made with ease. With the glide path indicators set on $4\frac{1}{2}^{o}$ and $5\frac{1}{2}^{o}$ the approach can be made at 110 m.p.h. from 500/600 ft. in the funnels coming in on a green.

Aimability Trials

The Meteor as an Aiming Platform

114. The trials of the Meteor as an aiming platform were covered by this Establishment's Report No. 54 (A.F.D.S. Report No. 172) dated 10th November, 1945. These trials took the form of comparisons between the majority of current fighter aircraft, using the pilot's ability to hold a fixed sight on the target as a yardstick. Attacks were made against other aircraft and against ground targets and it was concluded that, with the exception of the Meteor, the magnitude of aim wander was so small as to be insignificant in comparison with the overall gun group. size now in use on Fighters.

115. The failure of the Meteor to come within an acceptable standard is due to the directional snaking which occurs in operational conditions of flight so far experienced and the heaviness and consequently slow operation of the ailerons to bring the sight back on to the target. This snaking tends to increase with increase of speed and, once it has commenced, it is impossible to correct it within the limits of time available during an attack. It is understood that modifications are in hand in an attempt to eliminate snaking, but the aeroplane as tested is unsuitable for operations.

/Weapon Training ....

Weapon Training

116. Towed Targets. Apart from its snaking qualities, the Meteor is a simple and straightforward aeroplane for air firing against towed targets. Positioning for beam, quarter and shallow deflection attacks is especially easy due to the good forward vision. Dive brakes were used on some attacks and reduced the speed of approach to the neighbourhood of 250 m.p.h. with no de-stabilising effects. Without dive brakes the shallowest dive approach at minimum cruising r.p.m. produced speeds of the order of 300 I.A.S. which is the maximum practical speed for attacks against existing targets.

117. To summarise, the following points should be observed:-

(i) Commence the attack from the same level as the target to prevent a rapid build up of speed.

(ii) Concentrate on an accurate curve of pursuit and put the sight on the target as soon as possible.

(iii) Make sighting corrections on the stick only.

(iv) Use the dive brakes to get rid of excessive speed out of range, but not during the attack and breakaway.

118. Ground Attack. The higher speeds which are unavoidable in diving attacks introduce a greater degree of snaking than in air to air gunnery. Although the speed can be kept down by the use of dive brakes, for the reasons given in Para. 127, this is undesirable if pilots are to be trained in the operational use of their aircraft, and the use of dive brakes is not advised except prior to entry into the dive. The bumpy conditions which normally occur at low altitudes also aggravate snaking.

119. Two types of attack were found most effective:-

(i) A dive well back from the target from 4,000 ft. flattening out until a height of 300 ft. is reached at a speed of 400 - 500 I.A.S. Opening fire at this height at a range of approximately 1200 yards and ceasing fire at 300 yards and breaking violently to right or to left at low altitude.

(ii) A medium dive attack of about 15°, using dive brakes at entry. The conditions for the dive and pull-out are as follows:-

Height at entry	Speed at entry	Engine Settings	Dive Angle	Ht. at cease fire	Range at cease fire	Speed at pull-out
2000/4000	250/275	14000 rpm	15°.	300 ft.	300 yds.	380/400

120. Both these types of attack are designed to give plenty of time in which to get the sight steady on the target as it is essential to avoid violent manoeuvring. As with air-to-air firing, the rudder should not be used for aim corrections.

121. On occasions when carrying out ground attacks it was found that the debris thrown into the air from the target area has caused damage to the aircraft. Therefore, it is essential for the pilot to break off

/his attack ....

his attack by changing direction and keep from flying over his target. The Meteor is prone to damage from debris owing to its high speed and poor manoeuvrability.

Dive Brakes

122. The tactical use of Dive Brakes has been investigated, with special reference to the following points:-

(i) Escort evasion.
(ii) Dog Fighting.
(iii) Ground attack dive.
(iv) Quick circuit and landing.

Escort Evasion

123. For escort evasion, that is to say, diving through an escort of fighters and applying the brakes to attack the bombers, a number of trials established that if sufficient warning is given by the Leader for the brakes to be used, the aircraft stay in formation very well, and it is considered that with good briefing this would apply to Squadron and even Wing formations. It is, however, considered that the serious loss of speed resulting would place the attacking aircraft at a tactical disadvantage.

Dog Fighting

124. For the tactical reason stated above, the use of dive brakes is advised only on selected occasions. Two such occasions are to avoid immediate attack by an overtaking aircraft and when overshooting a target with no immediate prospect of being attacked oneself. At all other times the maintenance of a high speed is necessary in case it is required to break off engagement.

125. The use of dive brakes for controlling the speed in a half-roll and pull-out has been investigated. From 15,000 ft. a half-roll and pull-out is completed by 10,000 ft. without using brakes, from a starting speed of 200 I.A.S. The speed on reaching level flight is 380 I.A.S. When the brakes are used at the start of the dive immediately after rolling, level flight is regained at 10,000 also, at a speed of 320 I.A.S. As the brakes are extended the elevator becomes very light and insensitive, and it is considered probable that owing to this lack of "bite", there might be a tendency for pilots to pull back too far on the control column and flick into a spin.

Ground Attack Dive

126. Enough speed must be kept for get away and zoom when using dive brakes to slow up to a convenient speed for ground attack. The dive brake should be taken off before putting the sight on as its retraction unsettles the aim.

Quick Circuit and Landing

127. To find out the effect of using dive brakes to slow down preparatory to landing, a number of straight runs were done with and without brakes. At 1,000 ft. at a speed of 350 I.A.S. the throttles were closed and the time recorded for the speed to fall to 150 I.A.S. The average of these trials showed that:-

(i) Time using brakes - 51 secs.
(ii) Time without using brakes - 1 min. 57 secs.

/PART III ....

PART III

TACTICAL COMPARISON WITH TEMPEST V

Level Speeds

128. The Meteor III is faster than the Tempest V at all heights. The following table gives the approximate comparative figures at various heights with full throttle:-

Height	Speed T.A.S. Meteor	Tempest	Difference
1,000 ft.	465	381	84
15,000 ft.	471	416	55
30,000 ft.	465	390	75

Acceleration and deceleration in straight and level flight

129. Comparative acceleration trials have been carried out throughout the height range, and the results are similar, irrespective of height. At 8,000 ft. accelerating from a Meteor indicated speed of 190 the Tempest V has a slight initial advantage, but after approximately 30 secs., and as the speed approaches 300 Meteor I.A.S., the Meteor III draws away rapidly and is out of range, i.e. 600 yards, in approximately 1½ mins. At 250/260 m.p.h. Meteor III I.A.S. their acceleration is identical at 8,000 ft.

130. Comparative retardation trials at the Tempest V's maximum speed, shows that when the Meteor does not use its dive brakes, if the throttles of both aircraft are closed, the Tempest V will be behind the Meteor III in a position to shoot it down almost immediately at all heights. When the dive brakes are used, the position is reversed. After using them, however, it is necessary to retract them to avoid dropping out of range.

Climbs

131. A graphical comparison of the climbing performance of the two aircraft is shown in Appendix "F".

Zoom Climbs

132. In a pull-out and zoom climb at 40° with full throttle, from 500 I.A.S., during the pull-out the Tempest and Meteor are identical, but immediately the nose of the Meteor comes up to the horizon, it starts pulling away quite rapidly, and, by the time its best climbing speed, i.e. 225 m.p.h. is reached, it is approximately 750 ft. above and 600 yards ahead of the Tempest. By steepening the angle of zoom the Meteor can convert this lead into a further height advantage. These facts apply at whatever height the zoom is commenced.

Turning Circles

133. The Meteor III which has a lower wing loading turns inside the Tempest V under all conditions, and can get on to its tail in approximately four turns.

Rates of Roll

134. The Tempest V outrolls the Meteor III very easily at all speeds, and the latter is therefore at a disadvantage in the initial manoeuvres of a combat.

Dive

135. If both aircraft are dived from any set level conditions up to the Meteor's limiting speed, and the throttles are not opened during the dive, there is nothing to choose between the two. If, however, the throttles are fully opened in a dive from 12,000 feet, the Meteor is 500 yards ahead of the Tempest by the time its limiting speed of 500 m.p.h. I.A.S. is reached.

Conclusions

136. The Meteor III is superior to the Tempest V in almost all departments. If it were not for the heaviness of its ailerons and its consequent poor manoeuvrability in the rolling plane, and the adverse effect of snaking on it as a gun platform, it would be a comparable all-round fighter with a greatly increased performance.

PART IV

SUMMARY OF CONCLUSIONS

137. The Meteor has a high performance at low and medium altitude, its performance at high altitudes is moderate owing to the power output of the turbines being reduced by surging.

138. Range at 20,000 ft. with 180 gallon drop tank is 581 miles compared with the range of the Tempest of 809 miles at 5,000 ft. with two 45 gallon drop tanks. These heights are chosen as the average operating heights of the two aircraft. (See Appendix "C").

139. The Meteor has an instability in yaw, ("snaking"), which makes it unsuitable as a gun platform at operational speeds.

140. It is pleasant to fly and handles satisfactorily except for the heaviness of the aileron control which is unsuitable for a fighter. This turbine jet engine gives slower acceleration at low speeds.

141. Dive brakes are valuable tactically on selected occasions and also for economical flying as they allow a steeper dive at the limiting speed and curtail the time and space occupied when reducing speed before landing.

142. The forward view is normally very good, but is bad in rain as the front and front-side panels become entirely obscured. The clearness of vision to the rear is reduced by three transparent layers; and additionally it is difficult to clean the inner surface of the bubble canopy. (See Appendix "G").

143. The position of the present cockpit lighting is not acceptable, but with the re-positioning as suggested in para. 106 it becomes more satisfactory.

/144. ....

144. The armament of four 20 m.m. guns grouped in the nose is ideal, but the restricted adjustment makes harmonisation on the first diagram impossible. The duration of fire is limited to 15 seconds.

145. An increase in damage by debris occurs in air-to-ground firing owing to the high speed and some lack of manoeuvrability.

146. As ground crews become experienced on the new engine, the mechanical reliability is likely to be superior to that of previous engines.

RECOMMENDATIONS

* 147. The elimination of snaking on this, and future fighters is essential.

* 148. The performance figures should show the performance actually attainable and should allow for unavoidable surging.

* 149. Light aileron control is essential to a fighter and the Meteor III aileron control should be considerably improved.

* 150. The forward visibility in rain should be improved. The rear hood should be modified to give access for cleaning (Appendix "G", Fig. 11). The standard of clearness and distortion in the rear view of this and future fighters is ripe for improvement.

* 151. The duration of fire should be increased to 20 seconds.

Pilots Aids

* 152. An indication of the limiting speed is needed, which should if possible show the structural limit or the compressibility limit whichever is the less.

* 153. A small stand-by compass is needed in case of the failure of the electrical system; even if it must be small and of reduced accuracy, it is still an essential.

* 154. All instruments should be positioned to be visible to the pilot in his normal flying position.

* 155. The cockpit lighting needs to be redesigned to eliminate reflections, and to illuminate all instruments and trim indicators.

* 156. The brake pressure indicator dial cannot be illuminated by any of the existing lights and it is recommended that this instrument is made partially luminous, i.e. needle and two datum points.

* 157. It is recommended that in view of the excessive visual ranges recorded on the exhaust of the turbines, investigations are stated to consider the problem.

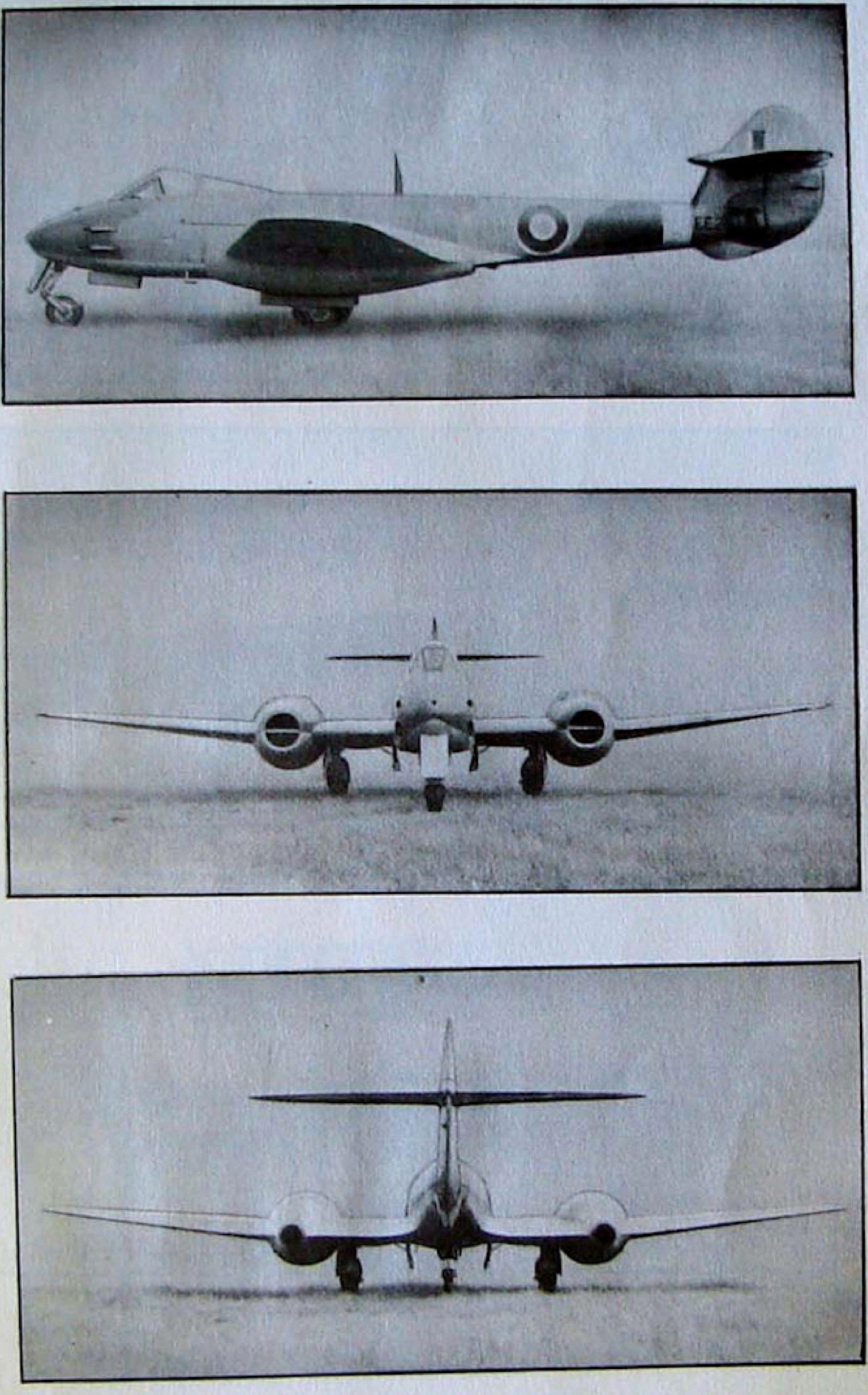
* 158. It is desirable to have a sure method of relighting the turbine. The controls should be simplified so that the pilot can do this by one movement.

Ancillaries

* 159. A dynamo should be fitted to both engines.

/160. ....

APPENDIX "A"



GENERAL VIEWS. METEOR III

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APPENDIX "C"

CALCULATION OF RADIUS OF ACTION

Meteor III with 330 Galls. Fuel

10,000 ft. Altitude

Conditions	r.p.m.	Consumption two turbines Gall/hr	Total	T.A.S. m.p.h.	Knots	Range - Miles Statute	Nautical
3 mins. at take off power	16,500	640	32	-	-	-	-
5 mins. climb to 10,000 ft.	15,400	-	30	-	-	19	17
5 mins. combat	16,500	480	40	470	408	-	-
15 mins. cruising	15,400	325	81	395	343	99	86
Balance at economical	M.E.C.	210	147	328	285	230	200
Totals			330			348	303
Less 20%						70	61
						278	242
					Radius	139	121

20,000 ft. Altitude

Conditions	r.p.m.	Gall/hr	Total	m.p.h.	Knots	Statute	Nautical
3 mins. at take-off power	16,500	640	32	-	-	-	-
12 mins. climb to 20,000 ft.	15,400	-	65	-	-	52	45
5 mins. combat	16,500	360	30	472	410	-	-
15 mins. cruising	15,400	240	60	385	334	96	83
Balance at economical	M.E.C.	195	143	345	300	253	220
Totals			330			401	348
Less 20%						80	69
						321	279
					Radius	160	139

With 330 galls. plus 180 galls. drop at 10,000 ft.

Conditions	r.p.m.	Gall/hr	Total	m.p.h.	Knots	Statute	Nautical
3 mins. at take-off power	16,500	640	32	-	-	-	-
6 mins. climb to 10,000 ft.	15,400	-	35	-	-	24	21
5 mins. combat	16,500	480	40	470	408	-	-
15 mins. cruising	15,400	325	81	395	343	·99	86
Balance at economical with tank	M.E.C.	210	145	308	268	213	185
" " " less "	"	210	177	328	285	276	240
Totals			510			612	532
Less 20%						122	106
						490	426
					Radius	245	213

With 330 galls. plus 180 galls. drop at 20,000 ft.

Conditions	r.p.m.	Gall/hr	Total	m.p.h.	Knots	Statute	Nautical
3 mins. at take-off power	16,500	640	32	-	-	-	-
16 mins. climb to 20,000 ft.	15,400	-	70	-	-	80	69
5 mins. combat	16,500	360	30	472	410	-	-
15 mins. cruising	15.400	240	60	385	334	95	83
Balance at economical with tank	M.E.C.	195	110	325	282	183	159
" " " less "	M.E.C.	195	208	345	300	368	320
Totals			510			726	631
Less 20%						145	126
						581	505
					Radius	290	252

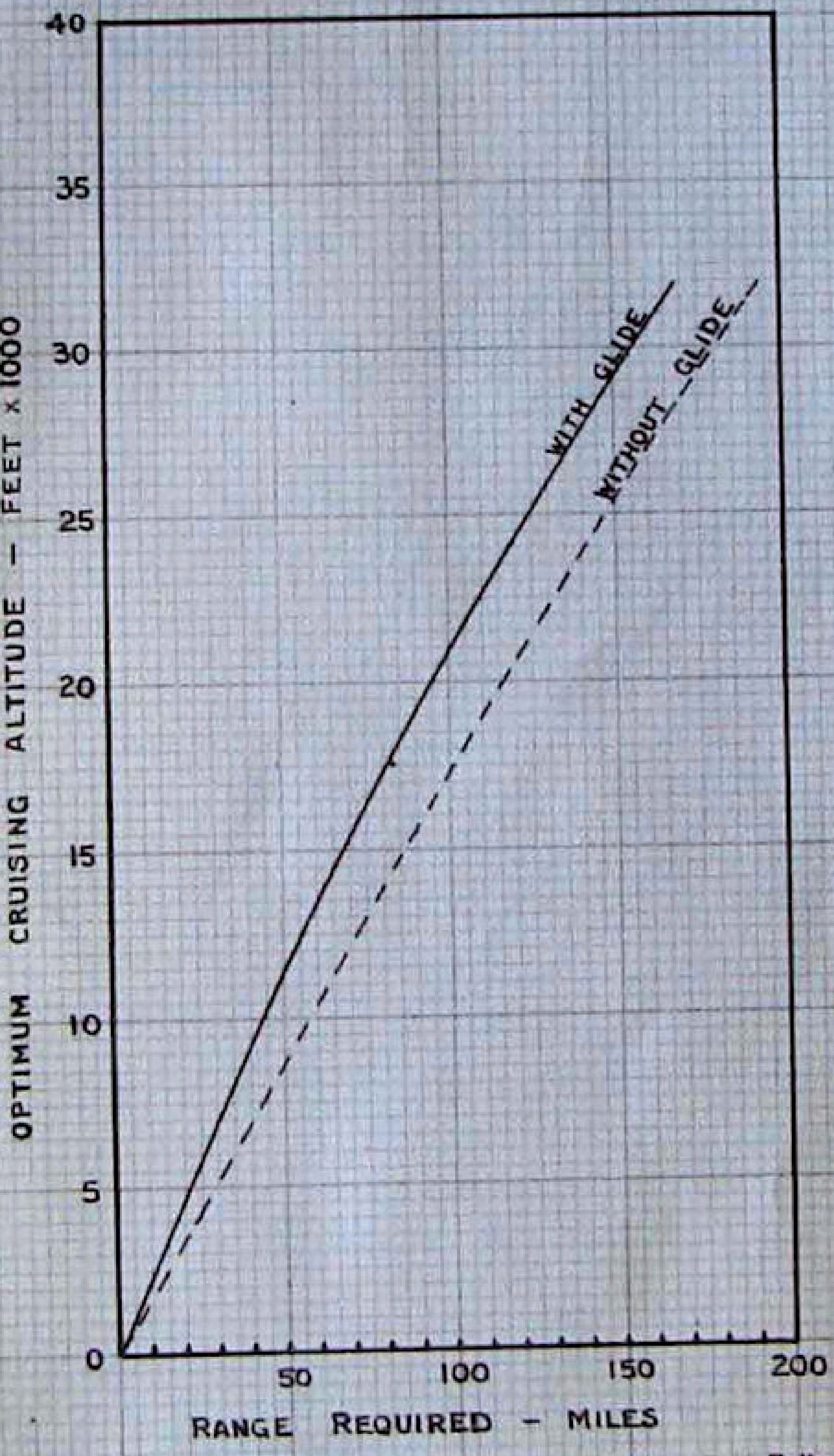
NOTE: Consumption at idling r.p.m. (5000 r.p.m.) is 120 gallons per hour.

APPENDIX 'C'
FIG. 1

BEST HEIGHT FOR RANGE REQUIRED

METEOR III - DERWENT I

FOR MAX. RANGE, CLIMB TO SELECTED ALTITUDE
AT MAX. CLIMBING R.P.M.



Rolls - Royce Curve
HKS 401

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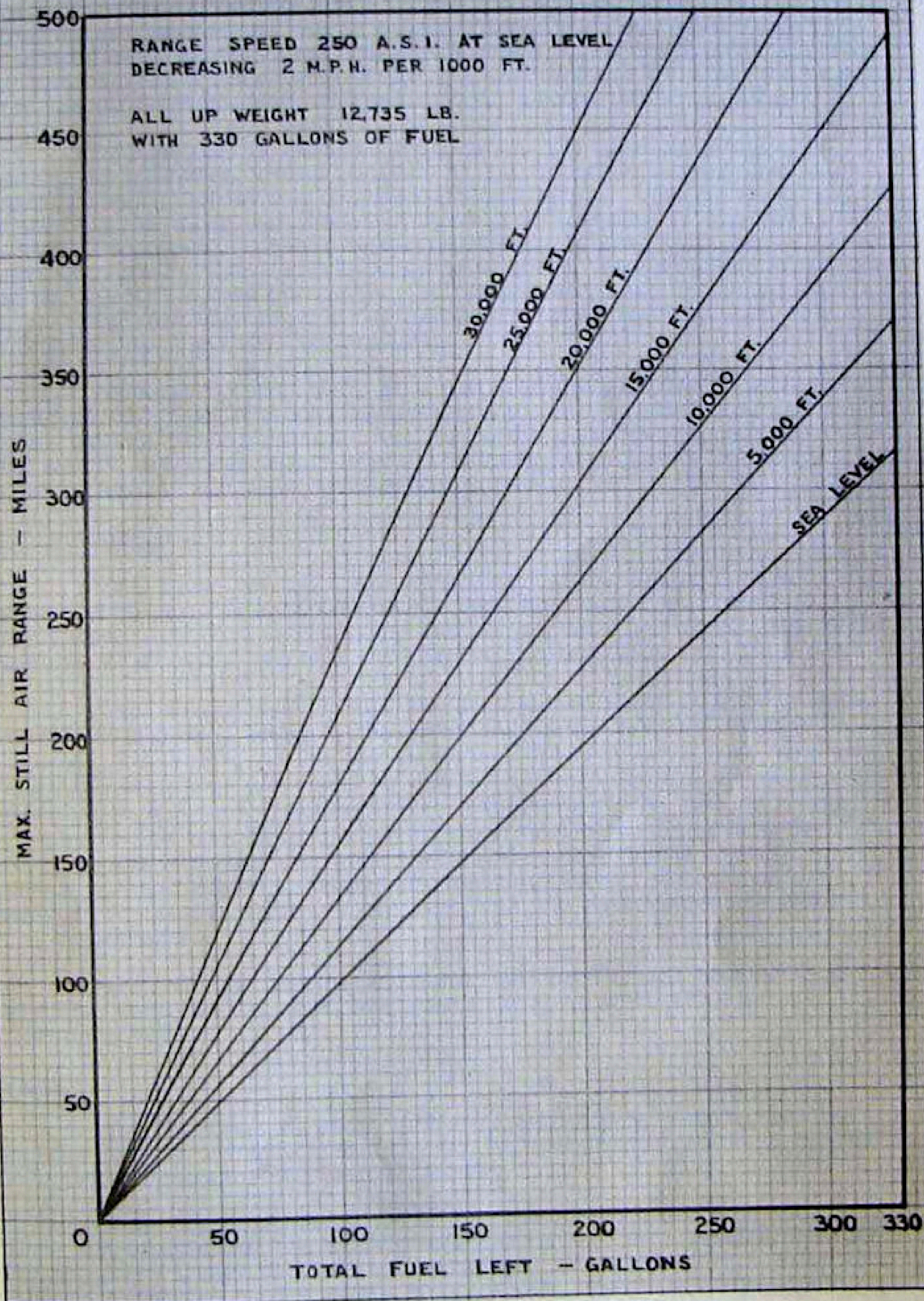
APPENDIX 'C'
FIG. 2

MAXIMUM STILL AIR RANGE

METEOR III - DERWENT I

I.C.A.N. CONDITIONS



CHARACTERISTICS OF TURBINE JETS

Power Output

1. The effect of speed on the power and thrust of a turbine jet is different from that on a propeller, and this affects the performance of the aeroplane and can be used to get and to keep the tactical advantage. The difference can be stated in two ways, either that the thrust of the jet remains nearly constant throughout the speed range while the thrust of an engine driven propeller decreases as the speed increases; or, that the thrust horsepower of the jet increases as the speed increases while the thrust horsepower of the propeller remains nearly constant.

2. In a comparison between a jet driven and a propeller driven fighter, the advantage at low speeds will lie therefore rather with the propeller driven fighter for acceleration and climb; at high speeds the jet will tend to have the advantage where it is enjoying an increased available horsepower. For a comparison between a given jet and a propeller fighter, there will be a definite speed at each height at which they are equal, (unless the future jet has greater power at all speeds) and the propeller fighter will try to fight at lower speeds, while the jet will try to fight at higher speeds.

3. Examples of the tactical consequences which have to be considered in the light of these characteristics are the cases when the jet fighter can use its air brakes; the air brake slows the jet fighter down, and it is at slow speed that the jet engine is giving its least thrust horsepower and loses its advantage.

Fuel Consumption

4. The turbo jet has a low efficiency at low powers and its greatest efficiency at maximum power. The fuel consumption of the Derwent when idling is nearly sixty gallons per hour per engine, and this increases to about 100 gallons per hour at taxying r.p.m.

5. The consumption at full speed at ground level is high in spite of higher efficiency, owing to the great horsepower output; at high altitudes, the density of the air is several times reduced, and the power to give the same true air speed is reduced correspondingly, and this combined with a slight increase in the efficiency of the turbine causes the reduction in consumption which is shown by the charts at Appendix "B". These show the advantage in range that results from flying at high altitude and the height to select for maximum range. The economy advantage in gaining height is so great that the most economical climb is at combat climb.

6. Although the turbine jet gives increased thrust horsepower at any given r.p.m. as the speed increases, the fuel consumption is not affected by this.

Surging

7. The Derwent, and other turbines, suffer from surging which is the term given to a rumbling and bumping irregularity of air flow through the engine with loss of r.p.m. and thrust.

8. This can occur at ground level when the throttle is being opened too quickly and the turbines will accelerate less quickly and will give irregular thrust while it is happening. This can cause a swing on the Meteor when one engine surges and should be avoided by opening the throttles gradually.

/9. ....

9. At high altitudes it occurs during steady flying, and can only be stopped by reducing the throttle opening. The occurrence depends on the air temperature as well as the height; a typical set of conditions for a particular engine is given in the table below.

Max. r.p.m. attainable without surge	Height	Air Temp.	Remarks
16400	20,000	- 19°C.	Single pops occurring at this height and above.
16200	24,000	- 30	
16000	26,000	- 35	
15500	28,000	- 39	
15200	30,000	- 43	
	31,000		

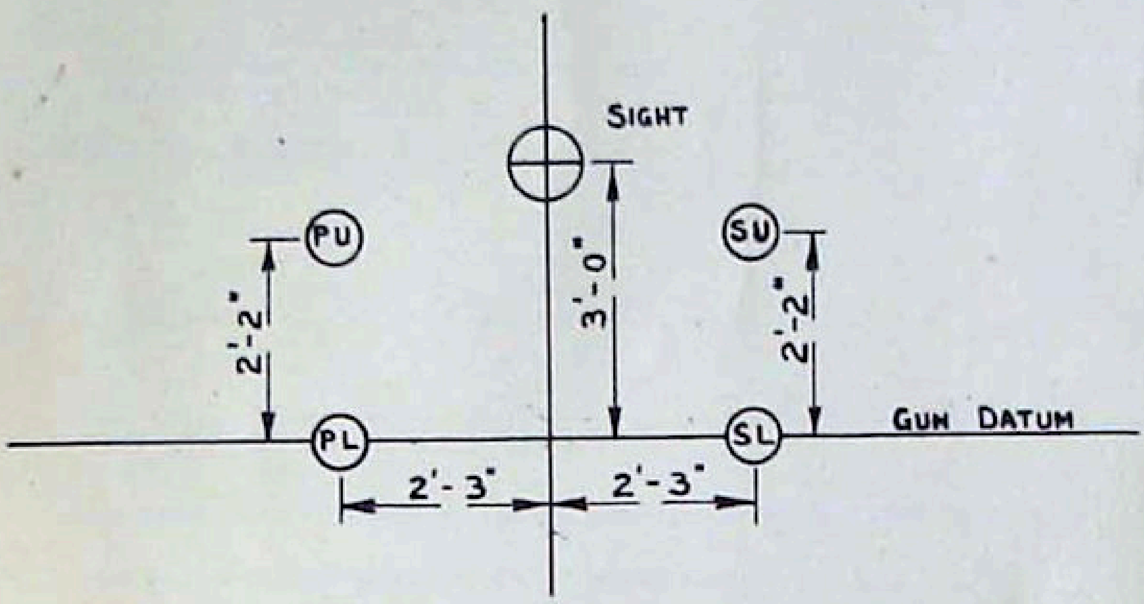
10. Improved designs of turbine in the future will reduce and perhaps cure this fault; at present it is little or no disadvantage at low altitudes to the pilot who handles his throttle with normal steadiness and an occasional momentary occurrence does not cause any harm to the engine; but the occurrence and the reduction of power caused by partially closing the throttle to stop it, prevents existing jet aircraft giving their calculated performance, or any useful combat performance at high altitudes.

/APPENDIX "E" ....

APPENDIX 'E'

FIG. 3(a)

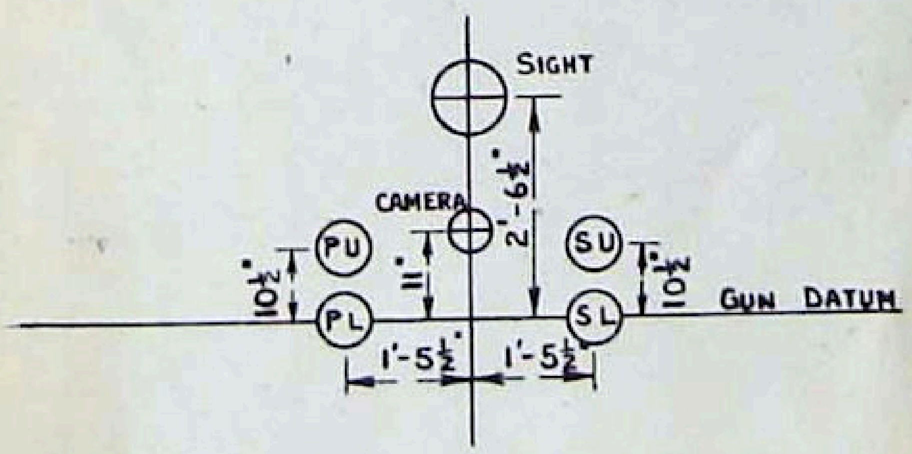
50 YDS. HARMONISATION DIAGRAMS AS USED ON TACTICAL TRIALS METEOR III



NORMAL SPREAD HARMONISATION

P.L. GUN 1° DOWN FROM AIRCRAFT DATUM
AFTER SETTING AIRCRAFT 1° TAIL DOWN
(O.R.S., H.Q.F.C. DIAGRAM)

FIG. 3(b)



POINT HARMONISATION AT 400 YDS.

P.L. GUN 1° DOWN FROM AIRCRAFT DATUM
AFTER SETTING AIRCRAFT 1° TAIL DOWN

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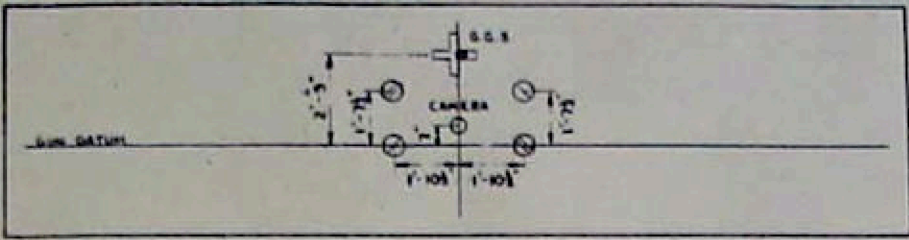
APPENDIX 'E'
FIG. 4

METEOR III

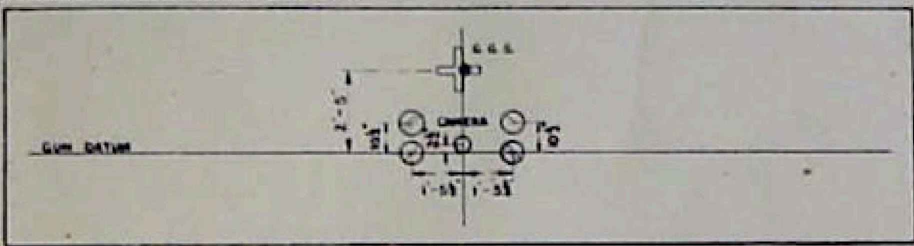
SUGGESTED 50 YDS. HARMONISATION DIAGRAMS FOR GYRO GUN SIGHT MK. II D

1 OPERATIONAL HARMONISATION



PORT LOWER GUN 1° DOWN FROM AIRCRAFT DATUM
AIRCRAFT 1° TAIL DOWN

2 TRAINING HARMONISATION



PORT LOWER GUN 1° DOWN FROM AIRCRAFT DATUM
AIRCRAFT 1° TAIL DOWN

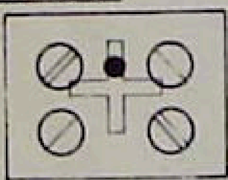
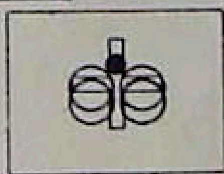
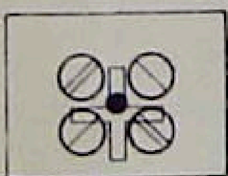
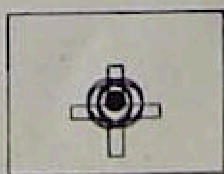
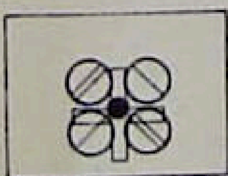
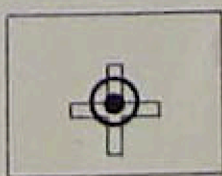
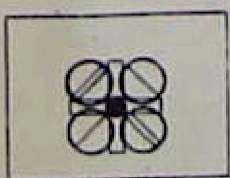
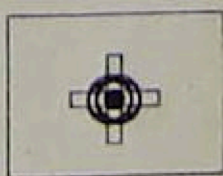
HARMONISATION TO BE DONE WITH AIRCRAFT SUPPORTED ON FRONT & REAR TRESTLES

600 YDS. TO BE SET WHEN HARMONISING MOVING GRATICULE

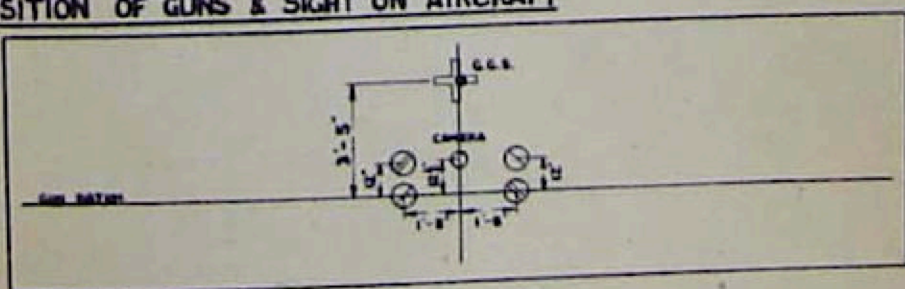
- PORT UPPER GUN
- PORT LOWER GUN
- FIXED GRATICULE
- STARBOARD UPPER GUN
- STARBOARD LOWER GUN
- MOVING GRATICULE

75% GROUPS SHOWN (½" DIA.) — GRAVITY DROP INCLUDED

3 BULLET PATTERNS

OPERATIONAL		TRAINING
	150 YDS.	
	300 YDS.	
	450 YDS.	
	600 YDS.	

4 POSITION OF GUNS & SIGHT ON AIRCRAFT



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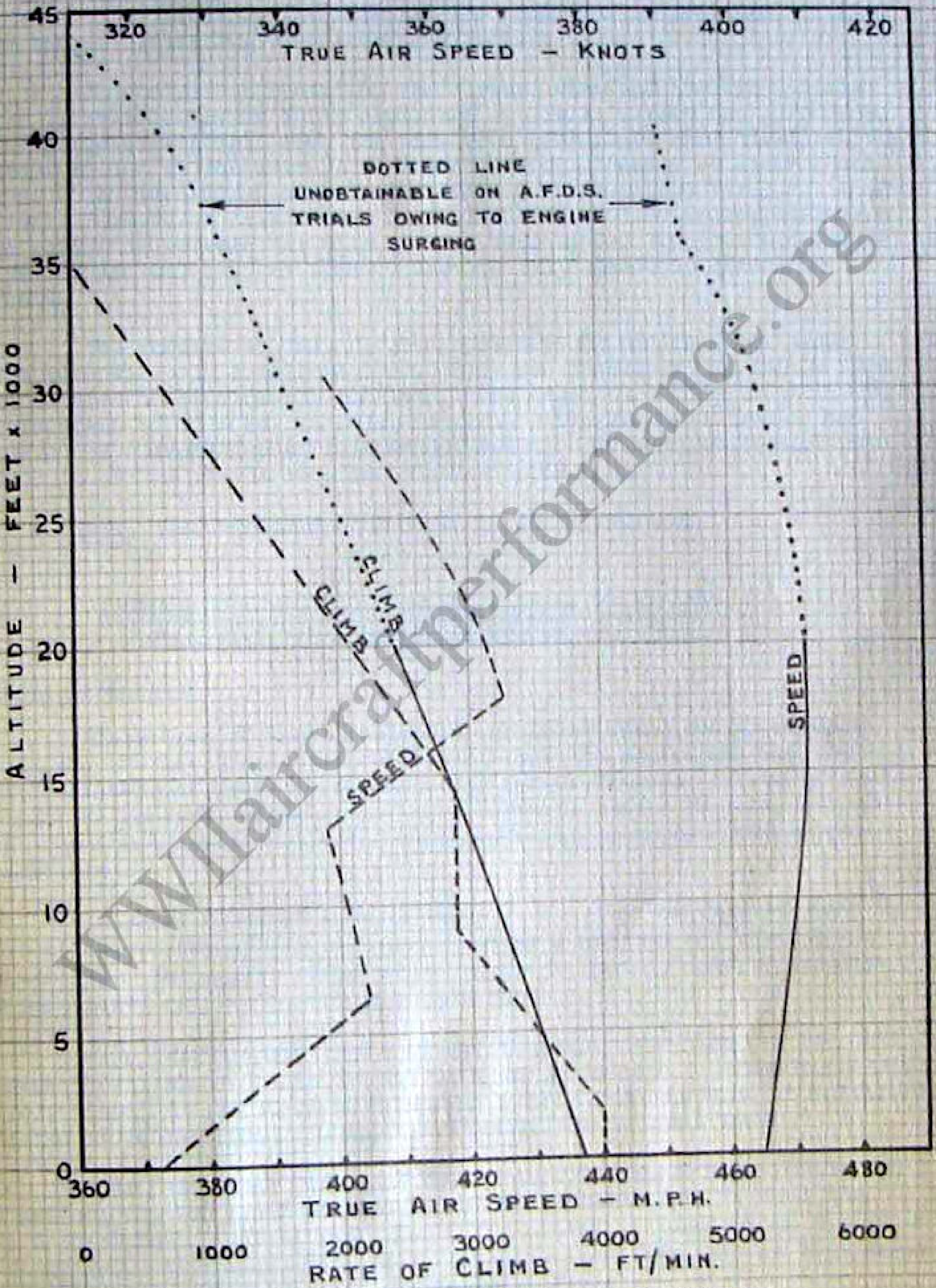
APPENDIX F.
FIG. 5

CLIMB & LEVEL SPEED PERFORMANCE

METEOR III 2 x DERWENT II (2000 LBS S.T.) A.U.W. 13,000 LBS. ———

TEMPEST V SABRE IIA (+9 LBS. BOOST) A.U.W. 11,500 LBS. - - - -

CURVES ARE R.D.T. I DATA



N.B. MAXIMUM CEILING WITH DERWENT I ENGINE ON ANY AIRCRAFT TESTED IS 37,000'. CLIMB & SPEED BETWEEN 20,000' & THIS CEILING IS REDUCED AS ENGINE MUST BE THROTTLED TO REDUCE SURGING.

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VISIBILITY FROM METEOR III

Summary

1. The following three aspects of visibility are considered: fields of view, clearness of view and the existence or avoidance of blind spots caused by framing when looking with both eyes.

2. The method of measuring the forward view and the blind spots caused by frames etc. is fully explained in R.A.E. Report No. Aero 2095. Briefly, the photographs show the view from a standard operational flying position chosen as the average head position of a number of operational pilots. The photograph shows a field of 45 degrees from straight ahead and the obstructions to the view in that field. Obstructions which are large enough to obscure the view of both eyes appear solid; those which are narrow and cut off the view of one eye only appear as ghosts or shadows.

3. The forward visibility from a Meteor III in the most usual flying conditions is excellent, but, with the fitting of the G.G.S., the field of view is appreciably reduced. The rear visibility is poor since the clearness of view in that direction may often be insufficient for spotting and recognition of distant aircraft. The matter of rain and misting up of the panels requires further attention.

N.B. The recommendations are listed at the end.

OVERALL VISIBILITY IN THE MOST USUAL CONDITIONS (i.e.) APART FROM ADVERSE ATMOSPHERIC EFFECTS

Forward Visibility

4. Clearness of view forward is excellent since the front-side panels are of flat glass (and, moreover, they are separated from the front bullet-proof panel by a reasonably narrow frame). Since glass is too hard to scratch, clearness of view forwards cannot be ruined except by the greatest mis-treatment of windscreens in transport, maintenance or servicing.

5. Forward field of view is very good. (By the forward view is meant the view over 45° to port and starboard and over 45° upwards and downwards). The angles given below relate to level flight at maximum cruising speed and to looking with both eyes.

6. The "horizontal" angle of the clearest view (i.e. of the view through the glass is $\pm 42\frac{1}{2}^\circ$ to the port and starboard. (This angle would be only $\pm 20\frac{1}{2}^\circ$ if the front side panels were of perspex worn or scratched by a period of storage, transport and normal operational use).

7. The "vertical" angle of the forward downwards view (below the horizon and in the plane of symmetry of the aircraft) is 9° when the G.G.S. is fitted. (This angle is 16° if either no gunsight is fitted or when the pilot deflects his head to the side and looks through the narrow gap between the G.G.S. and the neighbouring frame).

8. The overall forward view has been determined by the special photographic technique (published in the R.A.E. Report No. Aero 2095) and the results are represented in Figs. 6a and 6b.

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9. It is obvious from Fig. 6b that when looking with both eyes, the blind spots within the forward field of view are caused chiefly by the main front frame, (even when the balloon-hood is opened), and also by the G.G.S. The "vertical" frames of the front bullet-proof panel do not cause any blind spots and are considered satisfactory.

10. Reading the magnitude and the position of the particular blind spots from Figs. 6a and 6b may provide some initial difficulties for the average pilot. Therefore, the horizontal and vertical sections of the forward field of view are presented diagramatically in a simple form in Figs. 7, 8 and 9. These diagrams are made to scale (except for the silhouettes of the aircraft which, for clarity's sake, are greatly oversized). It should be borne in mind, however, that such diagrams as in Figs. 7, 8 and 9 present only a small part of the story and that the full survey of the forward field of view is determined only by Figs. 6a and 6b.

<u>Side and Upper Views</u>

11. The Meteor III has the conventional balloon hood made of perspex, which is easily scratched and marked, and gives some optical distortion. Thus, the actual standard of clearness of view will almost entirely depend on the servicing of the perspex panels in the units and also on the conditions in which the new hoods are supplied.

12. The exchange of worn or damaged hoods is easy and the only criticism of design of the hood is that no handgrip has been provided for opening the hood from the outside (the hood is rather "stiff" when trying to open it). Consequently, a mechanic usually grips or bumps against the perspex with his palms, thus soiling and scratching the surface.

<u>Rear View</u>

13. The field of view is sufficient for seeing through 180° to the rear, either over the left or the right shoulder. The pilot can look to the rear in flight provided he takes the trouble of loosening the shoulder straps and twisting his body round.

14. The rear frame where the sliding hood joins the rear fixed canopy is wide and causes an appreciable blind spot when using both eyes.

15. Clearness of view to the rear is poor. The pilot has to look to the rear through three layers (six surfaces) of glazed material, i.e. through the bullet-proof glass, and the double skinned rear hood of perspex.

16. Clearness of view to the rear is affected by distortion (see Figs. 10a and b) and by haziness of view. In some circumstances, the latter may be very great. As dirt is one of the chief causes of haziness of the rear panels, it can be partially remedied by careful cleaning <u>internally</u> and externally.

17. The rear canopy compartment is "closed" (by the bullet-proof glass behind the pilot's head) and the inner surfaces of the glazed material cannot be reached by the hand, without previously dismantling a portion of the canopy.

18. The usual disadvantages inherent in the present "closed" rear canopy compartments are possessed by the Meteor III. These are of two kinds:-

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(i) The air circulation within the compartment is poor, at least on the ground. Consequently, in damp weather on the ground, there is often some condensation either on the rear surface of the rear bullet-proof glass or on the inner surface of the rear hood. On one occasion it was impossible to see the tail of the Meteor when looking from the cockpit, although vision through the remaining panels was quite normal. The condensation tends to decrease after take-off but often remains patchy.

(ii) Normally with an open canopy compartment, a pilot or mechanic would remove some of the dirt or excessive condensation with a few strokes of a cloth or glove; with a closed compartment, however, it is likely to remain untouched, owing to the trouble of dismantling the hood.

Access for cleaning after removing the rear hood

19. Even when the canopy has been taken off, a man still cannot reach the rearmost portion of the internal surface of the rear hood for cleaning. This is illustrated in Fig. 11.

20. If access were available as illustrated by the marked area in Fig. 11, the cleaning facilities would be sufficient.

Handgrips

21. Handgrips should be positioned with the following objectives in view:-

(i) Visibility considerations - so that it is easier to use the handgrips than to grip or lean against the perspex which soils and scratches it.

(ii) General convenience of entering and leaving the cockpit and of opening and closing the hood.

VISIBILITY IN ADVERSE ATMOSPHERIC CONDITIONS

Effect of rain

22. This is dealt with separately in Para. 86 of the Report.

Freezing up of panels

23. The hot air spray (for preventing freezing up of the front panels) was not operative in the Meteors tested.

RECOMMENDATIONS

24. The rear canopy should be modified as illustrated in Fig. 11 in order that the inside rearmost portions are accessible for cleaning.

25. In accordance with Para. 22 (i) and (ii), from both aspects two additional handgrips are desirable for the Meteor. One for the left-hand is needed in the immediate vicinity of the front side port panel and another for opening the hood from outside is required.

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26. It is recommended that consideration be given to the problem of eliminating or decreasing distortion through the rear hood.

27. The rear view of the Meteor and of future fighters should be improved. The forward and sideway view from the Meteor shows a great improvement on that of earlier designs, but the vital view to the rear has a number of shortcomings.