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In Part of Report No. AM/17/6/T



MINISTRY OF AVIATION

**AEROPLANE AND ARMAMENT
EXPERIMENTAL ESTABLISHMENT**

BOSCOMBE DOWN

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MEMO NO. 17/6/T
AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

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3rd Part of Report No. AAEH/817/6/T

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT 18 JUN 1953
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Meteor T.T.20 WD.767

Handling and Performance Tests Towing a Dart Target

Presented by

J. Gregory
Performance Division

A. & A.E.E. Ref: AFP 5A1
Period of Test: July/September, 1952

Summary

Performance and Handling tests were made on the Meteor T.T.20 WD.767 towing a MK.3 Dart target and showed that the aircraft could be considered suitable for Service use in this role subject to the limitations and recommendations given in this Report.

The target launch and winch installation were assessed and operating techniques are described. Recommendations are made for improving certain items for Service use.

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1. Introduction

The Meteor T.T.20 target towing aircraft has been described in Parts 1 and 2 of this Report (Refs. 1 and 2). As then stated the aircraft could tow and exchange four sleeve targets, or could tow one sleeve target if a near miss detecting microphone were used. For the present tests the aircraft was modified to carry a Dart Mk.3 high speed target which incorporated a system for recovery by parachute. This target system was designed to meet a Naval requirement (A.W.365) for a high-speed target for operation at altitudes up to 10,000 feet. This requirement called for a near miss detector in the target, and SAAB equipment was envisaged for this purpose. At the time of the tests a suitable electrical conducting nylon halyard was not available and pending the supply of suitable halyards trials were made on the aircraft and towing system without the near miss facility. Trials were later made with suitable conducting halyards and a description of these will be given in a later report. Following these trials the aircraft was released for Service use in the Dart target towing role subject to the limitations and recommendations given in para.7 of the present report.

2. Description of Aircraft and Equipment

2.1 General

Trials were made on Meteor T.T.20 WD.767 which was suitably modified for air launching and towing the Dart target and is fully described in the Firm's publication; Sir W. G. Armstrong Whitworth Aircraft Handbook on the Meteor T.T.20 Dart Target Installation. Briefly, a Brooklands three-finned Dart target was stowed on the underside of the Meteor fuselage and the target was launched on a 25 foot, 3,200 lb. nylon cable (7/16 inch diameter). Figure 1 shows a Dart target in position prior to fastening to the Meteor, and Figure 2 shows the target stowed for flight.

The Dart was shackled to an M.L. 3,000 lb. release unit and was steadied at the rear by two short pylons on the underside of the fuselage and at the front by an adjustable screw support situated just aft of the ventral tank. To avoid undesirable restriction of ground clearance the dart was stowed with its bottom fin folded up to lie parallel with the port fin. The bottom fin was normally unfolded before the target was launched, and the mechanism for this was carried in the port rear pylon. The main operations required for launching and releasing the target are described below. Figures 3-6 show views of the aircraft and towing equipment.

The winch operator launched the target by raising one or other of two switches; labelled "Dart Launch" and "Emergency Launch". When the "Dart Launch" switch was raised the fin catch was released and this was followed after about four seconds by the operation of the M.L. release unit. Dolls eyes beside the switch gave indications of "Fin-Unfold" and "Target Launched". It was necessary to keep the switch raised for the whole of the four second period. Operation of the emergency switch released the folded fin and the target simultaneously. The two dolls eyes were operated by micro-switches, one in the port rear pylon and the other near the M.L. release. On launching, the Dart was towed by a 25 foot halyard of 7/16 inch diameter treated nylon rope. The initial launching load was in excess of the strength of the winch cable, and this initial load was therefore carried by the nylon rope only. To this end the nylon halyard was fastened to a small hook projecting from the underside of the rear fuselage, which itself was locally strengthened. After launching the target became detached from this hook and was then directly connected to the winch cable and could be winched out. The target was released automatically on winching in when a scissors unit which formed part of the tow line was compressed against a buffer unit, mounted beneath the fuselage. Mirrors were fitted to the engine nacelles to give the winch operator a view of the target.

General and detail views of the installation will be found in Figures 1-6 and the launch and release operations are illustrated in Figures 7 and 8.

/During ...

During the trials it became apparent that use of the "emergency launch" facility could be hazardous to the safety of the aircraft, and it was therefore replaced by a duplicate of the normal launch circuit (See para. 4.3).

2.2 Winch and Towing Cable

The winch was a standard windmill driven type G. Mark 4, which was fitted with slip rings for use with an electrical conducting cable (6,000 feet of S.A.A.B. type BT1311/5). The end of the cable was connected to the scissors release unit (the sleeve target exchanger unit being omitted) and the scissors in turn were joined to the 25 foot nylon halyard by a special coupling. This coupling hooked over the permanent hook on the fuselage underside in such a way that the shock load on launching the target was absorbed by the nylon rope and was not transmitted to the S.A.A.B. steel cable.

2.3 Buffer Unit

A buffer unit was mounted beneath the fuselage, the buffer having a travel of about four inches. The resistance of the buffer unit operated the scissors to release the target and compression of the unit applied the emergency brake on the winch. The spring in the buffer unit was stiffer than that in the scissors release unit so that the target was released before the winch brake was applied.

2.4 Target

This is described fully in the Firm's Handbook, which also gives details of the pre-flight checks and servicing of the target. Briefly however the target was of dart shape with three triangular plywood fins set at 120° with a spine of three 120° aluminium alloy angle sections. The spine of the target was longer than the fins and formed a long nose which incorporated provision for adjusting the c.g. of the target. One of the fins - the bottom one when the target was fitted to the Meteor - could fold and means were provided for locking it in the up position beside the port fin. At its rear the target carried a radar reflector, a parachute in a glass-fibre-reinforced plastic housing, and a dummy S.A.A.B. near-miss-detecting microphone. A shackle was fitted for slinging the target under the Meteor and after launching the target was towed from a towing arm at the centre of gravity. The towing arm was hinged to rotate forwards or backwards, and full backward movement initiated opening of the parachute by releasing the pin holding the door of the parachute housing. To prevent inadvertent release of the parachute during launching a stop was provided to prevent the towing arm moving far enough aft to release the parachute; this stop was designed to remove itself when a speed of 160-170 knots was attained; by this means the final drop could be made at a lower speed once the towing arm stop had been blown back by the slipstream. The 25 foot halyard of 7/16 inch nylon formed part of the target installation and was stowed in the pockets of a dispenser bag at the forward end of the target.

3. Limitations for Tests

Limitations were in general as for the standard Meteor T.T.20 except that with the target stowed or on tow the aircraft indicated speed was not to exceed 300 knots. Recommended speeds for launching and dropping the targets were given as 135 knots and 180 knots I.A.S. respectively but during the trials it was found expedient to reduce the dropping speed to 135 knots I.A.S. to prevent damage to the parachute anchorage to the target.

4. Assessment and Functioning of Equipment

4.1 Preparation and Mounting the Dart

Considerable experience was gained of the preparation and mounting of the targets, and certain defects became apparent.

The arrangement of the micro-switch operating the "target-gone" dolls eye was not satisfactory. Inadequate adjustment was provided on the micro-switch

/itself ...

itself, and the tow-arm stop against which the micro-switch operated was not suitable for this function. After a few flights its bearings became very sloppy and this caused difficulty in setting the micro-switch. The arms of the stop were also sometimes too far apart so that one or other of them could slip alongside the micro-switch instead of pressing against it. In view of these difficulties and the fact that the launch of the target could be observed in the mirrors, the micro-switch was finally omitted.

It was often necessary to repair the forward edge of the parachute housing after a flight trial before a target could be flown again. As a result of the trials, reinforcement was incorporated into the parachute housing at this point.

4.2 Launching

Initial tests showed that the launching of the target was attended by three defects. Firstly, it was found that occasionally the target would not launch when the launch switch was operated. This was found to be due to movement of the target causing the launch micro-switch to interrupt the supply to the release unit. The target movement was found to occur as a result of slackening of the adjustable front support; this was overcome by wire locking the support before flight.

The second defect that arose was a tendency for the parachute to open during or immediately after the launching operation. This was considered to be due to the towing arm moving back to the "parachute release position" during the launch, the tow arm stop itself moving back beforehand and thus allowing this to happen. The tow arm was then locked down with wire to restrict its movement but this was not effective. Some tests were then made in a blower tunnel and it was discovered that the tow arm blow back at about 125-135 knots, indicating that its retaining spring was not strong enough to meet the required speed for launching. Tests were made to determine the spring tension to prevent blow back until a speed of 170-180 knots was reached and a force of 60 ounces was found to be adequate. This tension was therefore used on all subsequent sorties together with the wired down arm, and no further trouble was experienced with inadvertent parachute deployment.

It was also found that after a few flights damage was sustained by the pin that operated the fin-unfold micro-switch. It became bent, and on one occasion fractured completely.

The pin passes through the port fin to contact the lower fin release mechanism, and it was found that insufficient clearance had been allowed between the pin and the hole so that the pin was struck by the target as it fell away. Enlargement of the hole eliminated this trouble.

4.3 Emergency Launching

The emergency launch switch was used once when the normal launching method proved ineffective. Immediately after launching the target rolled badly and when its fall was arrested by the nylon rope the towing arm pulled out of its anchorage and the target fell away. The nylon rope with the tow arm still attached catapulted up over the tailplane and elevator. Although a successful landing of the aircraft was subsequently made, the emergency launch switch was not used again and the emergency launch facility was modified to provide a duplicate of the normal launch.

4.4 Winching

Winching with the target on tow was done at 180 knots I.A.S. using 2,300 r.p.m. when winching out and 2,000 r.p.m. when winching in. No difficulties were encountered except that the footage indicator usually failed to work and once the emergency brake came on unaccountably when winching in from 6,000 feet. The footage indicator was operated by successive contacts of a micro-switch, and it was found that this switch was becoming clogged by the dust of an

/anti-rust ...

anti-rust compound used to protect the S.A.A.B. cable. A shield was made to protect the micro-switch and has proved effective.

4.5 Release of Target

4.5.1 Speed at Release

The speed for target release was initially given as 180 knots I.A.S., but at this speed, the parachute frequently broke away from the target. Subsequent releases were made at 135 knots I.A.S. or occasionally at 160 knots I.A.S. No further troubles were met with on this account, but it is considered 135 knots I.A.S. should be the recommended dropping speed for Service use.

The scissors units had to be scrapped after about six tows because excessive play developed in their pivots, and there was some evidence of bending of the arms. An improved type of scissors unit was supplied and this gave some improvement. Careful inspection of the scissors unit was still essential between flights and strained or damaged units were replaced.

4.5.2 Winch Operation for Target Release

The target was winched in during the approach to the dropping zone until 25 feet of cable were still out (red light indicated). The last 25 feet was then winched in, until the scissors unit opened as it came up against the buffer unit. The target fell away, the emergency brake was automatically applied and the windmill feathered.

On one of the first flights the buffer unit mounting on the aircraft was damaged when the target was brought in but a modification was introduced by the Firm to overcome this (Drawing No. ML.9807). The automatic operation of the brake was also advanced so that it occurred at an earlier stage during the compression of the buffer unit. As finally arranged, the brake was applied when $1\frac{1}{2}$ inches of buffer travel was still left. No further damage was caused.

4.5.3 Parachute Deployment

In general the parachute opened satisfactorily, although on two occasions the extractor chute failed to pull out the main chute, even though the latter was quite free in its housing. The cause of this trouble could not be definitely established, but it was thought that the cord attaching the radar reflector to the target could have wrapped itself round the line to the extractor chute. Accordingly this cord was omitted on subsequent flights and no further difficulties were encountered, although the number of flights made in this condition was not enough to confirm whether the trouble had been wholly overcome. The radar reflector, no longer attached by the cord, fell free from the target when the parachute deployed, and was usually recovered undamaged a few yards from the target.

4.6 Behaviour of Target on Landing

The target landed nose first, and then usually fell over in the direction of the wind. This fall usually caused damage to the parachute housing, by contact with the dummy microphone (see also para. 4.1); and occasional damage to the fins. The dropping area consisted of rough grass land and during the period of the trials was usually hard and dry.

Examination of the target on landing showed that the rivets which secured the towing arm to the parachute release catch were sheared. These were replaced by steel bolts on one target but it was found that although the bolts did not fail the parachute release rod was bent. It was finally considered preferable to have a riveted attachment and to replace the rivets after each flight.

5. Handling Tests

5.1 Handling Tests with Dart Target Stowed

These tests were made at altitudes up to 10,000 feet and covered take-off, climb, level flight, turns, sideslips, stalls, descent, and landing. The handling of the aircraft was also checked with one or other of the engines inoperative. In general the Dart had little effect on the handling of the aircraft up to the limiting speed of 300 knots I.A.S. and control was considered satisfactory. During asymmetric flight there was a tendency for the folding fin to drop into the "unfolded" position but this had no adverse effect in flight and the aircraft could be landed safely with the fin unfolded if nose-up attitudes were avoided during the landing. Flight on one engine at 180 knots I.A.S. required full rudder trim plus a moderate foot load.

5.2 Target Launch and Towing Flight

Tests included launching the target, winching out and in, towing up to maximum obtainable speed in level flight, asymmetric flight, and releasing the target.

5.2.1 Dart Target Launching

Launches were made using the same technique at heights of 1,000 and 10,000 feet. Speed was reduced to 135 knots I.A.S. using $\frac{1}{2}$ flap and about 11,000 engine r.p.m., and in straight and level flight the target was launched. When launching at a height of 1,000 feet a slight tug was felt in the aircraft but no loss in height occurred, whilst at 10,000 feet the jerk was more noticeable and engine speed was therefore increased momentarily to about 14,000 r.p.m. until the aircraft had settled down. No trim changes were required during the launching period. After launching the target, the aircraft speed was increased for winching.

5.2.2 Winching with Target on Tow

Operation of the winch at the recommended speed of 180 knots I.A.S. (in level flight) had no effect on the aircraft. Trim settings were neutral.

5.2.3 Handling with Target on Tow

With the target on tow up to the maximum cable length of 6,000 feet handling was satisfactory. In level flight, control of the airspeed and engine speeds was easy, rudder and aileron trims were neutral and elevator trim required a half division nose down at 300 knots I.A.S. The vertical separation between target and aircraft was 1,000 feet at 180 knots and about 400 feet at 300 knots I.A.S.

Turning flight presented no problems, 45° of bank was attainable from 180 to 300 knots I.A.S. It is considered however that 30° bank or Rate 1 would be adequate for target towing operations in service.

Descents were made at about 1,000 ft./min. using 10,000 r.p.m. and 180 knots I.A.S.: this speed also permitted winching in during the descent.

5.2.4 Asymmetric Flight

With the target on a tow length of 5,000 feet one or other engine was stopped. At maximum continuous r.p.m. a speed of just over 200 knots I.A.S. was obtained at 2,000 feet altitude, and winching was possible at 180 knots; although full rudder trim was applied, a residual foot force was also required. It is recommended that in the event of an engine failure while towing, the target should be winched in and released over a safe area at 180 knots I.A.S.

/5.2.5 ...

5.2.5 Release of Target

The target was dropped at a speed of 135 knots I.A.S. from a height of 600 feet above the ground. The target was winched in to about 200 feet during the approach to the dropping area and then to 25 feet during the circuit. On the final run-in the speed was reduced and $\frac{1}{2}$ flap selected. The winch was started about 5 seconds before the dropping point was reached and the target was released when the scissors pulled up against the buffer unit. It is considered that a dropping area should be at least 1,000 yards long and 400 yards wide.

5.2.6 Emergency Release

The emergency release button was operated on a single occasion, as described in para. 4.2. It was considered that the emergency launch provision should be omitted and a standby system fitted which duplicated the "Normal Launch" system, using the alternative electrical circuit in the M.L. release unit. This recommendation was later adopted.

5.2.7 Cable Clearance

An observing aircraft accompanied the Meteor T.T.20 on each towing sortie, and the clearance between the cable and the tug aircraft was found satisfactory under all conditions of flight.

6. Performance

Performance tests were made with the target stowed and on tow.

6.1 Climb

With the target stowed, climbs were made to 10,000 feet at intermediate power using a climb speed of 280 knots I.A.S. The time from 2,000 to 10,000 feet was about five minutes.

6.2 Level Flight

Level flight tests were made at 10,000 and 5,000 feet with the target on a tow length of 6,000 feet. The maximum continuous rating at 14,100 r.p.m. gave a speed just below 300 knots I.A.S. at 10,000 feet. At 5,000 feet 300 knots was obtainable at 13,700 r.p.m. Results of the level flight tests are given in Figure 9.

6.3 Jet Pipe Temperatures

Jet pipe temperatures were well below the limits in all conditions of flight.

7. Conclusions and Recommendations

(a) Trials with the Meteor T.T.20 towing the Brooklands Dart target showed that it is generally suitable for this purpose provided the following modifications are incorporated.

- (i) The "Emergency Release" facility must be changed to a "Standby Release" using the same sequence of operations as "Normal Release".
- (ii) The "target-gone" micro-switch must be deleted.
- (iii) Clearance must be provided between the fin release pin and the port fin of the target to permit the target to drop without striking the pin.
- (iv) The buffer unit mounting must be in accordance with the Firm's Drawing No. W29087.

/(v) ...

- (v) The emergency brake should be set so that it operates when $1\frac{1}{2}$ inches ($\pm \frac{1}{8}$ ") of buffer unit travel remain.
 - (vi) The tow arm stop should operate at about 170 knots I.A.S. With the existing stop the spring tension should be 60 ounces (measured according to the Firm's rigging instructions) to obtain this speed.
 - (vii) The parachute housing must incorporate the strengthened forward edge.
 - (viii) The line securing the radar reflector to the target should be omitted.
- (b) The performance of the aircraft was similar to that of the Meteor T.T.20 towing a sleeve target. Towing speeds up to 300 knots I.A.S. however are attainable and the towline is strong enough to permit this. This improvement over the sleeve towing capability is due to the Dart being a non-rotating target; this eliminates the need for a swivel in the towline and permits the cable to develop its full strength without untwisting.
- (c) The handling of the aircraft was generally satisfactory but the following recommendations are made:-
- (i) The maximum speed with the Dart stowed should be 300 knots I.A.S.
 - (ii) In the event of failure of either engine with the Dart stowed, speed should be reduced to 180 knots I.A.S., and the aircraft landed with the target stowed.
 - (iii) In the event of the Dart fin unfolding with the target stowed, the aircraft may be landed with the fin in the unfolded position.
 - (iv) The Dart should be launched at 135 knots I.A.S. with $\frac{1}{3}$ flap selected.
 - (v) The maximum speed for winch operation should be 180 knots I.A.S.
 - (vi) Turns should be limited to 30° bank or Rate 1.
 - (vii) Descents may be made at 180 knots I.A.S. with 10,000 engine r.p.m.
 - (viii) The Dart should be released from the tow line at 135 knots I.A.S. and at an altitude of about 600 feet above the ground.
 - (ix) The dropping area should be at least 1,000 yards long and 400 yards wide.
 - (x) In the event of an engine failure while towing, the target can be winched in but it then should be released over a safe area at 180 knots I.A.S.

References

<u>No.</u>	<u>Title</u>	
1	Meteor T.T.20 WD.767. Handling and Performance Tests Towing a 3 ft. x 15 ft. Sleeve Target	1st Part of AAEE/ 817/6/T
2	Meteor T.W.20 WD.767. Further Sleeve Target Towing Trials including Trials with S.A.A.B. Near Miss Recording Equipment.	2nd Part of AAEE/ 817/6/T

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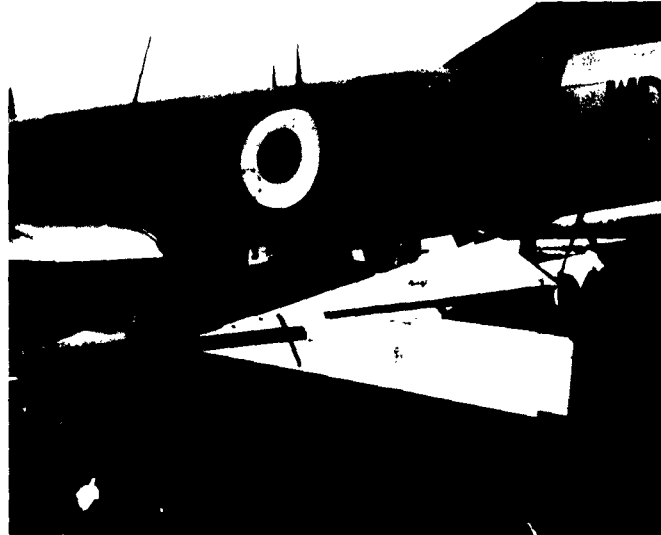


FIG. 1. DART TARGET READY FOR MOUNTING BENEATH METEOR TT 20.

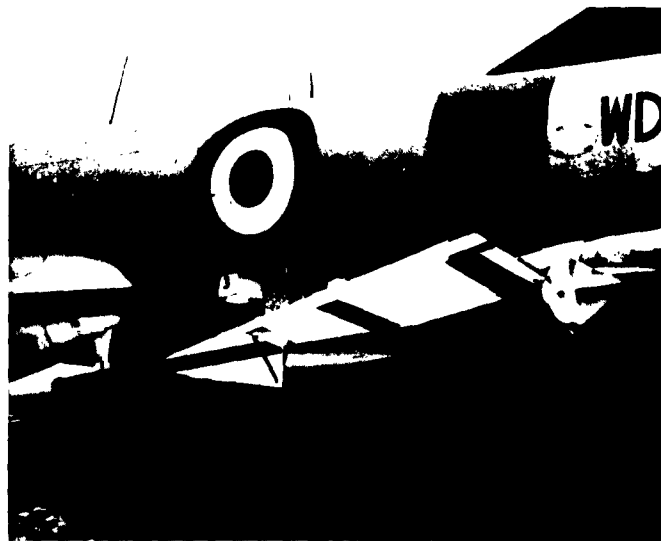


FIG. 2. DART TARGET MOUNTED AND READY FOR FLIGHT.

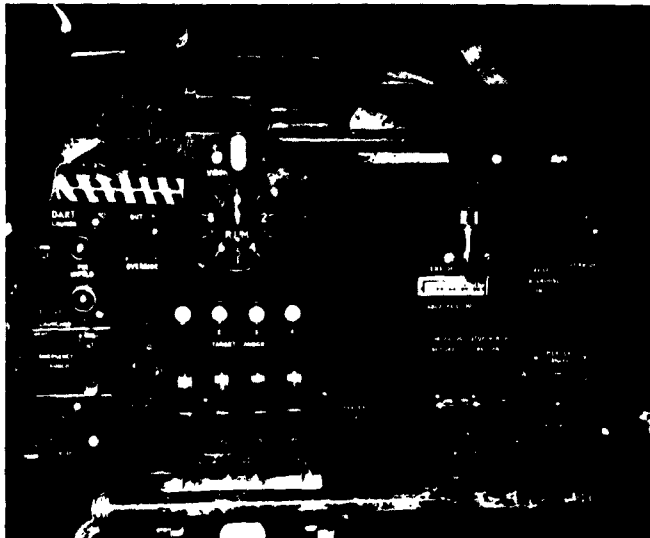


FIG. 3. WINCH OPERATOR'S PANEL. (ORIGINAL VERSION.)

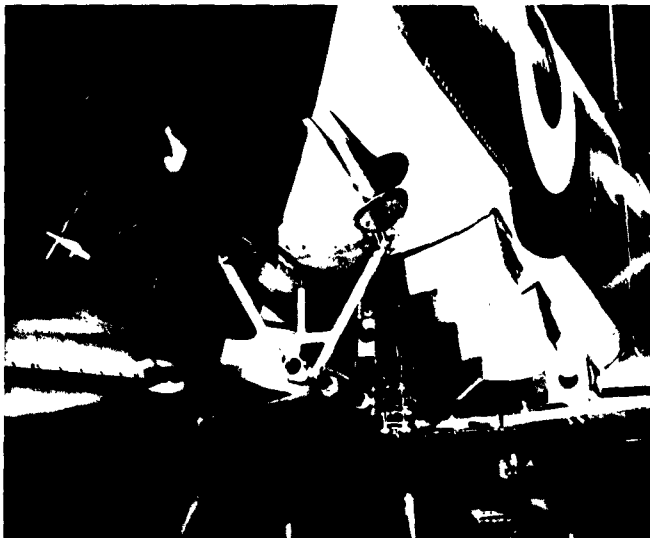


FIG. 4. TARGET-TOWING FITTINGS ON METEOR TT 20.



FIG. 5. DETAIL OF FOLDED-FIN RELEASE CATCH AND MICRO SWITCH PIN.

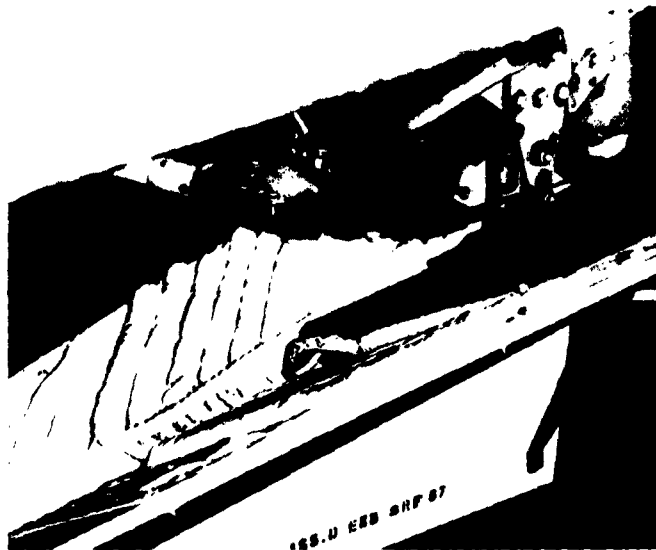
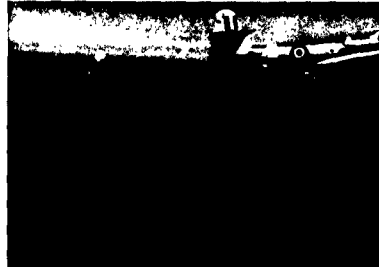


FIG. 6. DETAIL OF STOWAGE OF LAUNCHING HALYARD.

DART TARGET LAUNCH.



(A) AIRCRAFT CARRYING TARGET
FIN FOLDED. (TIME = 0 SECS.)



(B) TARGET WITH FIN UNFOLDED.
(TIME = 0.15 SECS.)



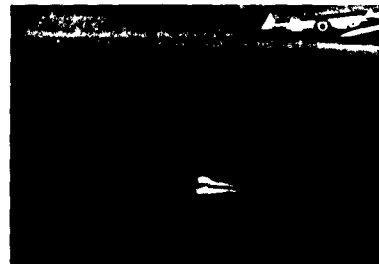
(C) TARGET LAUNCHED.
(TIME = 2.92 SECS.)



(D) TARGET DROPPING INTO TOWING
POSITION.



(E) TARGET FALL ARRESTED.
(TIME = 3.82 SECS.)



(F) LINK DETACHED FROM FUSELAGE
HOOK. (TIME = 3.87 SECS.)



(G) TARGET BOUNCES UP AFTER (F)
(TIME = 4.8 SECS.)



(H) TARGET IN NORMAL LEVEL FLIGHT,
PRIOR TO WINCHING OUT.

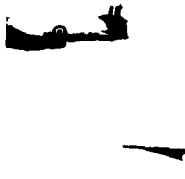
DART TARGET RELEASE.



(A) AIRCRAFT WINCHING TARGET INTO THE CASTING OFF POSITION.



(B) TARGET IN THE CASTING OFF POSITION.
(TIME = 0 SECS.)



(C) TARGET CAST OFF.
(TIME = 0.05 SECS.)



(D) TARGET IN FREE FALL, ROPE FALLING BACK TRIGGERS OFF REFLECTOR.



(E) REFLECTOR RELEASED AND DROGUE SHOT INTO THE AIRSTREAM. (TIME = 0.8 SECS.)



(F) EXTRACTION OF MAIN PARACHUTE BY DROGUE.
(TIME = 1.9 SECS.)



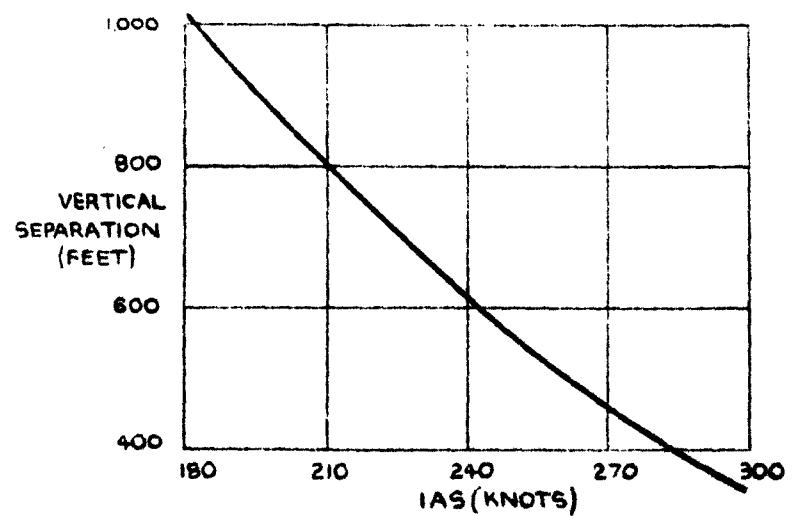
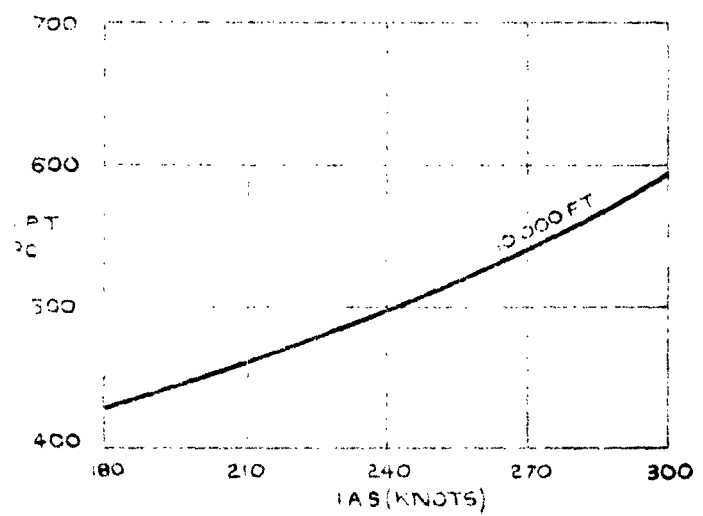
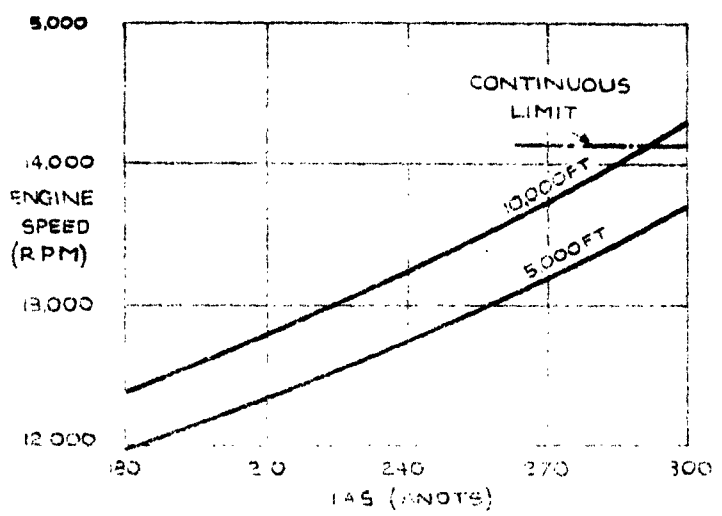
(G) MAIN PARACHUTE STARTS TO DEPLOY.



(H) MAIN PARACHUTE FULLY DEPLOYED, TARGET FALLING VERTICALLY.

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FIG. 9



**PERFORMANCE WITH DART ON 6,000 FT. TOW.
I.S.A. CONDITIONS**

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