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AIRCRAFT: ARROW 2 REPORT NO: 72/PERF/16

UNCLASSIFIED

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OVERLOAD RANGE MISSION

29 Mar 58

AVRO AIRCRAFT

SECRET

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PREPARED BY J.H.Lucas

APPROVED BY F.Brame

APPROVED BY C.V.Lindow

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A preliminary study has been made of some factors which influence range, namely, aircraft drag, propulsion system, and fuel stowage capacity. This study reduced the immediate consideration to modifying the propulsion system by the insertion of a jettisonable nozzle, optimized for the overload range mission. Largely, by this means the 1500 N.M. range can be achieved as detailed in R.C.A.F. Spec. AIR 7-4; the ranges being estimated as 1550 N.M. with the 500 gal. external tank jettisoned, and 1490 N.M. with the tank retained. The disadvantage of this system is the increased take-off distances, since afterburner cannot be used without jettisoning the nozzle insert. On a standard hot day at sea level the ground run is estimated to be 3750 ft. Consistent with Periodic Performance Report # 13, the distance to clear 50 ft. would be a very conservative 9,500 ft.

It is proposed that the inserted nozzle (see attached sketch) be made from A70 titanium. The weight of each nozzle is estimated to be about 80 lb., and the reduction in ground angle resulting from this afterbody extension would be only 15 minutes.

The design is relatively simple, the nozzle consisting of an inner cylinder with sixteen longitudinal ribs spaced around the periphery and two circumferential rings at the load transfer points. The outer skin would be stretch formed in two pieces and attached by blind rivets. Seam welding would be used where applicable. The nozzle would be secured by four ballistic fasteners electrically connected to the pilots throttle lever, so as to eject the nozzle upon selection of afterburner.

The attached curve shows the propulsion system inprovements obtainable from the nozzle insert at .92 M.N. at 40,000 ft. The fuel flow rate at cruise and therefore specific range is improved by 15%. The overall gain in range because of the improvements during climb and loiter is about 18%. The improvement in thrust with the nozzle insert is substantially derived in the duct and bypass system and not in the ejector proper as might have been expected. For example, during cruise at .92 M.N. at 40,000 ft., the estimated thrust increase (relative to the total thrust required) for the duct and bypass systems is 7% and 8% respectively. There is actually a loss of 0.5% in the ejector. This net gain permits the engine (Iroquois 2) to be throttled back reducing the fuel flow.

In addition to the large range improvement obtainable by a nozzle insert, refinements were made in two other areas. These were in the cruise speed, and the estimate of the fuselage external tank drag. Previously an effective reserve of some 4% had been allowed by cruising at .92 M.N. It is estimated that cruising at .90 M.N. results in maximum specific range.

A review of the external tank drag resulted in a new drag coefficient (based on wing area) of .0009. This is entirely an estimate (72/Aero Data/8)

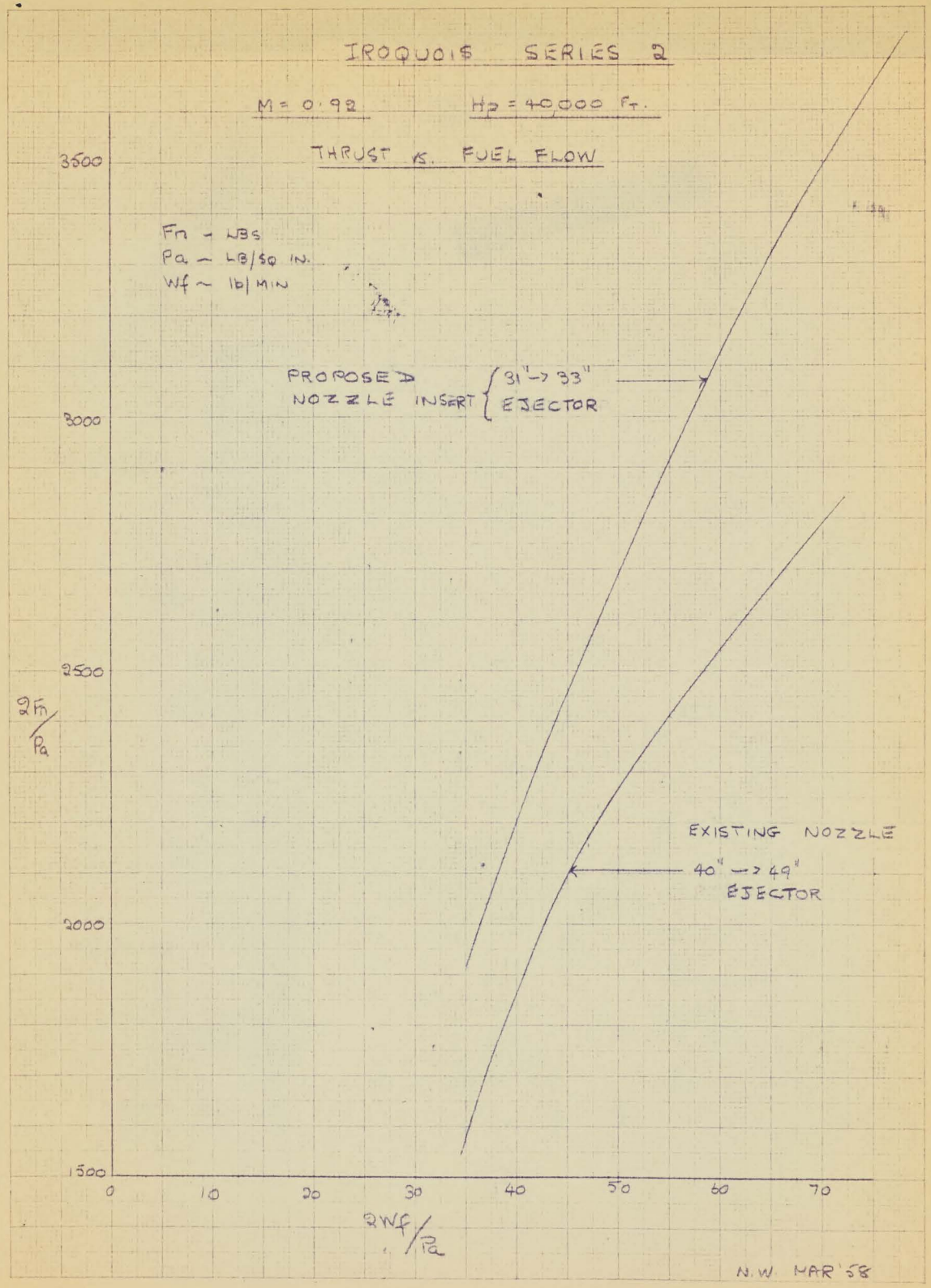
as the wind tunnel data at best can only be said to be indicative of this number. The configuration since the C.A.L. transonic tunnel tests has changed and the test at the N.A.E. low speed tunnel gave excessive scatter. The range improvement resulting from the new external tank drag estimate is less than 1% if the tank is jettisoned and about 3% if the tank is carried throughout the mission. ?

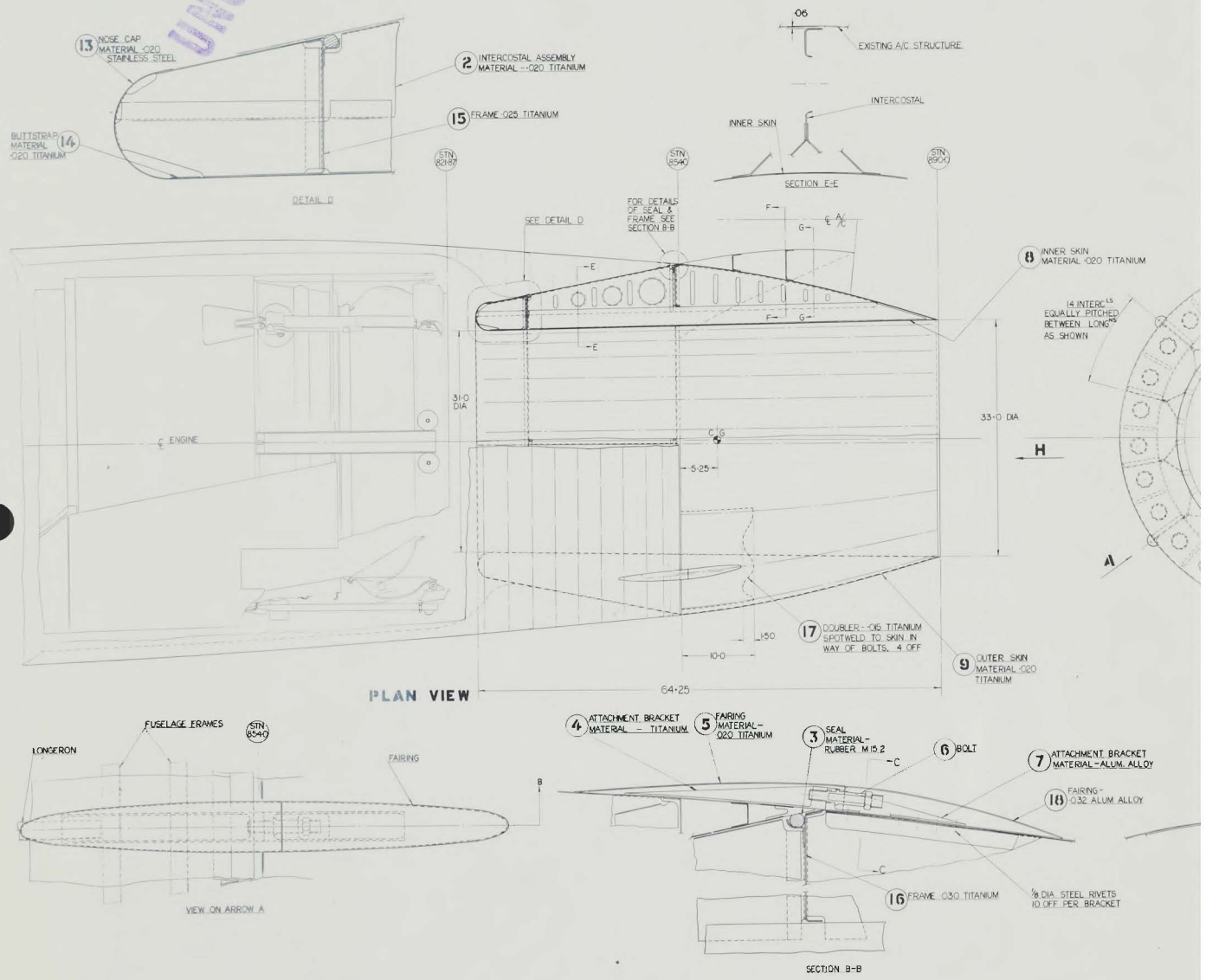
A more detailed study of the nozzle insert system is now in progress. The main outstanding technical consideration is the determination of the Arrow 2 flight envelope with the nozzle insert. It is possible that structural changes to the rear fuselage may be necessary resulting in a slight weight increase.

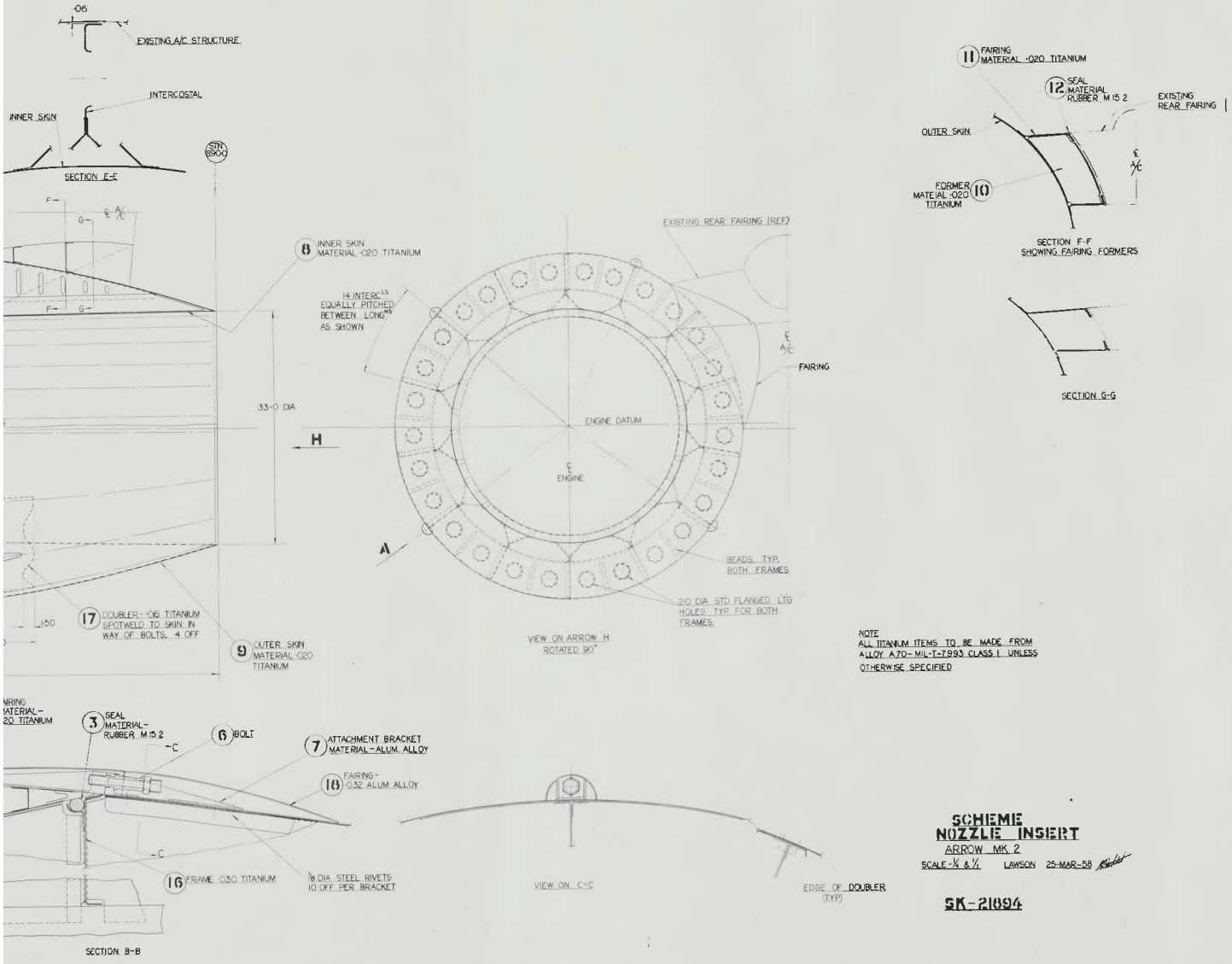
It should be emphasized that while the range gains claimed for the nozzle insert are fully expected, the absolute values are less predictable. For this reason it is noted that space other than in the armament pack is available for additional internal fuel stowage of up to 8,500 lb. However, the cost and effort would be considerable and is, as might be expected, somewhat proportional to the amount of extra fuel required. Therefore, this avenue of approach is not recommended until flight test data establishes the Arrow 2 range capabilities.

On the premise that it may not always be necessary to carry armament, it is interesting to note that an estimated range of 2000 N.M. can be achieved by replacing the armament pack by a fuel pack, carrying the external tank, but leaving the basic airframe fuel capacity unchanged. The fuel pack would be limited to approximately 775 gallons, for relatively little cost and effort.

It should be noted that reverting to the 'so called 1.5 M.N.' Arrow 2 having a nozzle with a 40 in. throat diameter and a 42.8 in. exit diameter would result in only a 2% gain in specific range compared to the 15% gain obtainable with this proposal. Further an area rule estimate indicates considerable improvement at 1.5 M.N. for the present 49 in. exit diameter relative to the 42.8 in. exit diameters.







NOTE
ALL TITANIUM ITEMS TO BE MADE FROM ALLOY A.70 - MIL-T-7993 CLASS I UNLESS OTHERWISE SPECIFIED

SCHIEMIE
NOZZLE INSERT
ARROW MK 2
SCALE - ¼ & 1/1 LAWSON 25-MAR-58

SK-21694