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A BRIEF NOTE ON THE C-105 INTAKES

SECRET February 1955.

A BRIEF NOTE ON THE C-105 INTAKES

The C-105 is a delta wing all-weather fighter powered by two J 75 engines (see Fig. 1). Its primary role is high altitude interception and its basic specification mission is a climb to 50,000 ft., cruise out at a Mach number of 1.5 for 200 nautical miles, combat for 5 minutes at M = 1.5 followed by an economic cruise back to base. The specification lays down stringent requirements for performance at M = 1.5 particularly with respect to turning radius and ceiling, but there are no performance requirements for speeds in excess of this. The aircraft is designed structurally to fly up to a M = 2.0.

The intakes of the C-105 are located on the side of the fuselage about 14 ft. from the nose. They are approximately D-shaped and external compression is achieved by a two-dimensional ramp with a 12° wedge attached to the side of the fuselage (see Fig. 2). The duct from inlet to engine diffuses from 5.6 sq. ft. at the inlet to 7.0 sq. ft. at 9 ft. from the inlet - it then has a constant diameter circular section for a distance of 22 ft. back to the compressor face. The duct area variation curve is shown in Fig. 3.

Immediately upstream of the compressor face is located a flush intake of variable area which completely encircles the duct. This intake opens into the engine bay and its purpose is to bleed air from the main intake duct into the bay, the air then being dumped through a suitable exit at the rear. It is our intention at this time for reasons of simplicity, to have the flush 'bypass' intake fully open at Mach numbers greater than 1.5 and to close it to a fixed intermediate setting at speeds less than M = 1.5. At the intermediate setting sufficient air will be allowed to pass through to cool the engine etc. The maximum area of the bypass has been chosen so that the main intake is just choked at M = 1.5 in the stratosphere.

One of the main reasons for incorporating a bypass in this installation was to increase the minimum mass flow ratio at which the intake would have to operate at M >1.5 in an effort to avoid 'buzz'. We incidentally, however, get an appreciable increase in performance due to (1) elimination of duct pressure losses (all the duct boundary layer is bled through the bypass) and (2) reduction in spillage drag.

It is generally agreed that variable intake geometry is not required up to a Mach number of around 1.5 and we estimate that with our particular intake-bypass arrangement that only a small performance gain would result if we went to a variable ramp intake.

The distance between the inner surface of the external compression ramp and the fuselage side is 2.5 inches, this distance we estimate will be sufficient to enable all the fuselage boundary layer ahead of intake to flow under the ramp. In this way we hope to avoid a reduction in pressure recovery due to fuselage boundary layer air entering the intake and possibly complicating the 'buzz' problem.

The air flowing under the ramp passes over a boundary layer splitter (see Fig. 4) and in the centre of the splitter is located an intake which we call the 'splitter bleed'. The splitter bleed provides the charge air for the air-conditioning system and the splitter bleed charge air circuit is designed so that the bleed operates just off the choking mass flow ratio throughout the high speed range (M >0.8). In this way we prevent any shock waves due to the splitter from moving out in front of the ramp and thickening up the boundary layer entering the engine intake.

As the flight speed is increased the pressure rise across the normal shock in front of the intake increases and eventually the flow at the foot of the shock separates. According to Ref. 1, the separation occurs when the Mach number ahead of the shock exceeds 1.33 - with a 12° ramp this corresponds to a free stream Mach number of 1.73.

It is not certain whether this separation is a particularly bad thing or not, tests on an intake similar to ours (Ref. 2) do not indicate anything worse than a slight decrease in pressure recovery whilst on others it seems to have precipitated buzz.

We decided therefore, as an insurance policy, to suck a portion of the boundary layer off the ramp through a porous strip running parallel to the shock. The boundary layer air is sucked away by a fan in the air-conditioning system - this fan absorbs the load from expansion turbine. The big question was - How much air do we have to suck away to prevent separation? As far as we know no tests have been made on a similar arrangement, and so we decided arbitrarily to suck twice the amount of air contained inside the displacement thickness of the boundary layer.

The choice of intake area for the J 75 installation has been influenced by two primary considerations, one is to obtain optimum performance at high altitudes at about M = 1.5, and the other is to keep structural modifications to a minimum.

A critical structural case occurs in the whole of the intake duct when the engine is run at Military Rating on the ground. The variation of suction in the duct with inlet area is shown in Fig. 5.

The variation of installation thrust loss with intake area at the tropopause is shown in Fig. 6. The installation thrust loss is defined as the loss in thrust due to shock and duct skin friction losses plus spillage drag plus momentum loss in the bypass. It can be seen that the installation losses with our particular scheme are fairly insensitive to intake area and the area was therefore, chosen to comply with our structural requirement at S.L. static. The chosen area was 5.6 sq. ft.

The variation of the choking mass flow with Mach number through a 5.6 sq. ft. intake at the tropopause is shown on Fig. 7, also shown in the variation of the required engine flow at Military and idling rating plus cooling and bypass flow.

The sort of wind tunnel test programme we would like to have would be similar to that carried out by the N.A.C.A. on the F 102, with additional tests at M = 2.0. We would be particularly keen on testing our ramp suction scheme at the higher Mach numbers.

REFERENCES

1. RM E51L26 - Some observations of shock-induced turbulent separation on supersonic diffusers by T.J. Nussdorfer - Lewis Laboratory

2. NACA RM E52H29 - Performance characteristics at Mach numbers to 2.0 of various types of side inlets mounted on fuselage of proposed supersonic airplane
IV - Rectangular-cowl inlets with two dimensional compression ramps by Paul C. Simon - Lewis Laboratory

February 24th, 1955.

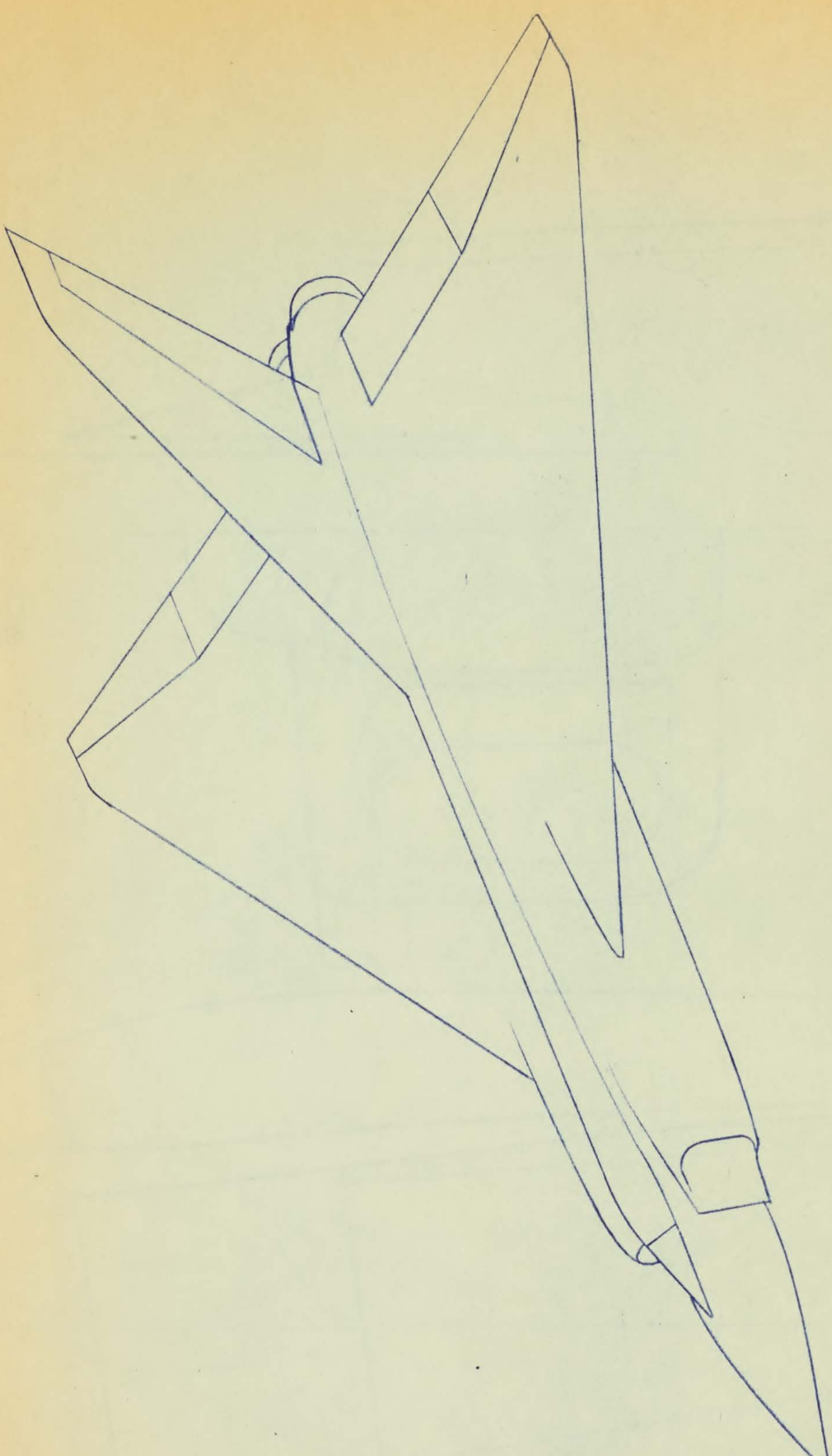

Fig. I

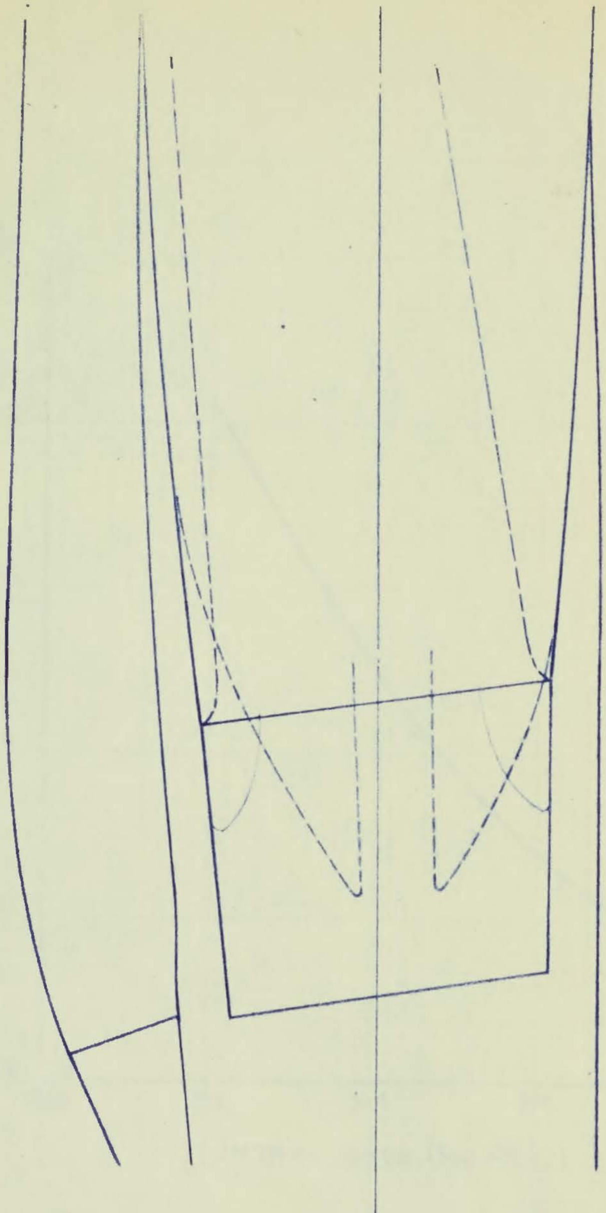

FIG. 4

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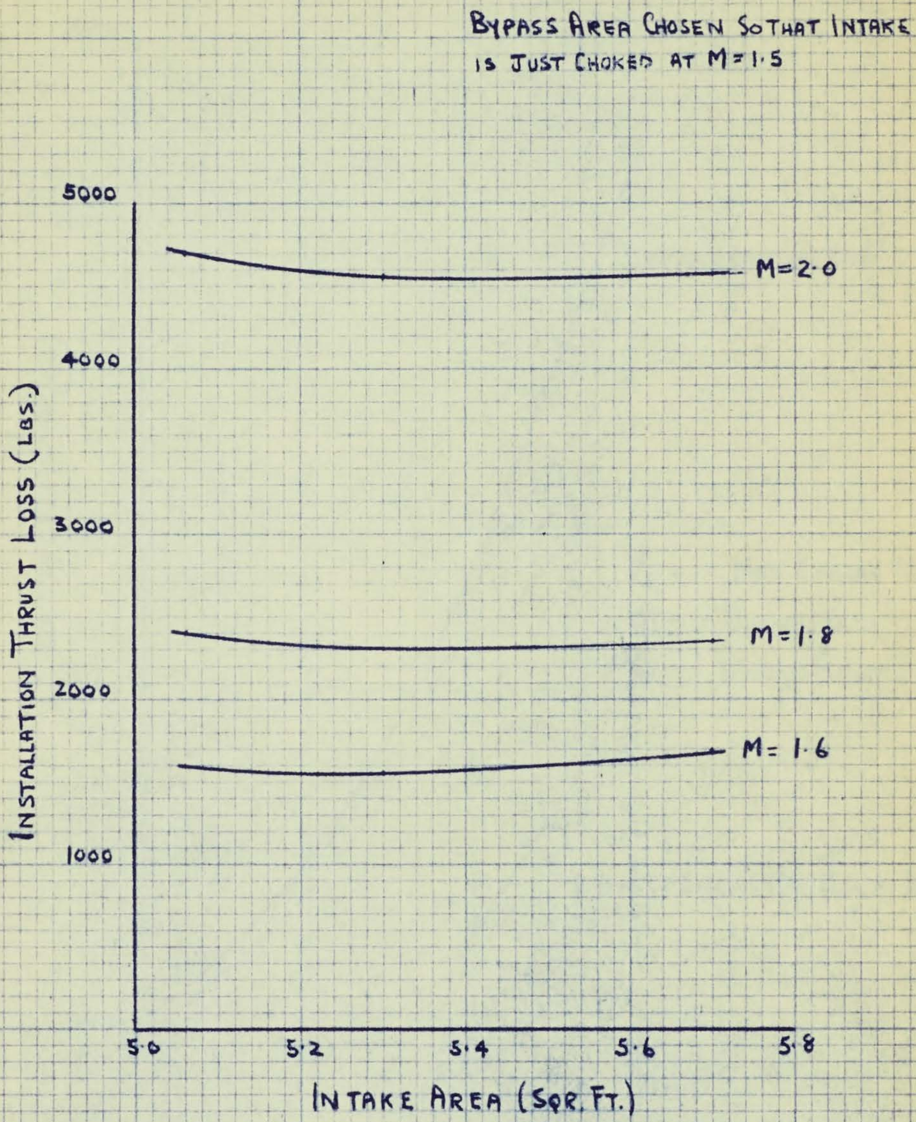

EFFECT OF INTAKE AREA ON INSTALLATION THRUST LOSS

ALTITUDE - 35000'
ENGINE - J75. 820

FIG. 6.

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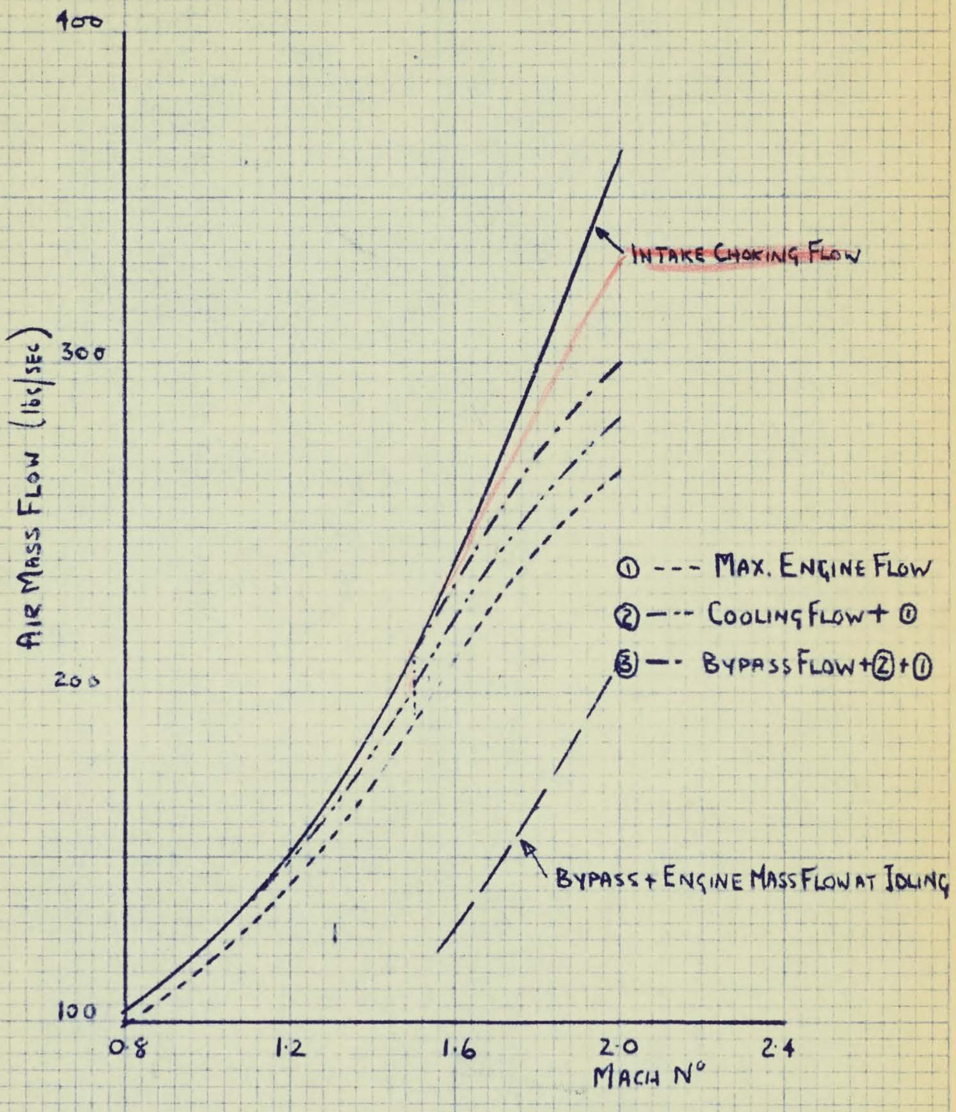

AIR MASS FLOW VARIATION AT 35000'

INTAKE AREA 5·6□'

ENGINE J75-B20

FIG. 7

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