Tests on a model of the working section of the proposed propulsion wind tunnel

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PAGE 1 OF 4
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SECURITY CLASSIFICATION O P E N

SUBJECT TESTS ON A MODEL OF THE WORKING SECTION OF THE PROPOSED PROPULSION WIND TUNNEL.

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ISSUED TO

TESTS ON A MODEL OF THE WORKING SECTION
OF THE PROPOSED PROPULSION WIND TUNNEL.

In view of the unusual nature of the air flow to be expected in this tunnel, when wind and fan streams interact, it was thought desirable to test models of various types of working section. In order to obtain maximum speed from the available power, a 10' x 15' working jet was assumed, with the wing spanning the 10' dimension, leaving a 10' span x 7 1/2' high jet above it, and the same below it. A 9' chord wing was assumed, with a 3' dia. fan in it. The tests described covered various configurations of working section, divided into two main groups, namely, open-jet and closed-tunnel working sections.

Description of Model

(Note: All dimensions are stated as for the full-size tunnel, and should be reduced to 1/12th to describe the model tested.)

The model was built mainly of plywood, at a scale of 1" = 1', and was supplied with wind from a 40 hp electric blower, while the jet from the wing fan was simulated by a 1 1/2" dia. (actual model size) pipe from the Workshops' compressed air line. This also entrained some air from the main stream above the wing, by acting as a very crude ejector pump.

With the aid of two gauzes in the inlet diffuser and the convergence after the settling chamber, a uniform stream at up to 100 mph (± 2 mph) was obtained over the 10 x 15 working-section inlet.

The outer envelope for the various working sections was provided by a box-like building of approximately 50-foot cube inside, through which the wind stream was allowed to blow from a 10 x 15 opening in one wall. In the experiments described, the opposite wall was left off. A 9' chord Clark 'Y' 15% t/c wing was fixed in the box, spanning the 10' dimension of the jet, and with its leading edge 4 1/2' downstream from the exit plane of the 10' x 15' nozzle. A 1 1/2" dia. (model size) compressed-air pipe led vertically down to the wing upper surface, over the 3' dia. fan hole, to provide simulated fan flow.

Various deflecting cascades were made from brass sheet, and mounted in the large 50-foot cube room, or in closed-jet working-section tunnels which were mounted inside the large room, as described in the notes on experiments.

Air speeds were measured with a pitot tube and an aircraft-type air-speed indicator, and directions were estimated with cotton tails on wire probes. The steadiness of flow was estimated from the air-speed indicator readings and the antics of the cotton tails.

Details of Experiments

The aim of the experiments was to provide a qualitative comparison of the uniformity and stability of flow over wing and fan, with various tunnel working-section configurations, and to show whether any of these tunnel arrangements modified the flow 'round the wing. In order to cover the operating conditions, each arrangement was tested at:

(a) Zero forward speed, high fan flow (hovering).

(b) High forward speed, zero fan flow (normal flight).

(c) High forward speed, high fan flow (worst transition case).

The test observations are shown graphically in Figures 3 to 8.

General Conclusions

It is well known that when a two-dimensional wing is placed in a uniform air flow the airstream is distorted. It is also obvious that if the wing contains a high-lift device, such as a fan, the air stream distortion will be increased and made three-dimensional, since the lift is increased and increased locally. The problem in the present case is to provide a free stream which can be distorted by the wing and fan, without having its distortion modified by the walls of the wind tunnel.

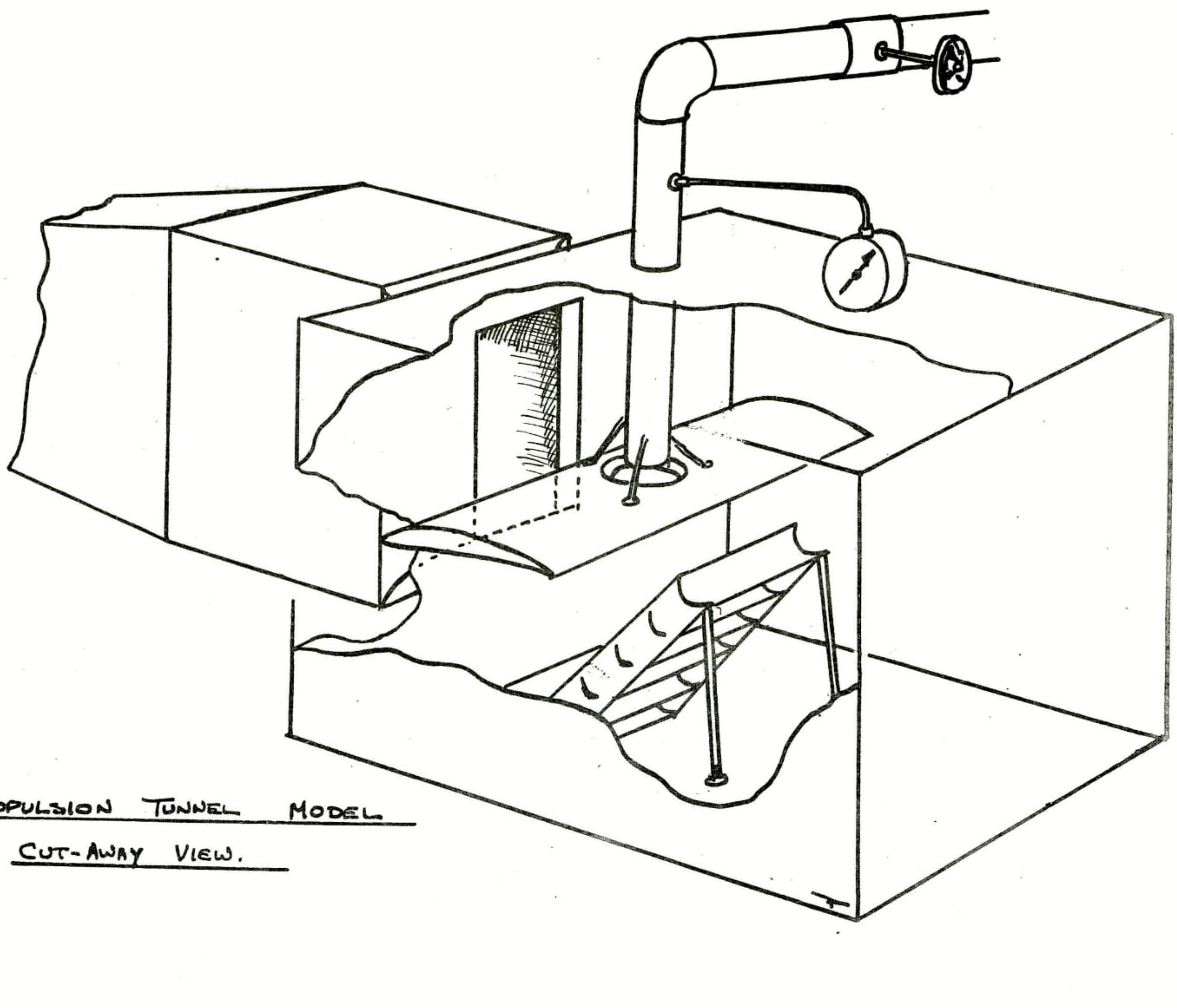
It appears from the experiments shown here that the distorted flow will be seriously modified by tunnel walls:

(a) If the walls, and particularly the floor, are close enough to bounce the fan-in-wing jet back near the wing, thus increasing the pressure and choking the flow in the part of the tunnel below the wing.

or

(b) If the jet leaves the tunnel through a small hole in one wall, in which case it may act as an ejector pump and suck an appreciable part of the tunnel flow out with it.

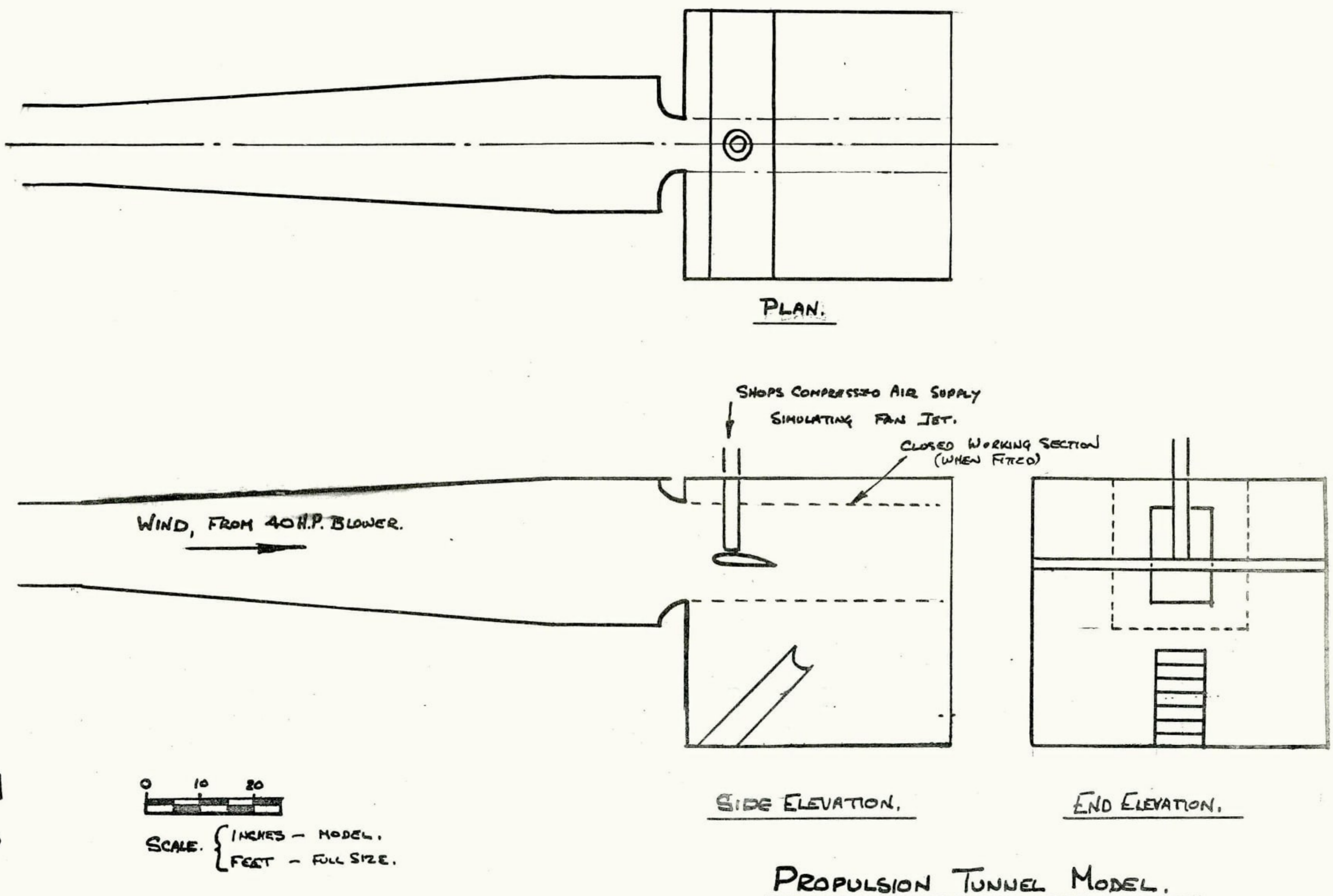
It appears from these tests that the lower wall, at least, of the working section should be omitted and the jet allowed to escape in this direction, to be deflected out of the tunnel building by a suitable deflector cascade.



PROPULSION TUNNEL MODEL

CUT-AWAY VIEW.

FIG. 1.



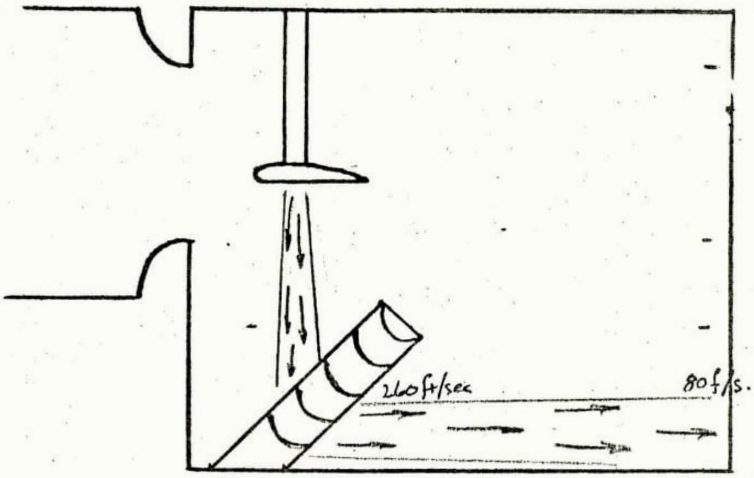
PLAN.
SHOPS COMPRESSED AIR SUPPLY
SIMULATING FAN JET.
CLOSED WORKING SECTION
(WHEN FITTED)
WIND, FROM 40 H.P. BLOWER.
0
10
20
SCALE. INCHES - MODEL.
FEET - FULL SIZE.
SIDE ELEVATION.
END ELEVATION.
PROPULSION TUNNEL MODEL.

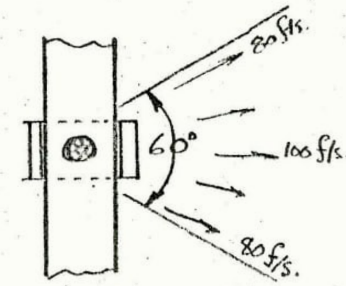
FIG. 2.

CONFIGURATION Nº 1.

DESCRIPTION.

OPEN SECTION, DEFLECTOR CASCADE ON FLOOR.

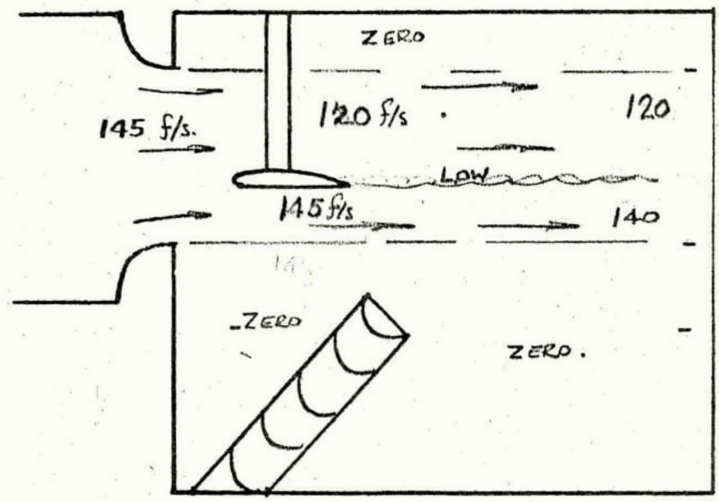




PLAN OF SPREADING FLOW.

1A

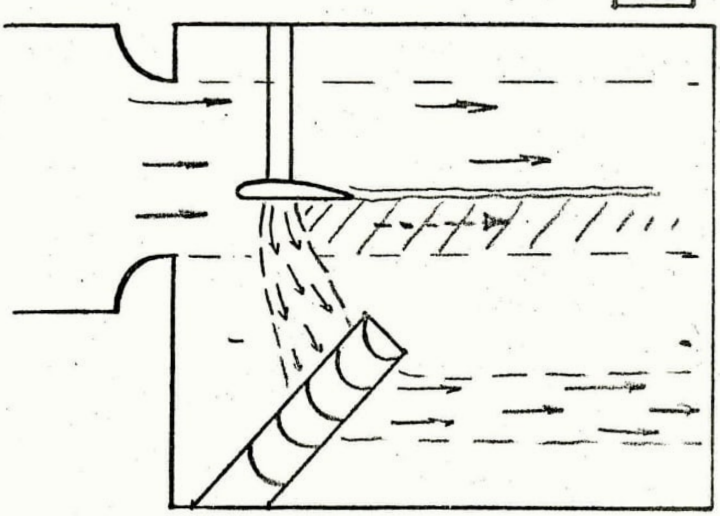
WIND SPEED = 0 FT/SEC.
JET SPEED = 550 FT/SEC.



FLOW SMOOTH & STEADY.

1B

WIND SPEED = 145
JET SPEED = 0



SMOOTH STEADY FLOW.

← ZERO STREAM BEHIND JET. JET WAKE LIKE THAT FROM SOLID OBSTACLE

← NO SIDEWAYS SPREAD IN THIS JET.

1C

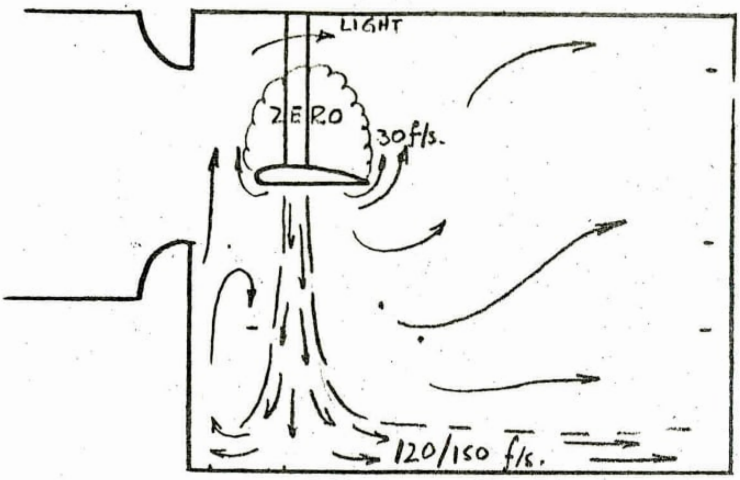
WIND SPEED = 145.
JET SPEED = 550.

FIG. 3.

CONFIGURATION Nº 2.

DESCRIPTION.

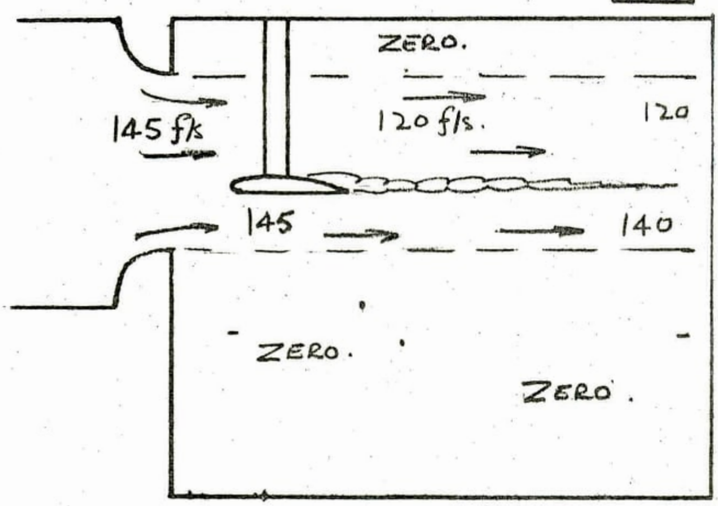
OPEN SECTION, NO DEFLECTOR.



VIOLENT SPLASH FROM FLOOR. UNSTEADY FLOW ROUND WING, STRONG UPFLOW ROUND TRAILING EDGE, LIGHT UPFLOW ROUND LEADING EDGE.

2A

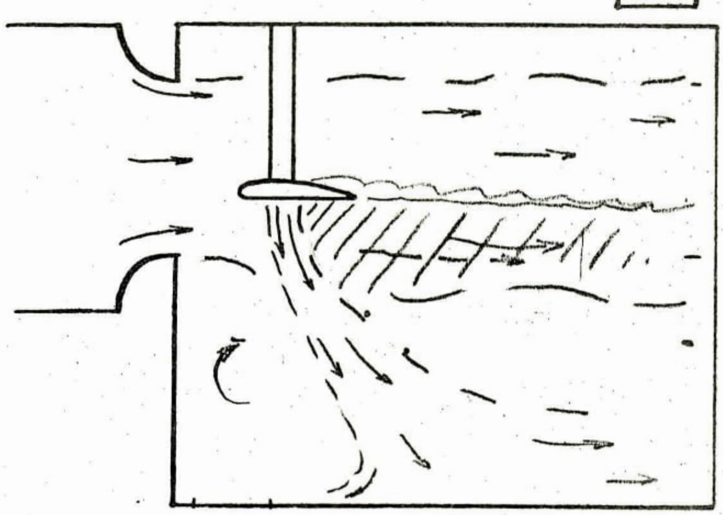
WIND SPEED = 0 FT/SEC.
JET SPEED = 550 FT/SEC.



IDENTICAL WITH 1B.

2B

WIND SPEED = 145.
JET SPEED = 0



ALMOST THE SAME AS 1C, BUT SOMEWHAT LESS STABLE, DUE TO VIOLENT SPLASH.

CONDITIONS IN ROOM IN GENERAL WERE VERY BLUSTEROUS.

2C

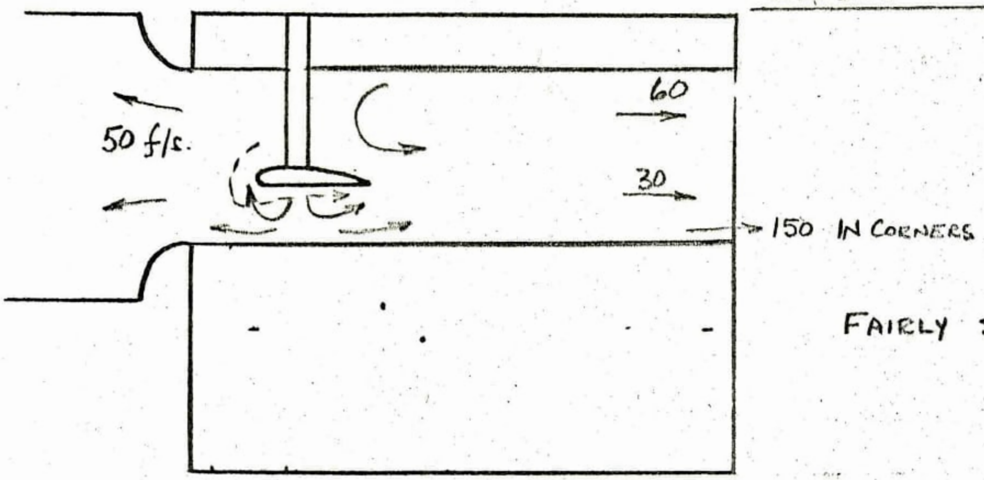
WIND SPEED = 145
JET SPEED = 550

FIG 4.

CONFIGURATION Nº 3.

DESCRIPTION.

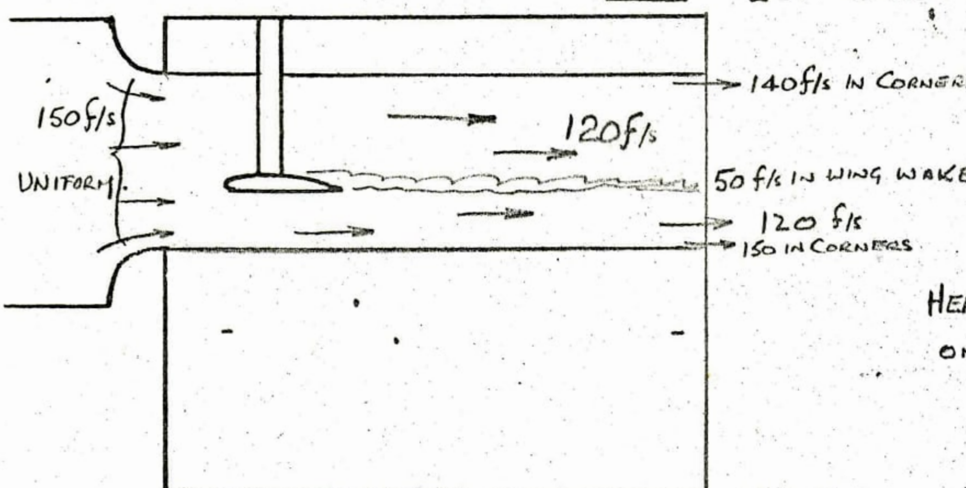
CLOSED WORKING SECTION.



FAIRLY STEADY FLOW.

3 A

WIND SPEED = 0 FT/SEC.
JET SPEED = 550 FT/SEC.



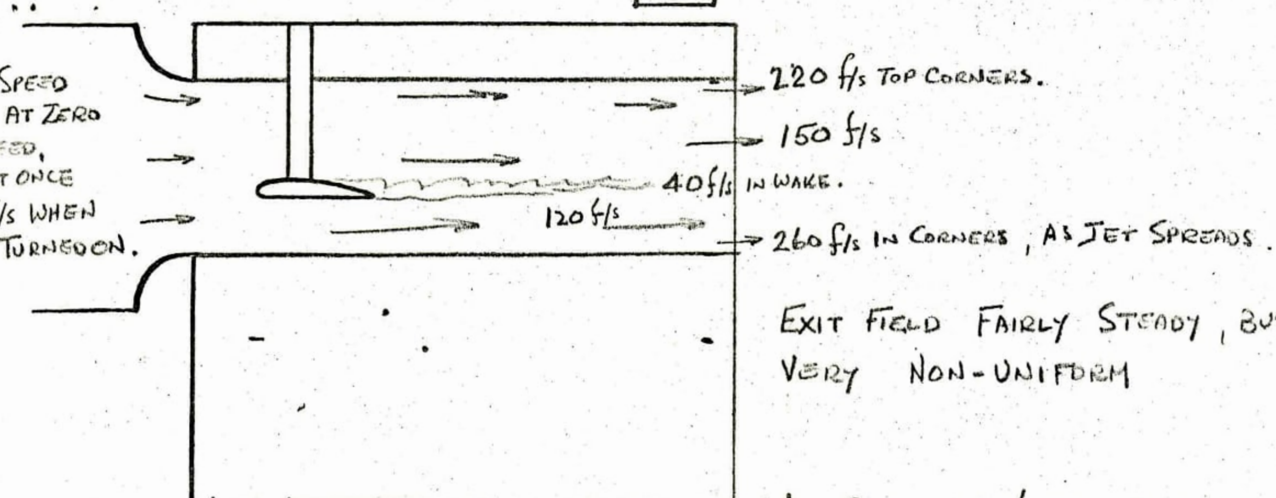
HEAVY BOUNDARY LAYER ON WALLS.

3 B.

WIND SPEED = 150
JET SPEED = 0

NOTE !!

INLET SPEED 150 f/s AT ZERO JET SPEED, RISES AT ONCE TO 180 f/s WHEN JET IS TURNED ON.



EXIT FIELD FAIRLY STEADY, BUT VERY NON-UNIFORM

3 C

WIND SPEED = 150/180 — SEE NOTE
JET SPEED = 550

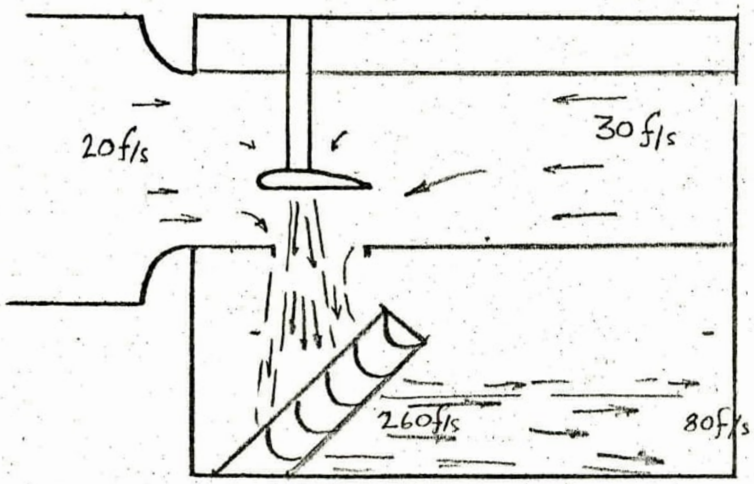
FIG. 5.

CONFIGURATION Nº 4.

DESCRIPTION.

CLOSED WORKING SECTION, WITH JET VENT IN FLOOR.

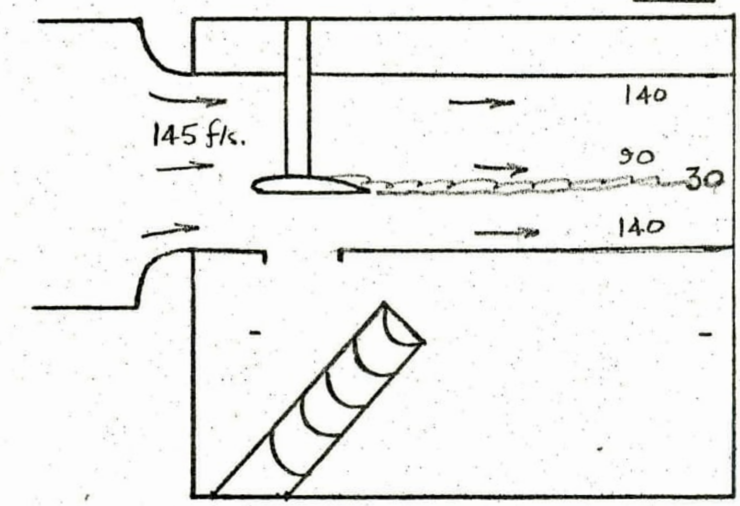
NOTICEABLE EJECTOR PUMP EFFECT, DEPENDING CRITICALLY ON SIZES & RELATION OF JET & VENT HOLE.



4 A

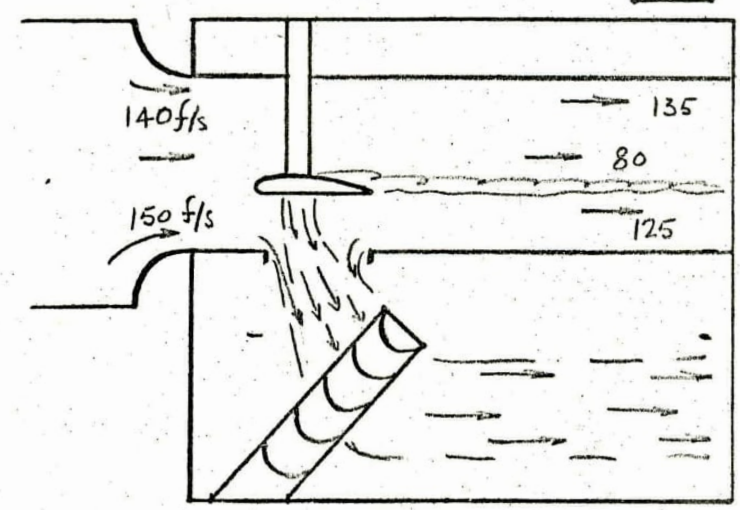
WIND SPEED = 0 FT/SEC.
JET SPEED = 550 FT/SEC.

HIGH SPEED WAKE ON ℄.
VERY THICK WALL BOUNDARY LAYER.



WIND SPEED = 145
JET SPEED = 0

4 B



5/15 f/s DROP OF SPEED WHEN JET IS TURNED ON.
VERY UNEVEN FLOW DISTRIBUTION.

4 C

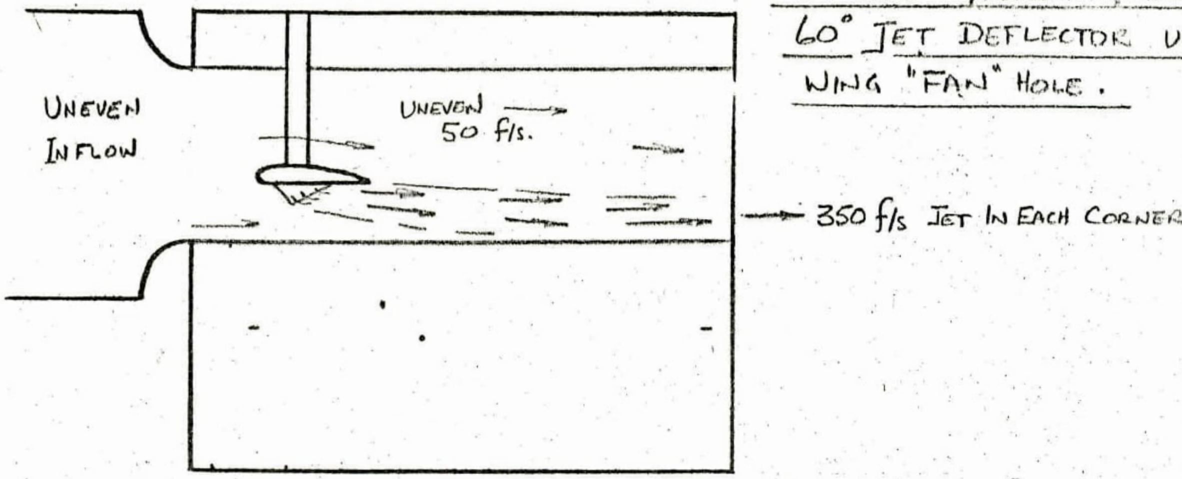
WIND SPEED =
JET SPEED =

FIG. 6.

CONFIGURATION Nº 5.

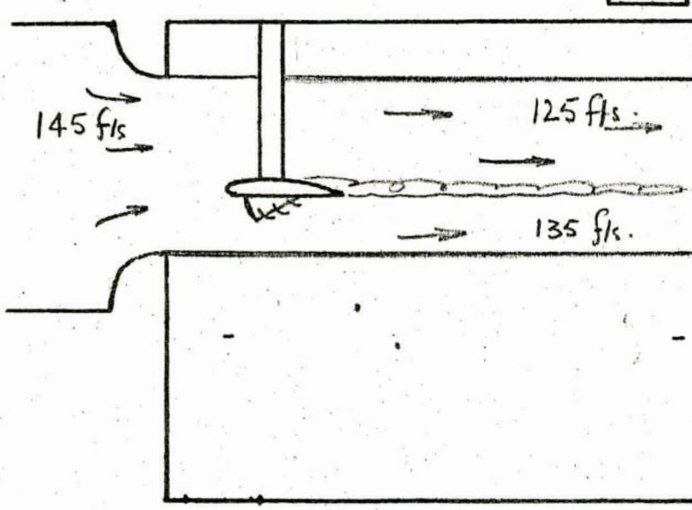
DESCRIPTION.

CLOSED WORKING SECTION.
60° JET DEFLECTOR UNDER WING "FAN" HOLE.



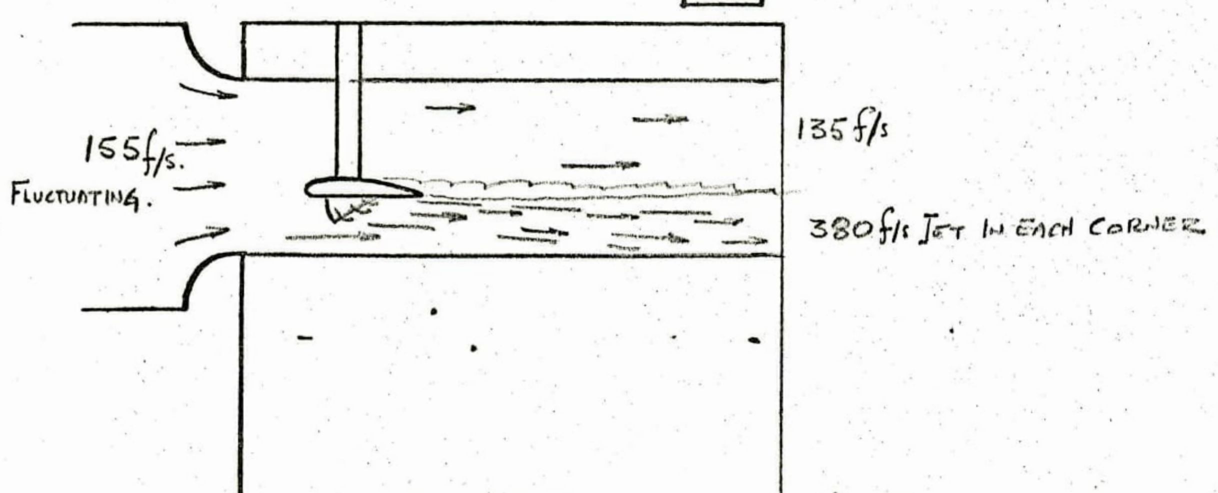
5A

WIND SPEED = 0 FT/SEC.
JET SPEED = 550 FT/SEC.



5B

WIND SPEED = 145
JET SPEED = 0



5C

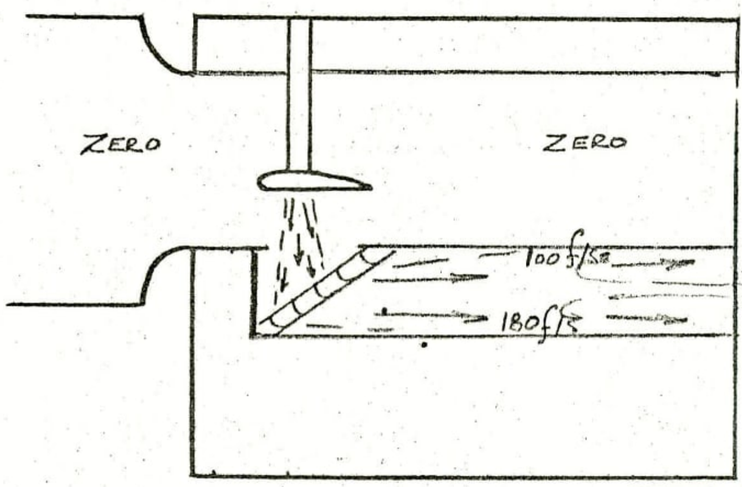
WIND SPEED =
JET SPEED =

FIG. 7.

CONFIGURATION Nº 6.

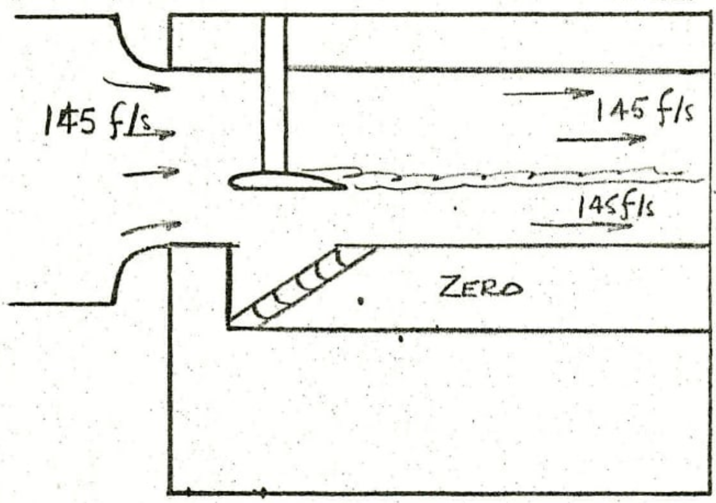
DESCRIPTION.

CLOSED WORKING SECTION, JET VENT IN FLOOR, CLOSED JET VENT DUCT.



6A

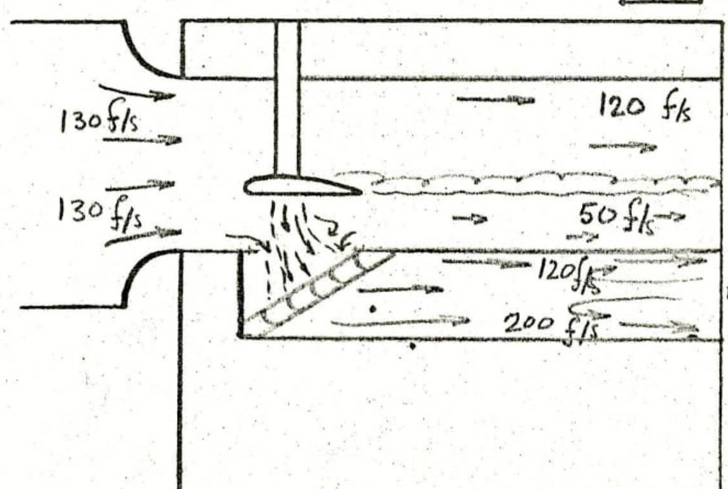
WIND SPEED = 0 FT/SEC.
JET SPEED = 550 FT/SEC.



6B

WIND SPEED = 145
JET SPEED = 0

VENT DUCT ACTS AS EJECTOR, SUCKING AIR FROM BELOW WING & FALSIFYING TUNNEL FLOW & PRESSURE FIELD ROUND WING.



INLET SPEED FALLS FROM 145 TO 130 WHEN WING FAN JET IS STARTED.

6C

WIND SPEED = 145 /130
JET SPEED = 550

FIG. 8.