A NOTE ABOUT THE EFFECT OF EXIT SIDE WALLS ON CASCADE PERFORMANCES*

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Introduction

It may be advisable to use exit side walls long as much as possible in the cascade experiment, but shorter walls may be recommended from the standpoint of experimental techniques. This report is to contribute to the future cascade experiments by the examination on the difference of performances of two cases, in which, one series of cascade has short exit side walls not to prevent the traverse of an ordinary yaw probe, and another has sufficiently long side walls.

Symbols

a : blade pitch
B : a half of cascade span
c : chord length
h_1, h_2, h_3: see Fig. 4
p : pressure
V : velocity
w : velocity component
α : stagger angle
α_i : attack angle
δ^* : boundary layer displacement thickness
ε : turning angle
ζ_2 : total pressure loss coefficient, $\zeta_2 = \dfrac{p_{T1} - \overline{p_{T2}}}{\frac{1}{2}\rho \overline{V}_2^2}$
ρ : density
$\overline{}$: mean value along cascade direction

Subscripts

1 : before cascade
2 : behind cascade
a : axial
T: total

Apparatus and Procedure

The cascade wind tunnel used was a high-speed one which belongs to authors'

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laboratory. The schematic drawing is illustrated in Fig. 1. Experiments were performed at low subsonic speed (about 70 m/s at cascade inlet).

The blade profile is RAF-6 of 10% thickness, and profile data are illustrated in Fig. 2. Model dimensions are 24 mm in chord length, 50 mm in span and 2.08 in aspect ratio.

Symbols concerning cascade arrangement are illustrated in Fig. 3.

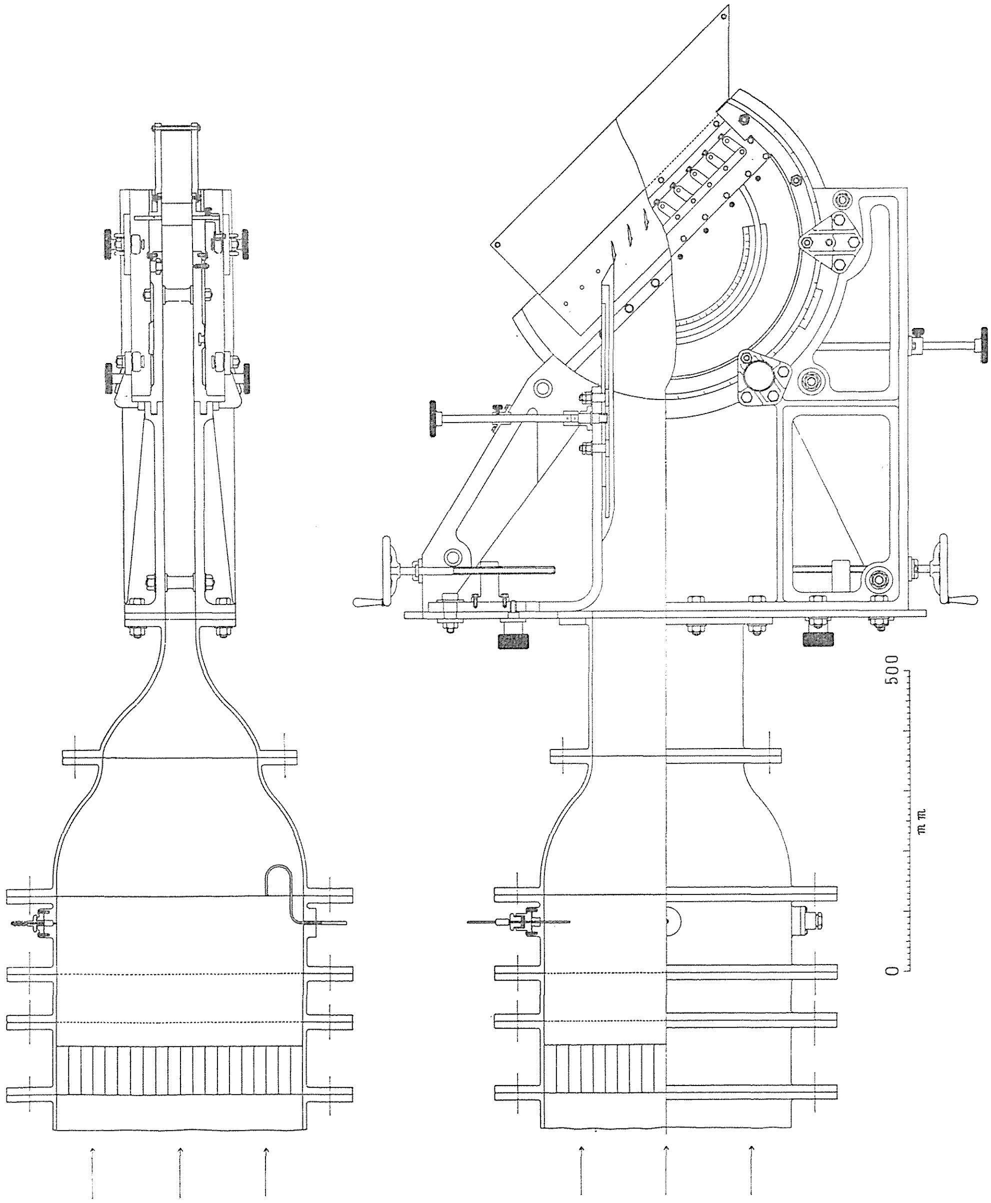
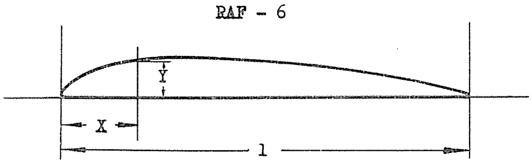


FIG. 1



X	Y
0.025	0.041
0.050	0.059
0.100	0.079
0.200	0.095
0.300	0.100
0.400	0.099
0.500	0.095
0.600	0.087
0.700	0.074
0.800	0.056
0.900	0.035
leading edge radius	0.010
trailing edge radius	0.0077

FIG. 2

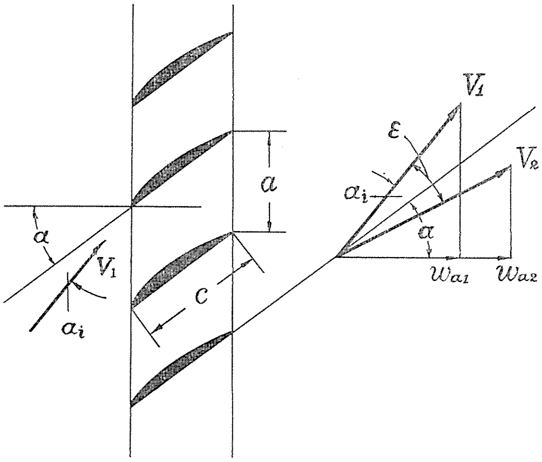


FIG. 3

Scopes of experments are as follows:

$a=20,\ 30,\ 40$ mm.
$a/c=0.83,\ 1.25,\ 1.67$
$\alpha=0°,\ 30°,\ 50°,\ 60°$.
$\alpha_i=0°,\ 5°,\ 10°,\ 15°$.
With and without exit side walls.

Surveying positions in upstream and downstream, and dimensions of exit side walls are illustrated in Fig. 4.

Measurements carried out are spanwise traverse of air velocity at the position of h_1 upstream of the cascade (see Fig. 4), and air velocity (direction and speed) at midspan and h_2 downstream of the cascade. Measurements were repeated with and without exit side walls.

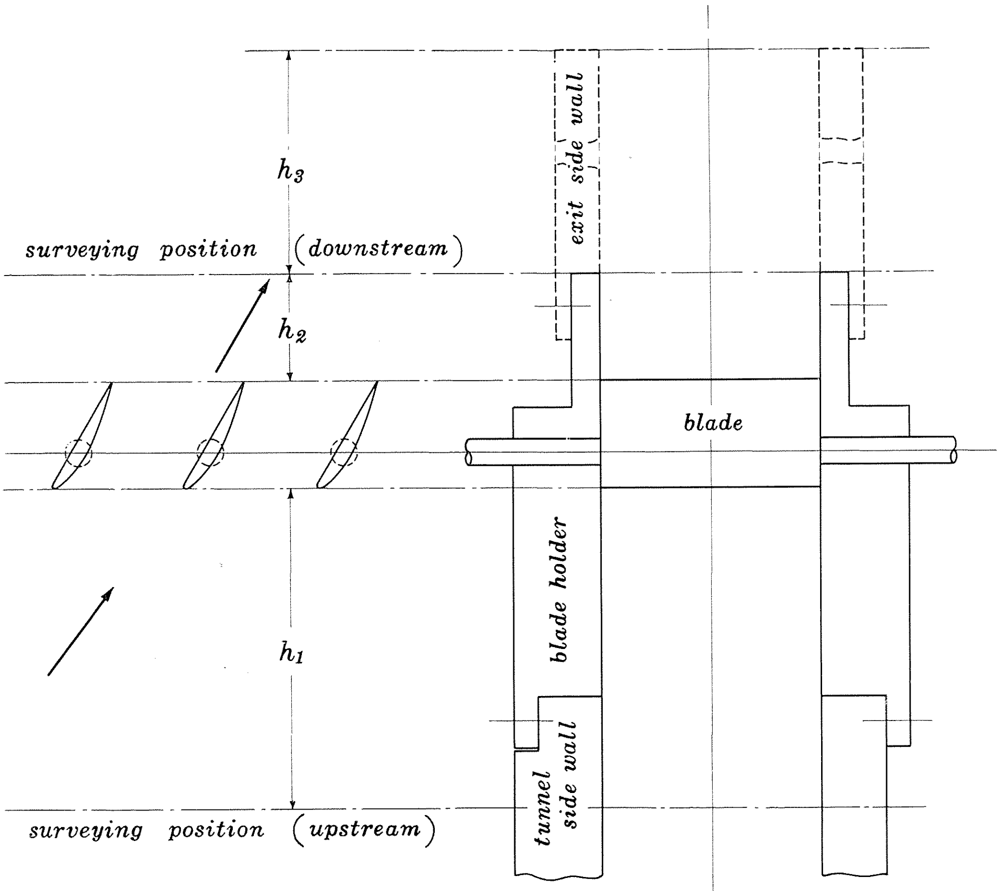
Measuring probes were made by cupro-nickel tube of 0.7 mm in diameter. Yaw probe was of arrow head type with a total pressure tube at the center. Fig. 5 is the photograph of yaw-total probe in position.

Reynolds Number was about 1.1×10^5 in every experiments.

The procedure is not so much different from the experiment of reference [1] except for excit side walls.

Results and Considerations

One typical example of inlet velocity distribution is illustrated in Fig. 6. No qualitative difference is recognized in other cases. The difference between the cases of short exit walls and long ones is also unnoticeable. On the displacement



α	h_1	h_2	h_3
0°	72	24	115
30	73	26	115
50	75	30	70
60	76	32	70

FIG. 4

thicknesses of inlet boundary layers in each cases, the reader refer to Table 1.

Turning angle ε, loss coefficient ζ_2 and axial-velocity ratio w_{a2}/w_{a1} (these are values at the center of span) are also listed up in the same table. The pressure and flow direction at the outlet side were represented by the mean values in cascade direction. ζ_2 was based on the dynamic pressure at the center of span of outlet side. The reason not to take the inlet dynamic pressure is to be referred to reference [2], in which ζ_2 are considered to be practically constant in the range of $AR=1.5\sim6$.

From Table 1 we can say that there appears no effect of exit side wall length on cascade performances. This is a very simple and clear conclusion, but authors think that some supplemental remarks must be added as follows.

Firstly, it is supposed that the conclusion above mentioned is not to be con-

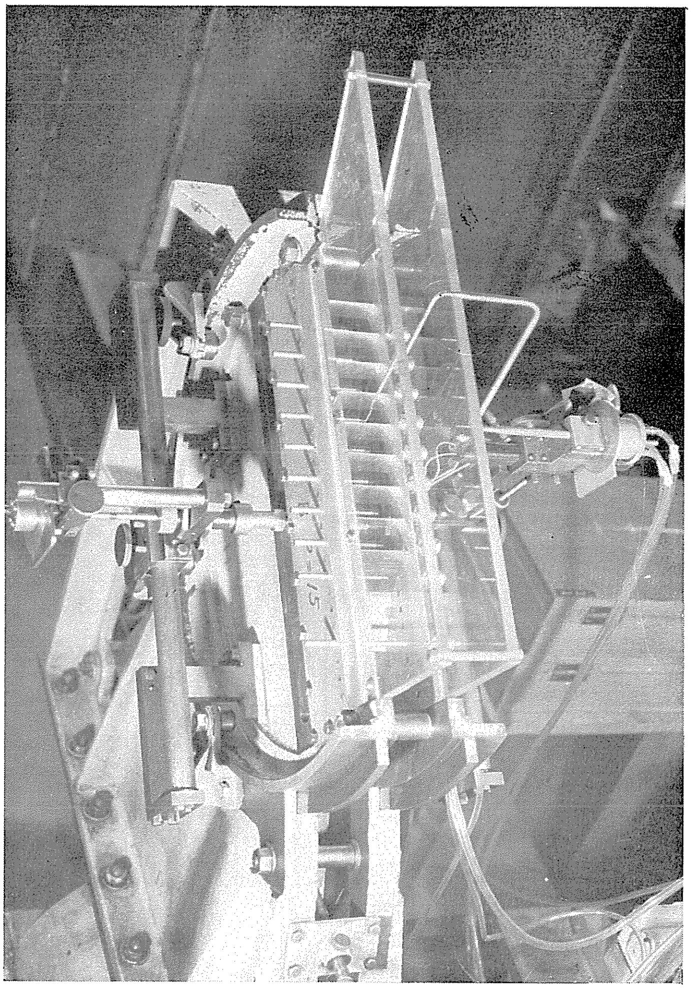


FIG. 5

sidered as an universal one. In this experiment, the shorter exit side walls has the length $h_2=1\sim1.5\,c$ as illustrated in Fig. 4. We must therefore say, if we say a little more strictly, that "If we provide exit side walls having the approximate axial length $h_2=1\sim1.5\,c$ from the trailing edge of cascade and do measurements of exit flow at the exit plane of these side walls, we can get the values for the configurations with exit side walls infinitely long".

Secondly, this conclusion is the one concerning the value only at the center of apan and the spanwise distribution of exit flow has not yet been investigated. Almost same conclusion is expected to be obtainsd, but the experiment is now at the stage of contemplation and we can say nothing about it.

Thirdly, we have no data about the case of $h_2=0$. But since in almost all cascade experiments the traverse is done at the fairly downstream position, the setting of exit side walls of $h_2=1\sim1.5\,c$ produces no inconvenience on experimental techniques. We recommend, therefore, to use exit side walls of such length.

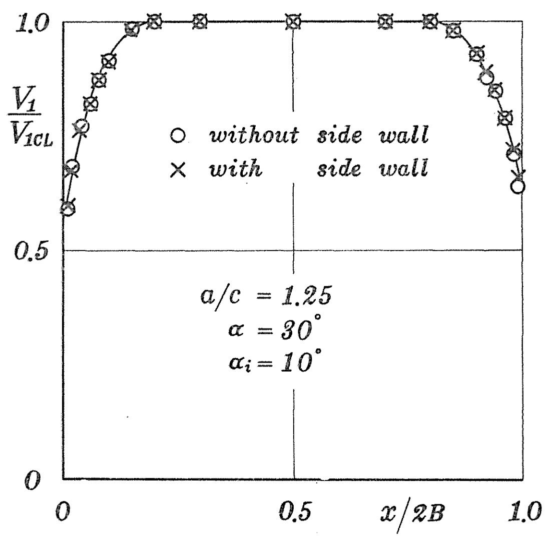


FIG. 6

Conclusions

In the cascade experiment, if we provide exit side walls having the approximate axial length $h_2 = 1 \sim 1.5\,c$ from the trailing edge of cascade and do measurements of exit flow at the exit plane of these side walls, we can get the value for the configurations with exit side walls infinitely long.

TABLE 1 (a)

a/c	α	α_i	δ_1^*/B (%)	ε		w_{a2}/w_{a1}		ζ_2	
				without	with	without	with	without	with
0.83	0°	0°	5.6	5.2°	5.0°	0.956	1.004	0.048	0.047
		5	5.6	10.7	10.7	1.002	1.007	0.032	0.029
		10	5.6	15.6	15.5	1.014	1.011	0.018	0.024
		15	5.5	19.7	19.7	1.016	1.013	0.021	0.025
	30°	0°	4.8	1.3°	1.5°	1.022	0.997	0.079	0.072
		5	4.6	8.1	8.2	1.038	1.035	0.046	0.046
		10	4.4	13.3	13.7	1.066	1.082	0.032	0.024
		15	4.9	17.6	17.6	1.107	1.100	0.036	0.031
	50°	0°	4.5	−2.0°	−1.8°	0.986	0.998	0.105	0.106
		5	4.4	5.4	5.6	1.049	1.050	0.092	0.093
		10	4.3	11.6	11.5	1.148	1.151	0.064	0.062
		15	4.2	17.6	17.3	1.396	1.400	0.068	0.064
	60°	0°							
		5	4.4	5.5°	5.6°	1.070	1.068	0.154	0.161
		10	5.0	13.5	13.3	1.415	1.433	0.087	0.075
		15	4.8	18·5	18.3	1.911	1.923	0.092	0.157

TABLE 1 (b)

a/c	α	α_i	δ_1^*/B (%)	ε		w_{a2}/w_{a1}		ζ_2	
				without	with	without	with	without	with
1.25	0°	0°	5.0	4.1°	4.2°	1.003	0.974	0.033	0.023
		5	5.4	9.4	9.4	1.006	1.007	0.020	0.017
		10	5.3	13.4	13.4	1.015	1.017	0.012	0.014
		15	4.9	17.3	17.2	1.022	1.029	0.020	0.019
	30°	0°	5.3	3.0°	3.0°	1.028	1.020	0.040	0.041
		5	4.9	8.1	8.1	1.040	1.044	0.029	0.026
		10	4.7	12.0	11.9	1.078	1.054	0.018	0.021
		15	4.5	15.4	15.7	1.116	1.112	0.034	0.034
	50°	0°	4.7	0.3°	0.8°	0.983	1.021	0.065	0.062
		5	4.6	7.3	7.3	1.083	1.082	0.041	0.040
		10	4.3	11.8	11.7	1.218	1.223	0.023	0.024
		15	3.6	15.1	15.7	1.369	1.400	0.050	0.043
	60°	0°	4.2	0.5°	0.4°	0.995	0.994	0.083	0.086
		5	3.9	7.1	7.1	1.135	1.135	0.054	0.051
		10	3.5	12.3	12.2	1.418	1.406	0.037	0.040
		15	4.0	16.7	16.8	1.821	1.819	0.080	0.083

TABLE 1 (c)

a/c	α	α_i	δ_1^*/B (%)	ε		w_{a2}/w_{a1}		ζ_2	
				without	with	without	with	without	with
1.67	0°	0°	4.7	3.5°	3.4°	1.037	1.012	0.019	0.019
		5	5.1	8.1	8.1	1.014	1.018	0.013	0.013
		10	5.2	11.9	11.8	1.016	1.021	0.011	0.009
		15	5.2	15.1	15.4	1.035	1.037	0.016	0.016
	30°	0°	5.6	2.3°	2.3°	1.007	1.010	0.025	0.026
		5	5.5	7.2	6.9	1.045	1.035	0.017	0.017
		10	5.4	10.8	10.8	1.065	1.067	0.015	0.018
		15	5.0	13.8	13.8	1.105	1.105	0.030	0.031
	50°	0°	4.7	1.4°	1.4°	1.008	1.007	0.044	0.048
		5	5.0	6.6	6.7	1.078	1.079	0.028	0.029
		10	4.3	10.1	10.3	1.169	1.174	0.020	0.021
		15	4.0	13.3	13.4	1.309	1.314	0.055	0.059
	60°	0°	4.2	0.9°	1.1°	0.999	1.001	0.052	0.048
		5	4.0	6.2	6.3	1.114	1.118	0.034	0.033
		10	3.9	10.7	10.6	1.357	1.353	0.036	0.033
		15							

References

1) S. Otsuka and T. Sato: Experiments on the comparison between Cascade and Axial-flow Compressor Performances (Part I: Experiment on Cascades), Memoirs of the Faculty of Engineering, Nagoya University, **Vol. 14**, No. 1-2 (1962).

2) S. Otsuka and K. Masuda: An Experiment about the Effect of Aspect Ratio on Cascade Performances, Transaction of the Japan Society for Aeronautical and Space Sciences, **Vol. 9**, No. 14 (1966).