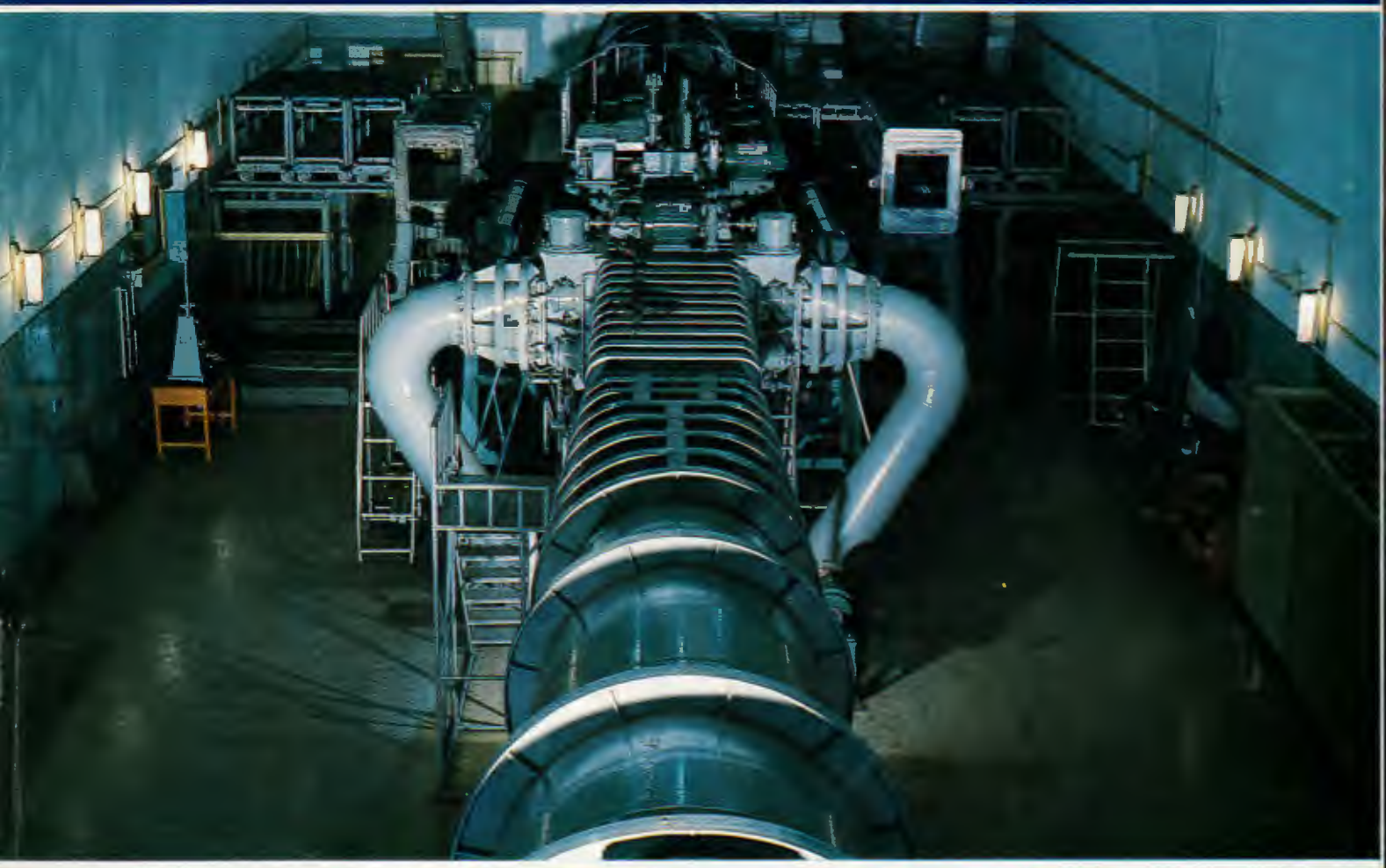
FD-06跨、超音速風洞

FD-06 TRANSONIC-SUPERSONIC WIND TUNNEL



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● Standard model testing in FD-06　● FD－06中的標準模型試驗

FD-06 was built and put into service in 1962. It is a trans-supersonic wind tunnel of intermittent semi-return type with Mach numbers ranging from 0.6 to 4.5. The cross section of the test section is 0.6m×0.6m and the length is 1.575m.

Fig. 1 is the layout of the FD-06. The main parts of the wind tunnel consists of the settling chamber, nozzle, test section, supersonic diffuser, inhaling injector with a mixing chamber, returnflow injector with a mixing chamber, return passage, silencer, subsonic diffuser and pipe valves.

In transonic experiment, different Mach numbers (M = 0.6~1.2) are obtained with a sonic-nozzle and by changing the pressure in the settling chamber. When doing supersonic experiment, nozzle replacements are needed for different Mach number (1.5~4.5). The angle of the ceiling and bottom wall of the test section could be adjusted within ±3 degrees. During transonic testing the ceiling and bottom walls are composed of porous plates with vertical holes of the porosity of 24.2%.

In each side wall of the test section there are two viewing-windows of diameter 235mm for flow visualization of the model with the Schlieren system. The second window is 360° rotatable and can be used to mount the semi-model balance.

The pressure in the air storage is 22.5 atm, its volume being 6600m^3. Therefore, the duration of each running is long enough.

The uniformity of the flow field in the wind tunnel is satisfactory and the axial pressure gradient is very low. In the Mach number range 0.6~4.5, the uniform cross sections of the flow field are 400×400mm^2 for nozzles No.1 to No.8, and 300/300mm^2 for nozzle No.9. The axial length of the uniform region is 625mm from x = 125mm to 750mm (with the origin of x at the inlet of test section). The transonic and supersonic flow fields have all-sidely satisfied the National Standards of the high speed wind tunnel (see Fig.2 and Table 1).

FD－06是1962年投入運行的跨、超音速風洞，它是半迴流暫冲式風洞，馬赫數範圍爲 0.6～4.5 、試驗段橫截面積爲 0.6 米×0.6 米，長 1.575 米。

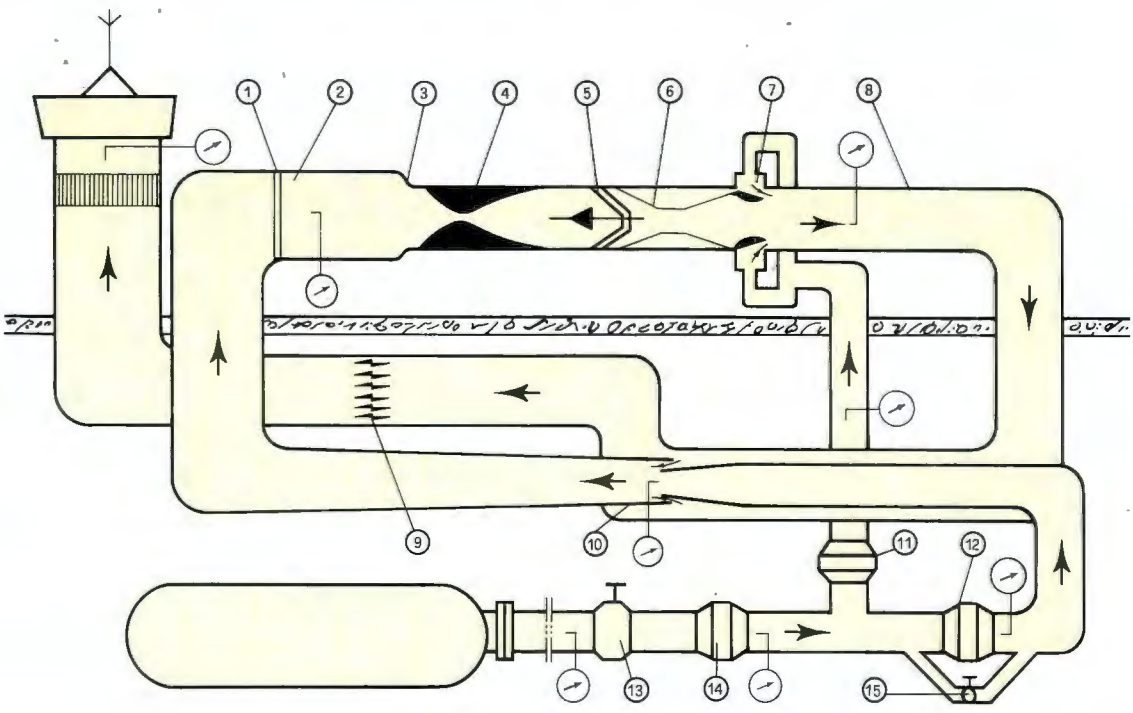
圖 1 是 FD－06佈局簡圖，風洞主要由前室、噴管、試驗段、超音速擴散段、帶有混合室的吸入引射器、帶有混合室的增量引射器、迴流段、消音器、亞音速擴散段及管道閥門等部件組成。

跨音速實驗時，用音速噴管並改變前室壓力來得到不同的M數（0.6～1.2）；做超音速實驗時，通過更換噴管塊得到不同的M數（1.5～4.5）。試驗段上、下壁的角度可以在± 3° 內調節。跨音速實驗時上、下壁爲帶有24.2%開閉比的直孔板。

試驗段的每一側壁有兩個直徑爲 235 毫米的觀察窗，可供模型的紋影儀流場顯示用，第二觀察窗可轉180° ，能支承半模型天平。

風洞氣源壓力爲22.5大氣壓，氣源容積爲6600立方米，由於氣源容量大，故風洞有相當長的工作時間。

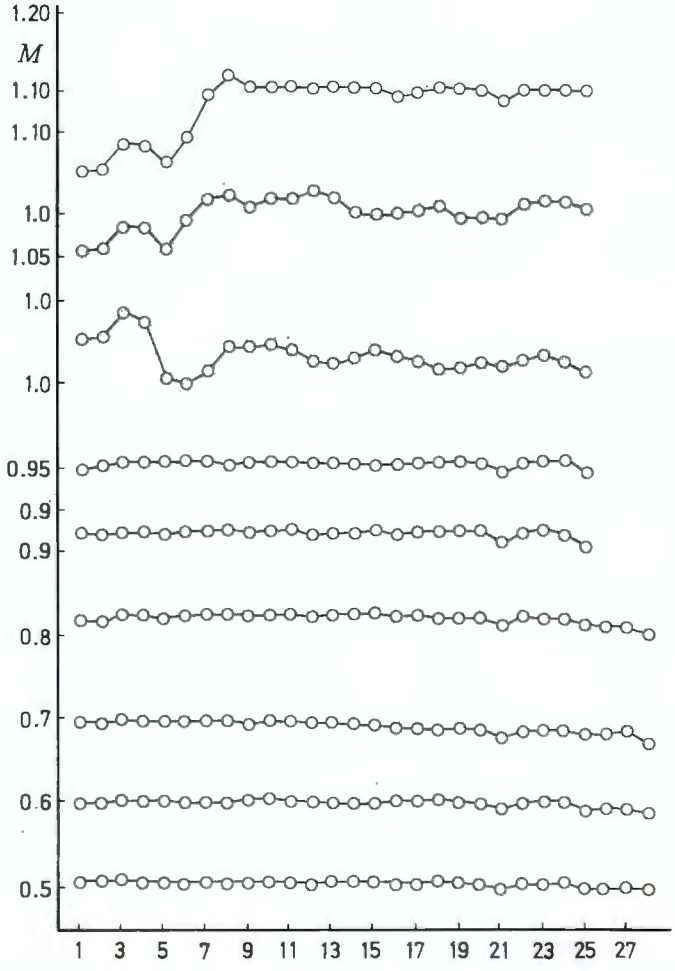
風洞有令人滿意的流場均勻性，軸向壓力梯度很低。在試驗M數範圍 0.6～4.5 內，流場均勻區的橫截面積如下：1#～8#噴管爲400×400平方毫米，9#噴管爲300×300平方毫米，均勻區軸向範圍總長爲 625 毫米，即X＝125～750 毫米（試驗段入口中心點作爲X軸原點）。跨超音速流場全面符合高速風洞流場標準（見圖 2 和表 1 ）。



1 Honey comb
2 Flow screen
3 Settling chamber
4 Nozzle
5 Testsection
6 Supersonic diffuser
7 Inhaling injector
8 Subsonic diffuser
9 Discharge
10 Returnflow Injector
11 1# adjusting Valve
12 2# adjusting Valve
13 Inlet valve
14 Start valve
15 By-pass valve

1. 蜂窩器
2. 阻尼網
3. 前　室
4. 噴　管
5. 實驗段
6. 超音速擴散段
7. 吸入引射器
8. 亞音速擴散段
9. 排氣節流門
10. 迴流引射器
11. 1#調壓閥
12. 2#調壓閥
13. 總閥
14. 啓動閥
15. 旁路閥

● Fig.1 Layout of FD-06　● 圖 1 FD－06簡圖



● Fig.2 Mach number distributions along the axis of test section　● 圖 2 沿試驗段的軸向馬赫數分佈

噴管號 No. of Nozzles	$\overline{M}$	εM	$\frac{dM}{dx}$（1/米）(1/m)	$\Delta\overline{\alpha}$（度）(deg.)
0	0.55 ~ 1.19	0.0016 ~ 0.0111		
1	1.53	0.010	0.031	0.06
2	1.80	0.014	0.017	0.09
3	2.04	0.0166	–0.014	0.27
4	2.28	0.015	–0.028	0.08
5	2.53	0.0185	–0.040	0.01
6	3.01	0.018	–0.069	0.15
8	3.54	0.015	–0.004	–0.06
9	3.99	0.012	0.032	–0.06
10	4.59	0.013	0.026	–0.03

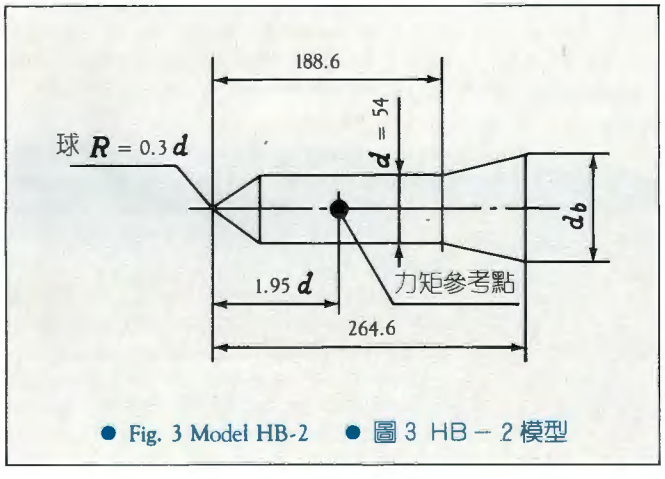
● Table 1 Flow field performance of FD-06 ● 表 1 FD－06流場性能

The experiment results of pressure distributions on a 20° cone-cylinder model in the wind tunnel with porosity 24.20% and diffuser angle 0.3° indicate that the wall effects have essentially been eliminated for subsonic region, and a little effects for sonic reigon.

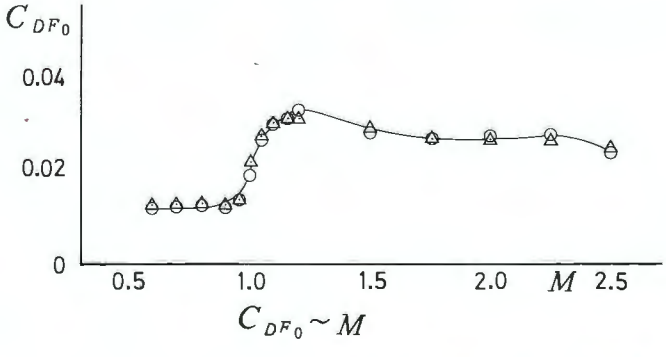
Force and moment result of model HB-2 are shown in Fig. 3 and 4. The curves indicate satisfactory regularity and in agreement with results obtained in three foreign wind tunnels. The experiment results of standard model AGARD-B are in agreement with the domestic averages and close to foreign results (see Fig.5 and 6).

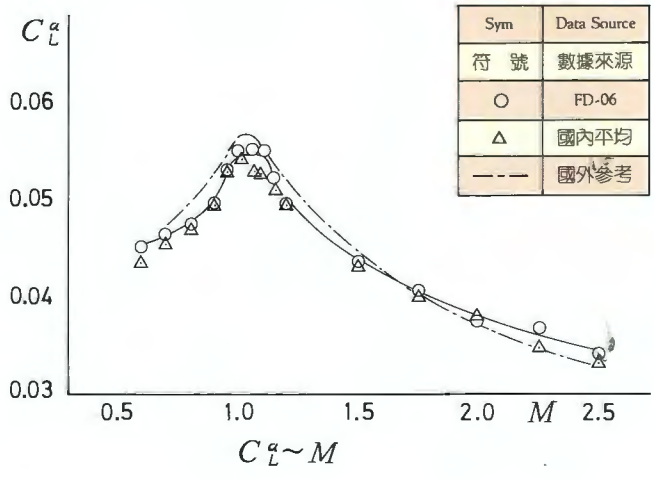
開閉比爲24.2%、δ =0.3° 時，20° 錐柱體模型測壓實驗結果表明，亞音速時基本上消除了壁面效應，近音速時有一小的影响。

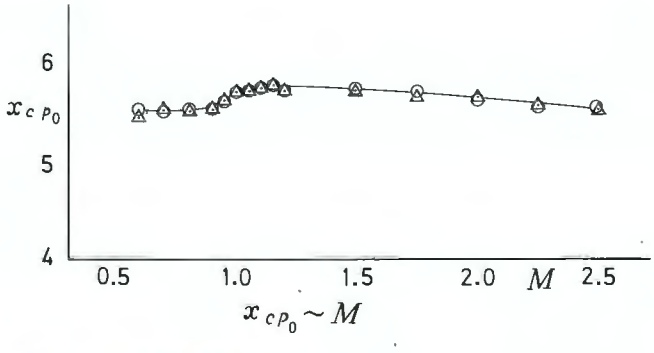
圖 3 和圖 4 標模 HB－2 的力和力矩結果，曲綫所示規律很好並和國外三個風洞結果比較符合，AGARD-B 小標模實驗結果與外國參考值及國內平均值相吻合（圖 5 和圖 6）。



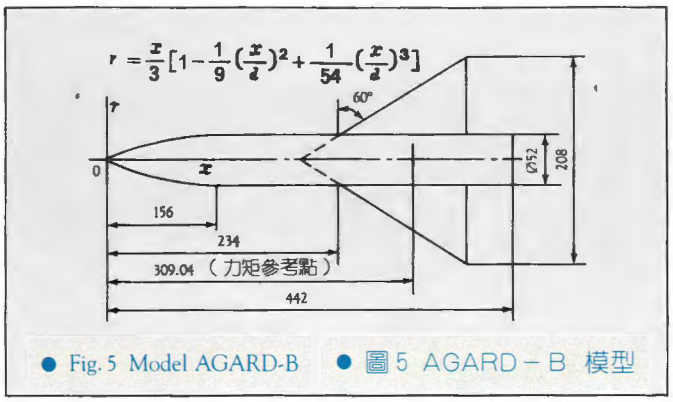
● Fig. 3 Model HB-2 ● 圖 3 HB－2 模型





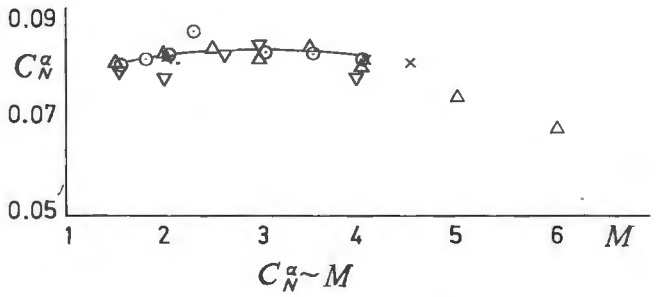


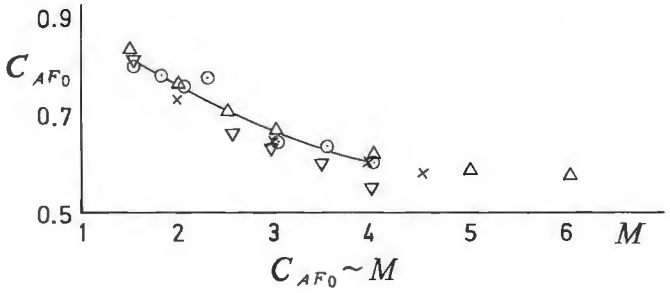
● Fig. 4 Curves for model HB-2 ● 圖 4 HB－2 模型實驗結果

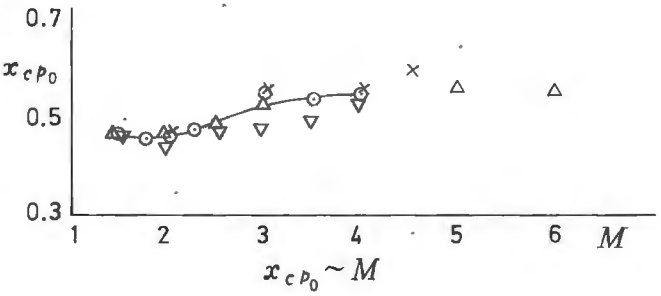


● Fig. 5 Model AGARD-B ● 圖 5 AGARD－B 模型

Sym	符號	○	△	▽	×
Wing Tunnel	風洞	FD-06	AEDC-A	1MX1M (Japan) (日)	BRL-(1)



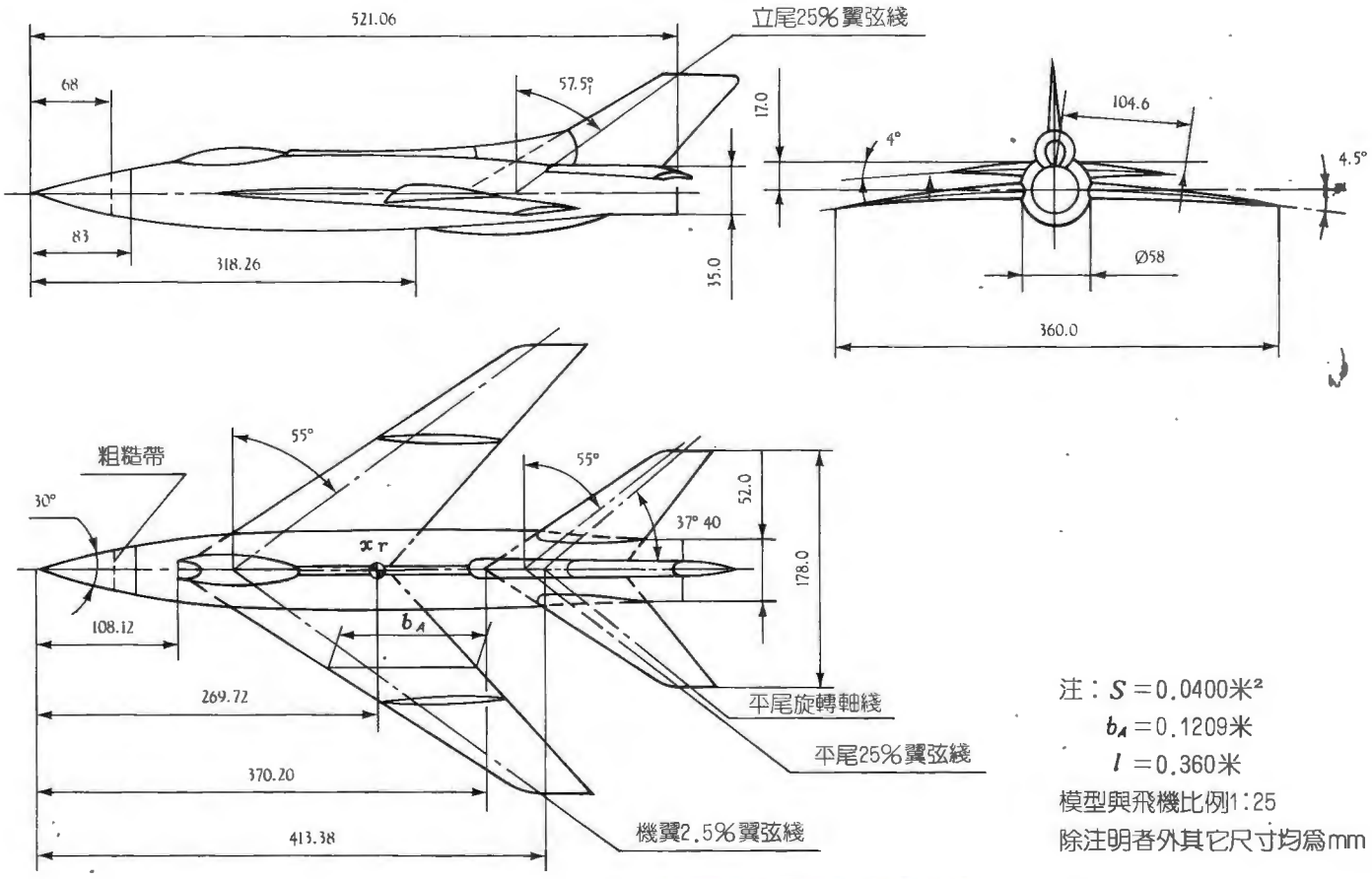




● Fig. 6 Curves for model AGARD-B ● 圖 6 AGARD－B 模型實驗結果

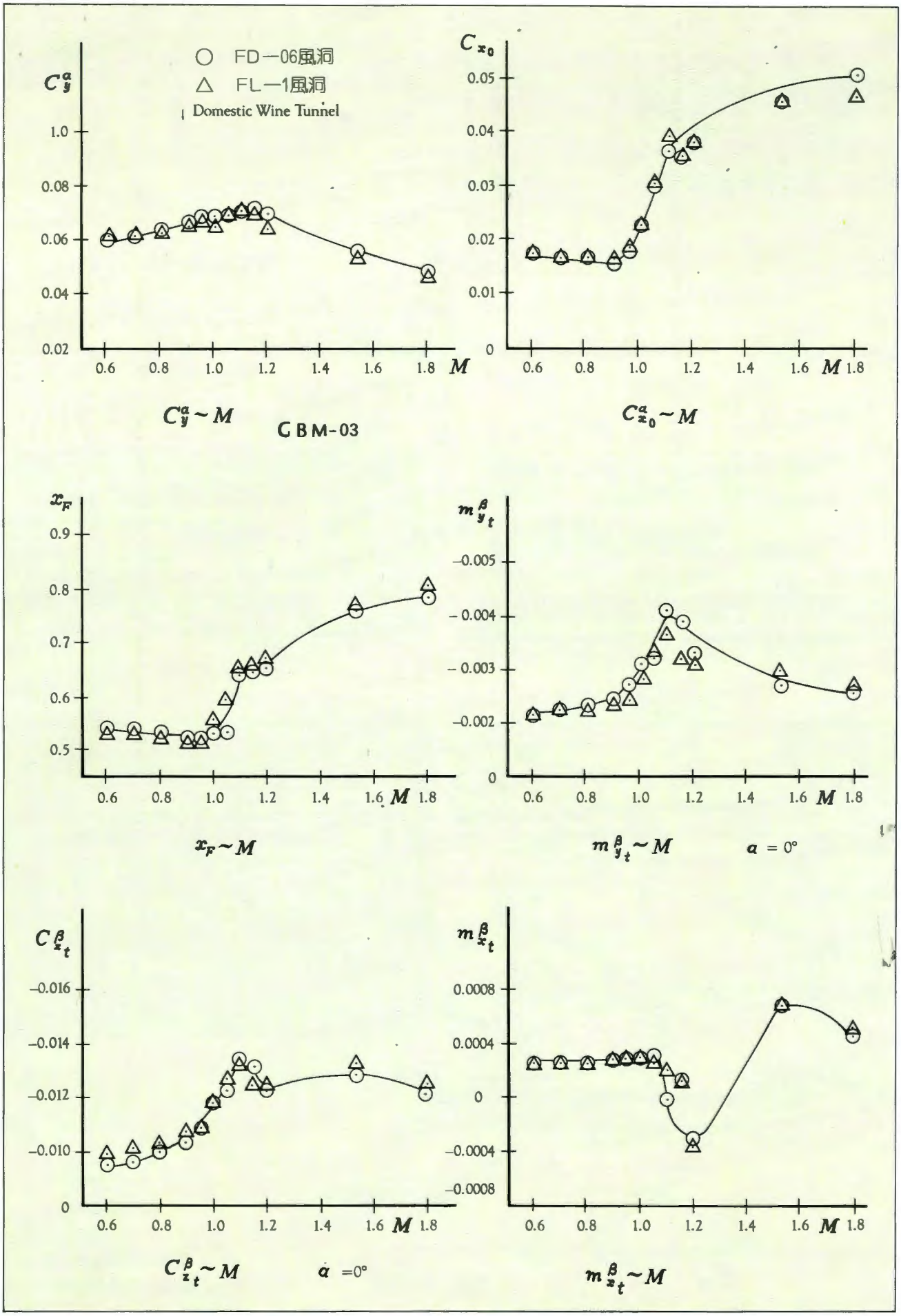
The six component results of forces and moments on the standard model GBM-3 obtained in the wind tunnel FD-06 also indicate satisfactory regularity with domestic reference values (see Fig.7 and Fig.8)

GBM－03 標模的力和力矩六個分力試驗結果和國內平均值很相吻合（見圖 7 和圖 8）。



注：$S=0.0400$米²
$b_A=0.1209$米
$l=0.360$米
模型與飛機比例1:25
除注明者外其它尺寸均爲mm

● Fig.7 Model GBM-03 ● 圖 7 GBM－03 模型結構



● Fig.8 Curves for model GBM-03 ● 圖 8 GBM－03 模型實驗結果

The operation of the wind tunnel is controlled by an electronic computer control system, which consists of the pressure-adjusting valves, angle of attack control and display device, Mach number monitoring and control device, supersonic diffuser position control and display device, start valve and discharge valve control and display device and safety lockout device.

This tunnel is equipped with data acquisition and processing system, measurement system, including scanning valve pressure transducers, various external and internal strain gauge balances with components from one to six for complete or semi-model tests, schlieren photo taking system, industrial video monitoring system, etc.

風洞由電子計算機控制，控制系統主要由調壓閥壓力控制顯示系統、攻角機構控制顯示系統、M數監控系統、超音速擴散段調節位置及顯示系統、啓動閥和節流閥的控制顯示系統及安全聯鎖等部份組成。

風洞配有數據檢測和處理系統、測量系統，後者包括掃描閥、傳感器、各種內式和外式天平，從單分量到六分量，全模型和半模型的天平，紋影照像系統，工業電視監察系統等。

● Control room of FD-06　● FD－06控制室

The main testing items in FD-06 are as follows:

— Longitudinal forces and moments
— Transverse forces and moments
— Air inlet experiments
— Pressure distributions
— Fluctuating pressures
— Air jetting
— Hinge moments of complete or semi-models
— Large angles of attack experiments
— Dynamic derivatives
— Buffeting
— Magnus effect
— Flow and vortex visualizations

FD－06主要試驗項目有：

—— 縱向測力試驗
—— 橫向測力試驗
—— 進氣道實驗
—— 測壓試驗
—— 脈動壓力測量
—— 噴流試驗
—— 全模型、半模型鉸鏈力矩試驗
—— 大攻角試驗
—— 動導數試驗
—— 抖振實驗
—— 馬格努斯效應試驗
—— 流態及渦迹顯示實驗

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