BIA

FD－09低速風洞

FD-09 LOW SPEED WIND TUNNEL

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FD－09試驗段
Test Section of FD-09 Wind Tunnel

飛機起飛着陸模擬試驗
Aircraft testing with a Ground Plane

FD －09 低速風洞於1966年建成。這是一個單迴路閉口風洞。除了試驗段（圖1 中①）和風扇段⑤爲鋼結構外，整個風洞系由鋼筋混凝土建造。試驗段長12米，其橫截面呈 3 米×3 米的四角圓化正方形，圓角半徑爲 0.5 米。試驗段兩個側壁互相平行，而上下壁則各有 0.2 度擴散角，以減少邊界層增長的影響。收縮段⑨的收縮比爲10:1。在穩定段⑥中安裝有寬 500 毫米的蜂窩器⑦和兩層阻尼網⑧，在第一、第二擴散段②末端設有換氣裝置③，以降低洞體內氣流的溫升。第二拐角後是直徑爲 5.5 米的風扇。風扇有10個業片，並由2060千瓦的直流電機驅動。風洞流速可以從每秒10米無極變化到每秒 100 米。

圖 1 是風洞氣動佈局圖和其實驗室外觀圖。

表 1 列出了風洞試驗段中的氣流流場品質，其質量是令人滿意的。

The FD-09 low speed wind tunnel was set up in 1966. It is of closed-circuit, single-return type. The whole tunnel is formed from armoured concrete with the exception of the test section (1) and the fan section (5), which are of welded steel construction. The test section is 12m long, 3m×3m square with circular corner fillets of 0.5m in radius. The sidewalls of the test section are parallel while the roof and floor are diverged 0.2 degree each to account for boundary layer growth. The contraction ratio of the contraction section(9) is 10:1. A honey comb(7) of 500mm in width and two damping screens(8) are installed in the settling chamber (6). The divergence angles of the first and second diffusers (2) are 5 degrees and 5.5 degrees respectively. Air exchanger(3) is provided for cooling the airstream,with an intake slot at the downstream of the first diffuser and an exit in front of the third corner. The fan just behind the second corner is 5.5m in diameter. It has 10 blades driven by a DC motor of 2060 KW in power. Flow speed ranges from 10m/sec to 100m/sec.

Fig 1 shows the layout of the wind tunnel and its relevant buildings.

The quality of the flow field in the test section is very satisfactory (see table 1).

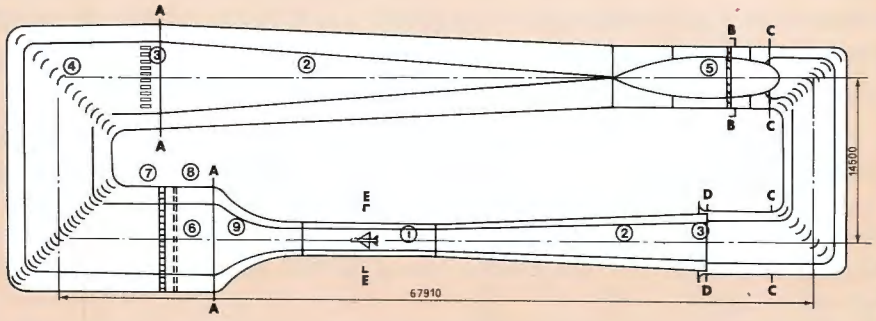
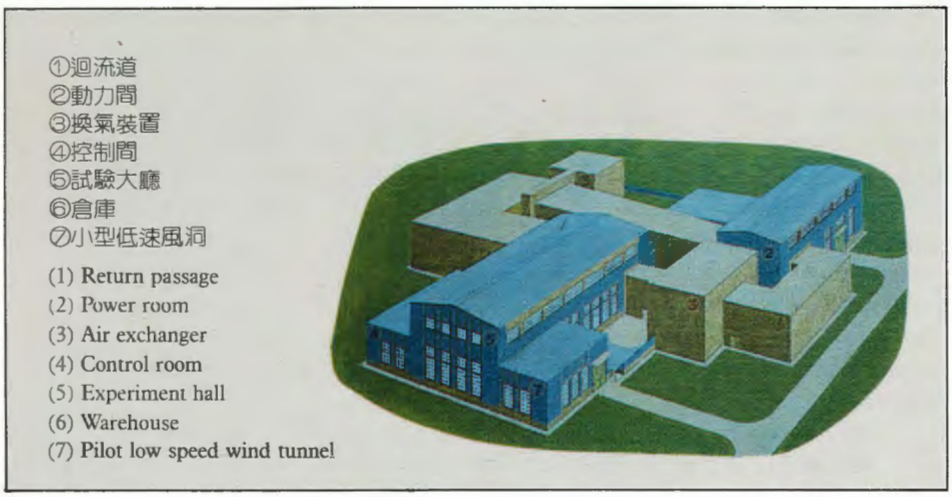


圖 1 FD－09氣動佈局圖 Fig 1. Circuit View of FD-09

①試驗段	(1) Test Section
②擴散段	(2) Diffuser
③換氣裝置	(3) Air exchanger
④拐角導流片	(4) Corner vanes
⑤風扇段	(5) Fan section
⑥穩定段	(6) Settling chamber
⑦蜂窩器	(7) Honey comb
⑧阻尼網	(8) Damping screens
⑨收縮段	(9) Contraction section

表 1 流場性能 Table 1 Flow Field Performances

縱向靜壓梯度 Longitudinal static pressure gradient	≈0
氣流穩流度 Turbulence level	ε =0.10~0.13%
動壓偏差 Dynamic pressure fluctuation	$\left\|\frac{\Delta q}{q}\right\| \leqslant 0.5\%$
縱向平均氣流偏角 Flow angularity	$\triangle\alpha$ ∠0.1°
邊界層厚度 Thickness of boundary layer	δ = 130 毫米mm



FD －09控制系統是一個以微機爲主，輔以電子機械和電子液壓器件的自動控制裝置。系統的作用是控制流速、模型姿態角和地面模擬板的高度。風洞還配備了數據檢測系統。試驗時實驗數據可以實時處理。曾用標準模型DBM-01-02(圖2)來校測風洞。圖3是該標模在FD －09中所得的實驗結果，由圖可見，實驗結果和國內公認的參考標準很相吻合。

FD-09 has an control system which consists of electronic-mechanical controls, electronic-hydrautic jack controls and a microcomputer. The functions of the system are controls of the flow speeds, model attitudes and ground-simulator-plate heights. This tunnel is equipped with data acquisition system. The experimental data are reduced on real time during testing. The standard model DBM-01-02 (Fig 2) was employed to calibrate the tunnel.

Fig 3 shows the experimental results obtained in the wind tunnel for the model DBM-01-02. It is indicated that the results are in good agreement with the national demands.

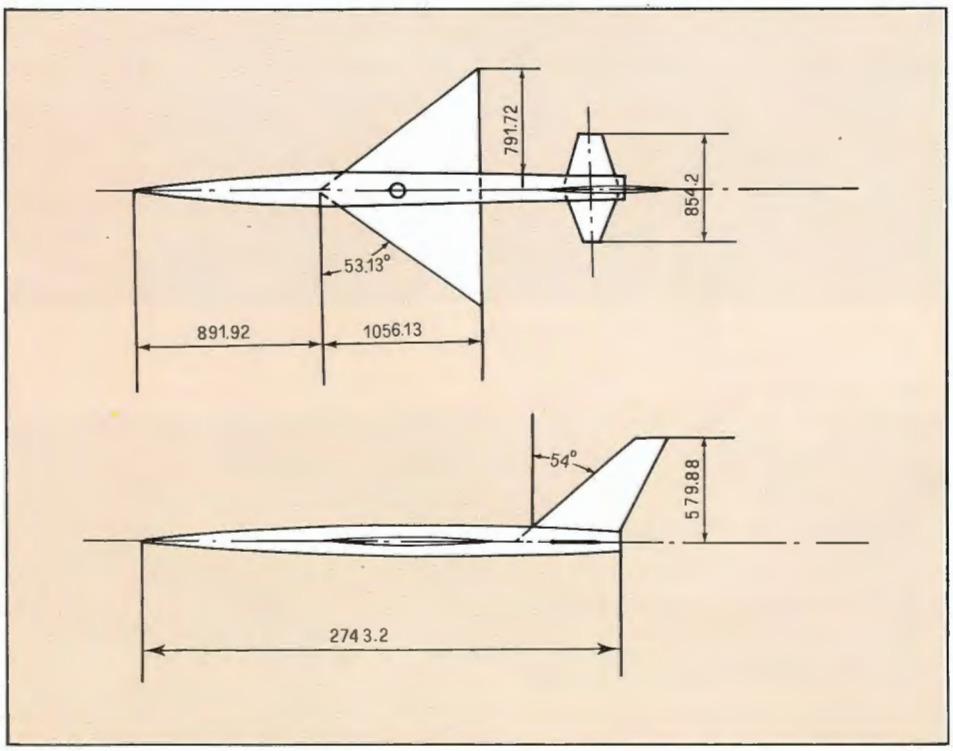
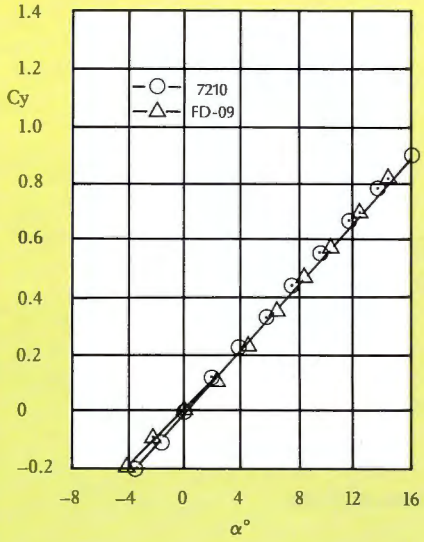


圖2 DBM-01-02標準模型 Fig 2 Standard Model DBM-01-02

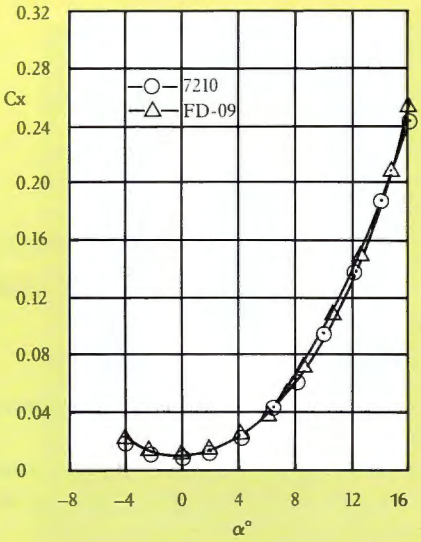
FD －09配有各種測量儀器和試驗裝置，如掃描閥、應變天平、塔式六分力和四分力天平，大攻角試驗裝置，捕獲彈道裝置、高速攝影機等。

FD-09 is equipped with many measurement apparatus and equipment, such as scanning valve unit, strain-gauge balances, four and six component pyramidal type mechanical balances, six-freedom support system, device of large angle of attack, high speed cameras..., etc.

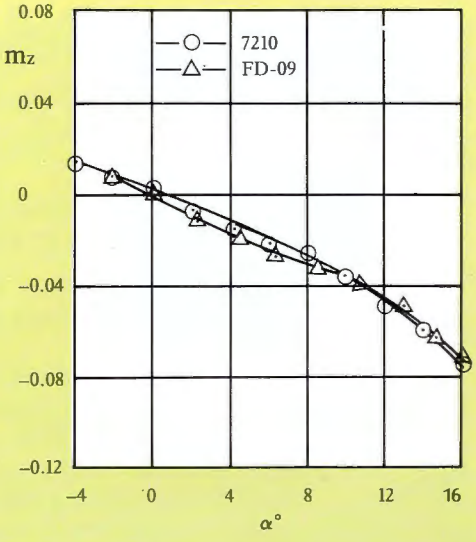
圖 3　DBM-01-02標模在 FD-09 中的實驗結果　Fig 3 Curves for the Standard Model DBM-01-02



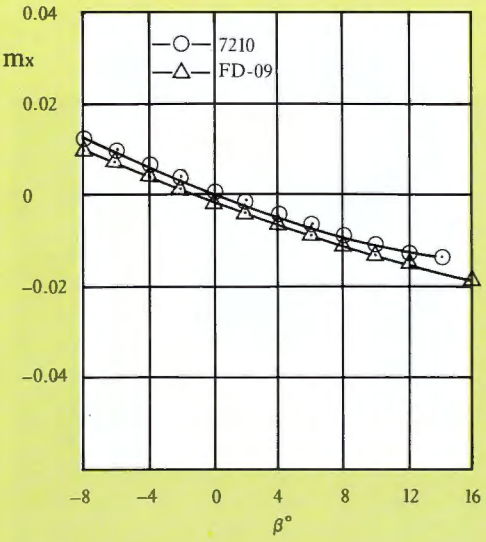
(a) Cy ~ α



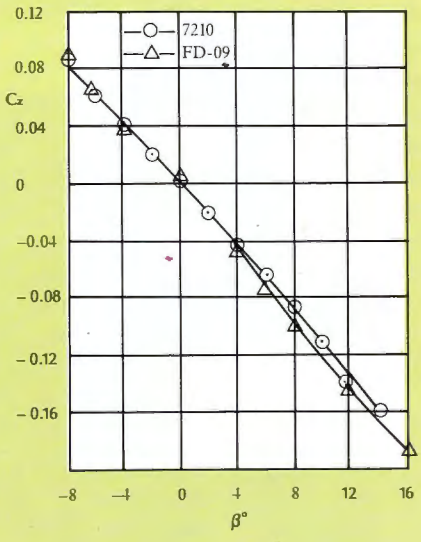
(b) Cx ~ α



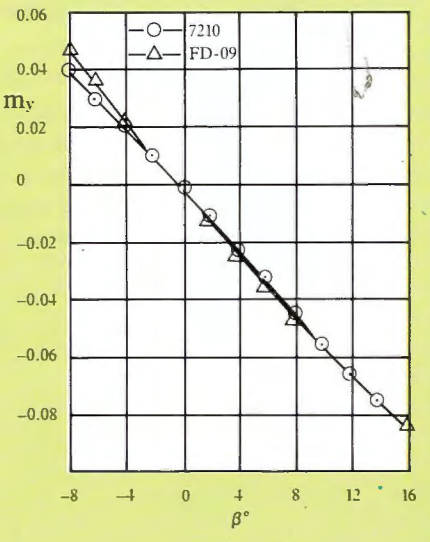
(c) mz ~ α



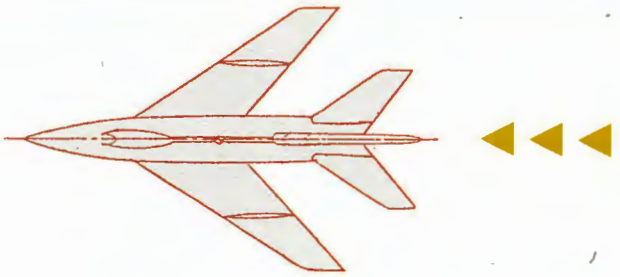
(d) mx ~ β



(e) Cz ~ β



(f) my ~ β



FD－09可以承担用戶要求的各類低速空氣動力試驗項目，已進行過的主要項目有：

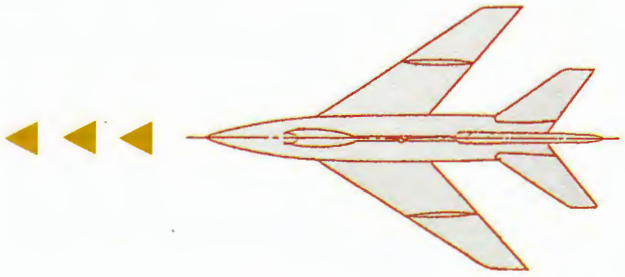
——各種模型常規測力測壓或帶噴流帶螺旋槳的航空飛行器特種測力測壓試驗；
——飛機、導彈和艦船等模型各種操縱舵面的鉸鏈力矩試驗；
——飛機彈射座艙蓋以及炸彈、付油箱等外掛物投放試驗；
——飛機外掛物之間相互干擾試驗；
——飛行器和橋樑的顫振試驗；
——高層建築、雷達機罩以及抛物面天綫等地面風載試驗；
——各種降落傘、阻力器試驗；
——高級機車、汽車試驗；
——直升機旋翼和風洞試驗；
——流場顯示實驗；
——比托管校測；
——自行車、風帆和滑雪等體育運動的氣動力研究試驗。

值得一提的是FD－09已被有關當局指定爲汽車空氣動力試驗的風洞，且在不影響風洞能做航空、航天等試驗的情況下，對風洞的測試裝置和地面模擬板、支架等作了改造，從而使風洞能做各類汽車的多種試驗。

Various kinds of tests are made in FD-09:

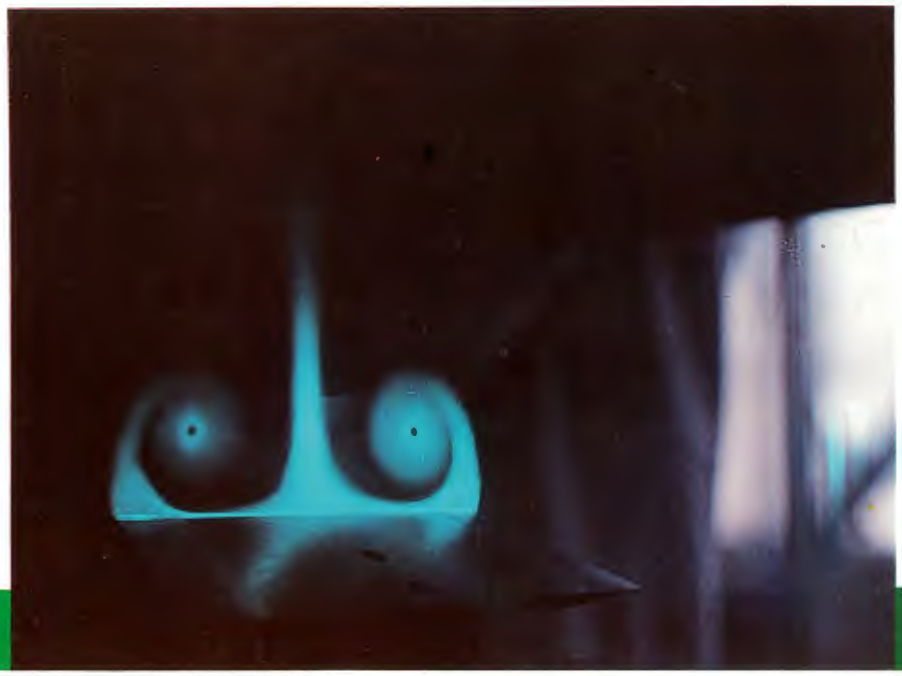
—— Forces and moments or pressure distributions on non-powered models or powered models with scaled propellers or air jets.
—— Hinge moments of rudders on aircrafts, missiles or submarines.
—— Catapulting of a pilot with a seat and dropping of external wares from aircraft, such as bombs, gasoline tanks and missiles.
—— Aerodynamic interference between an aircraft and its external wares.
—— Fluttering of aircrafts and bridges.
—— Wind loadings on tall buildings and structures, radar caps and paraboloid antennas.
—— Various parachutes.
—— High speed locomotives and automobiles.
—— Helicopter rotors and windmills.
—— Flow visualizations.
—— Calibration of Pitot tubes.
—— Sports aerodynamics researches on such as bicycles, boat sailing and snow skiing.

Especially, FD-09 has been reformed in measuring device, ground-simulator-plate and struts of supporting model for testing automobiles. Many tests of cars can be engaged in this tunnel.



賽車的阻力測量
Drag measuring for racing bicycle

香港天壇大佛的風載試驗
Wind load testing for large buddha statue



利用風洞蒸汽屏技術進行渦塲顯示
Vortex visualization using vapour screen technique

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