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Upgrade of a new T-35 wind tunnel test section by adding a tail support system

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In order to improve conditions for testing aircraft models and axially symmetrical bodies, a new T-35 wind tunnel test section has been upgraded. This superstructure enables placing of models and axially symmetrical bodies on a tail support system. Tests in the range of high subsonic velocities have been made possible since the reconstruction of some wind tunnel elements and the installation of the injection system during the 80s. Velocities up to 0.5 M ("A" regime) reached using fan drive, can be increased up to 0.80 M ("B" regime) due to the injection system.

Key words: **wind tunnel, reconstruction, tail support, aircraft testing.**

Introduction

THE project of T-35 wind tunnel has been executed in the former Aeronautical-Technical Institute between 1959 and 1964, the latter being the year of its first application. No significant improvements have been performed on the facility until the 1980s. During this period, the T-35 wind tunnel played an important role in the development of aeronautics in our country. Based on the results of the experiments performed in this tunnel, aircraft such as Galeb (G-2), Jastreb (J-1), Kraguj, Orao, Super Galeb (G-4 and G-4M) and Lasta were designed. The modernization of a new test section by the model tail support gives a wider application range to the T-35 wind tunnel.

The T-35 wind tunnel is one of the two most important installations in the Experimental Aerodynamics Department. The performed modernization makes it possible to work on two supports simultaneously (the TEM* support system and the MSS**). Combining the two expands possibilities for the examination of model + payload (airborne bombs, missiles, etc). The wind tunnel drive (fan + injectors) gives the airflow Mach number up to 0.8 in the wind tunnel tube, and allows using both standard and special measurement technique. The modernization of the wind tunnel and computer equipment has provided conditions for the testing improvement in the T-35 wind tunnel.

This knowledge was acquired mainly in the course of exploitation, during various experiments. Some "faults" were noticed in the construction of the existing test section, the only changeable wind tunnel component, and the adjoining equipment.

Taking into account research needs in the high subsonic velocity zone, th

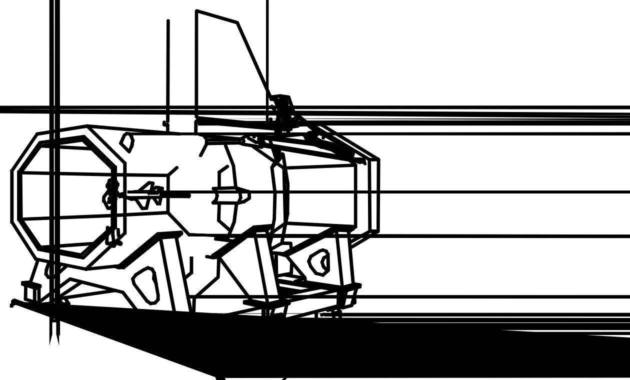


Figure 1

T-35 wind tunnel basic data

Test section

- Cross section
  - Octagon
- Dimensions
  - Width: 4.4 m
  - Height: 3.2 m
  - Length of the cylindrical part: 5.5 m

*) External sixcomponent aerodynamic balance, made by T.E.M. ENGINEERING LIMITED

**) Model holder with a tail support, English version MODEL SUPPORT SYSTEM

1) Military Technical Institute of the Yugoslav Army, Katanićeva 15, 11000 Beograd

Drive

- 4 asynchronous engines
- Total installed power 7.2 MW

Fan

- Radius 8.5m
- Number of blades 23
- Range of blade angles .... 0^0 to 25^0
- Rotation rate .... 400 o/min

Injection system

- Number of nozzles 8
- Injector pressure .... 6 bar
- Time of injector air discharge .... up to 6 min.

Mach number in the test section

- "A" regime .... from 0.1 to 0.5
- "B" regime .... from 0.5 to 0.8

Stagnation pressure

- From 1.00 to 1.52 bar

Reynolds number

- 20 x 10^6 per meter

Tail support system

The tail support system (Fig.2) is in fact a three-axis robot which enables placing the model into the air flow and model position shift during pitching, yawing, rolling, or a combination of these movements, while the center of rotation remains in the fixed position. When the yaw angle changes, the center of rotation remains fixed in its place, while the model draws backwards for approximately 280 mm, due to the tail support bending.

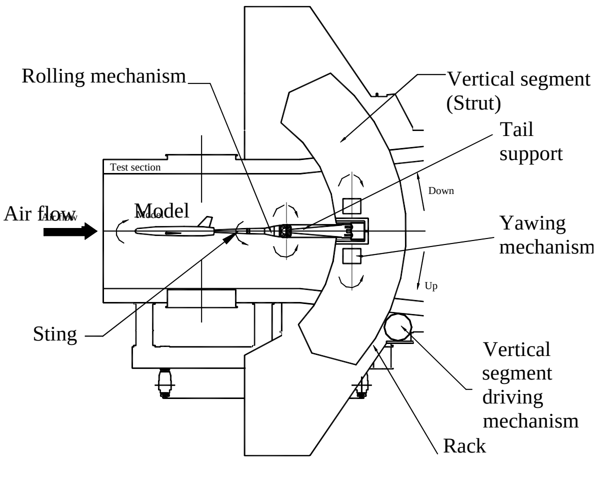


Figure 2

Tail support system (Model Support System – MSS) components

- Vertical segment (strut)
- Tail model support
- Rollers
- Breaks
- Balancing system
- Mechanism for changing the pitch angle
- Mechanism for changing the yaw angle
- Mechanism for changing the roll angle
- Control system

Technical data for the tail sting support system

Basic data:

- Mass of vertical segment (strut) with the tail model support 9300kg
- Mass of the model for static experiments 500kg
- Mass of the model for dynamic experiments 100kg

Loads:

- Drag .... Rx = 18000N
- Side force .... Ry = 8000N
- Lift .... Rz = 40000N
- Rolling moment .... Mx = 2000Nm
- Pitching moment .... My = 2500Nm
- Yawing moment .... Mz = 2500Nm

Angle range:

- Pitch angle .... -15^0 to $+25^0$
- Yaw angle .... -20^0 to $+20^0$
- Roll angle .... -42^0 to $+42^0$

Maximum rate of position change

- Pitch .... 5^0 /sec
- Yaw .... 2^0 /sec
- Roll .... 3^0 /sec

Angle position accuracy .... $\pm 0.1^0$

Vertical segment (strut)

The vertical segment (Figs.1 and 2) is a solid steel structure where the tail model support along with the mechanism for changing angles in two plane (X-Y and Y-Z planes) is situated (Figs.4 and 5). The gear rack enabling the position change in the vertical (X-Z) plane (Fig.4) is situated in the strut back part.

The vertical segment is shaped as a part of the ring 3.77 m and 5.69 m in diameter (inner and outer respectively). Its cross sections are profiled aerodynamically.

Rollers and an electrically coupled driving engine gear support the vertical segment, while two pneumatic cylinders on the outer side of the test section construction and linked with the strut are components of the MSS balancing system.

Tail model support

The tail model support (Fi.2) with a mechanism for changing the roll angle (Fig.6) is a part of the MSS. It is intended for standard (static) tests. Two consistent parts of the support have articulated coupling. The back part is coupled with the vertical segment and the mechanism for changing the yaw angle. The front part (sting) has a mechanism for changing the roll angle (Fig.6) and a model stand with possibility for the internal balance installation.

Rigid model supports with mechanisms for forced excitation are used for dynamic testings.

Rollers

Rollers are built into four blocks connected to the test section construction in the following manner: two of them are connected to the upper and two to the lower part. The arc trajectories for rolling are situated on the vertical segment brim. Rollers and arc trajectories keep the direction of the arc section, at the same time taking a part of the load from the model support. That is the main function of the rollers: to take a part of the load and to ensure circular rotation of the segment. Adjusting an exact circular trajectory is controlled by adjusting the clearance between the rollers and the rolling area, which is done with the help of excenters.

Breaks

Breaks are also situated in the space occupied by the vertical segment, being a constitutive part of the test section.

Their role is to block the vertical segment in the desired moment and at the desired position. Break blocking is achieved through springs activated by pneumatic cylinders, which are the part of the breaking mechanism.

Ballance system

This system operates on the principle of air pressure accumulating, its main use being to ensure the proper functioning of the vertical segment engine driving mechanism, i.e. to "reduce" the vertical segment mass simultaneously decreasing its inertia.

The system accepts approximately 95% of the segment mass along with the tail model support mass. The entire system consists of two parts connected with a rubber hose.

The pneumatic pult for distributing the air into two cylinders 355.6 mm in diameter and 2076 mm long is also a part of the test section.

The pressure battery (reservoir) containing 10 m^3 of air with the pressure of 7.8 bar absorbs the pressure change due to the cylinders pistons movement when the model angle of attack changes. The pressure in the battery is automatically PC controlled.

Fig.3 shows the pneumatic installation scheme.

Mechanism for changing the pitch angle

The mechanism for changing the pitch angle (Figs. 2 and 4) is situated under the test section. It consists of two coupled engines and a harmonic drive with gear wheel connected with the gear rack on the vertical section back part. Changing the pitch angle, i.e. vertical segment movement is done through the gear rack.

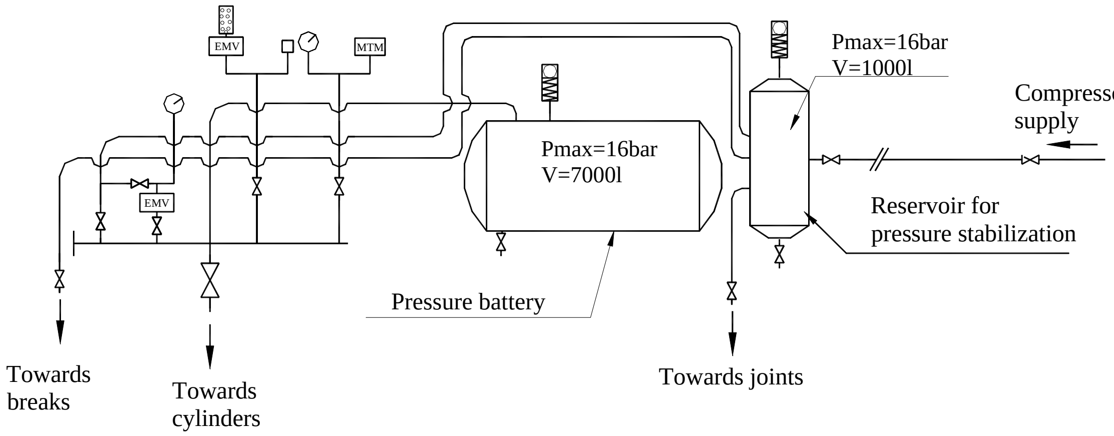


Figure 3

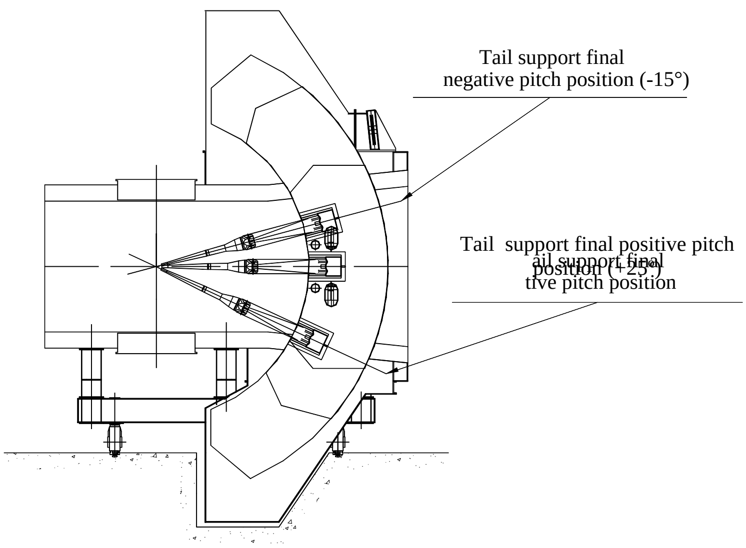


Figure 4

Mechanism for changing the yaw angle

The mechanism drive is situated in the vertical segment middle part. At the tail support back part there are levers (parallelogram). Tail support back part yawing is transferred through the lever parallelogram and the articulated coupling in the middle of the sting support. When the back part turns to one side, the front turns to another, along with the model (Fig.5).

Mechanism for changing the roll angle

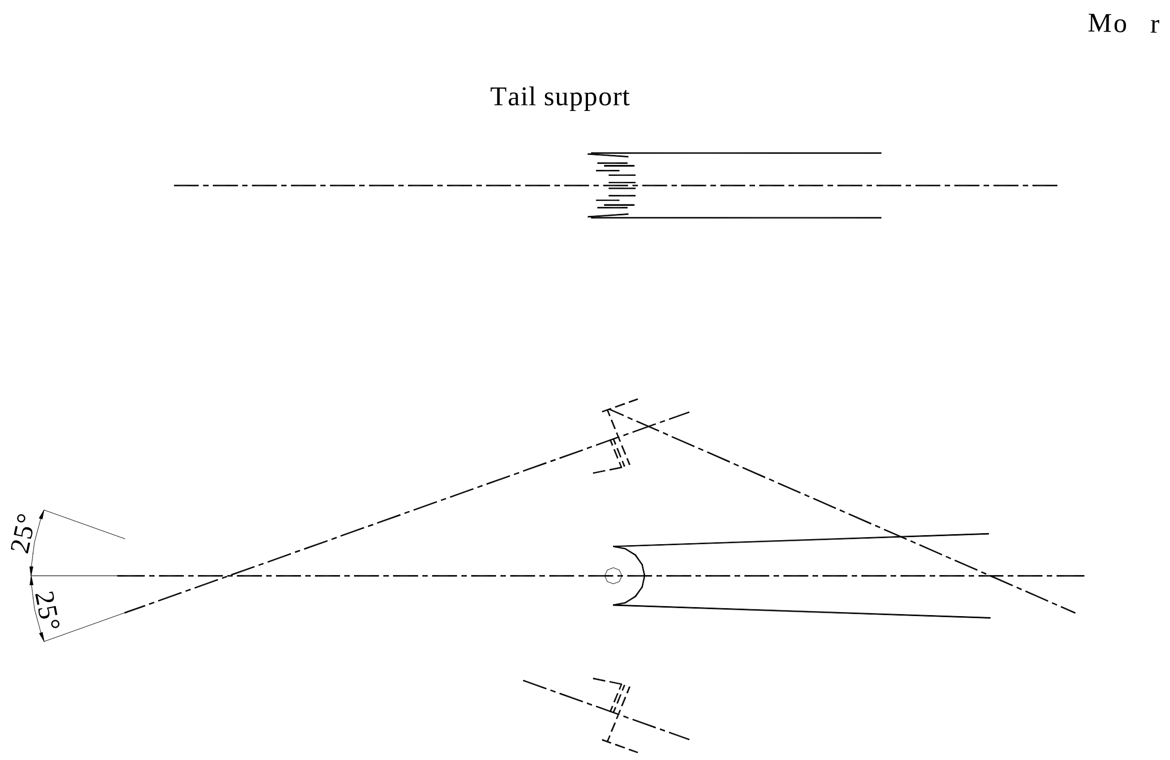
The mechanism is situated in the tail support front part, i.e. sting (Figs.1, 2 and 6). It consists of the engine and the harmonic drive with the shaft connected to the internal balance, and through it to the tested model.

MSS control system

The MSS control system consists of the control computer and the necessary command-control electronics. The control system is given in Fig.7.

Conclusion

The modernization of the T-35 wind tunnel has produced an extremely powerful installation for experimental support to aircraft and ballistic development. The technical characteristics of the wind tunnel ensure comprehensive research of highly subsonic training and combat aircraft, as well as respective civilian airbuses. A special emphasis ought to be put on the fact that this project has been realized under extremely difficult conditions, both for our country and the Institute. The T-35 wind tunnel test section with a tail sup-



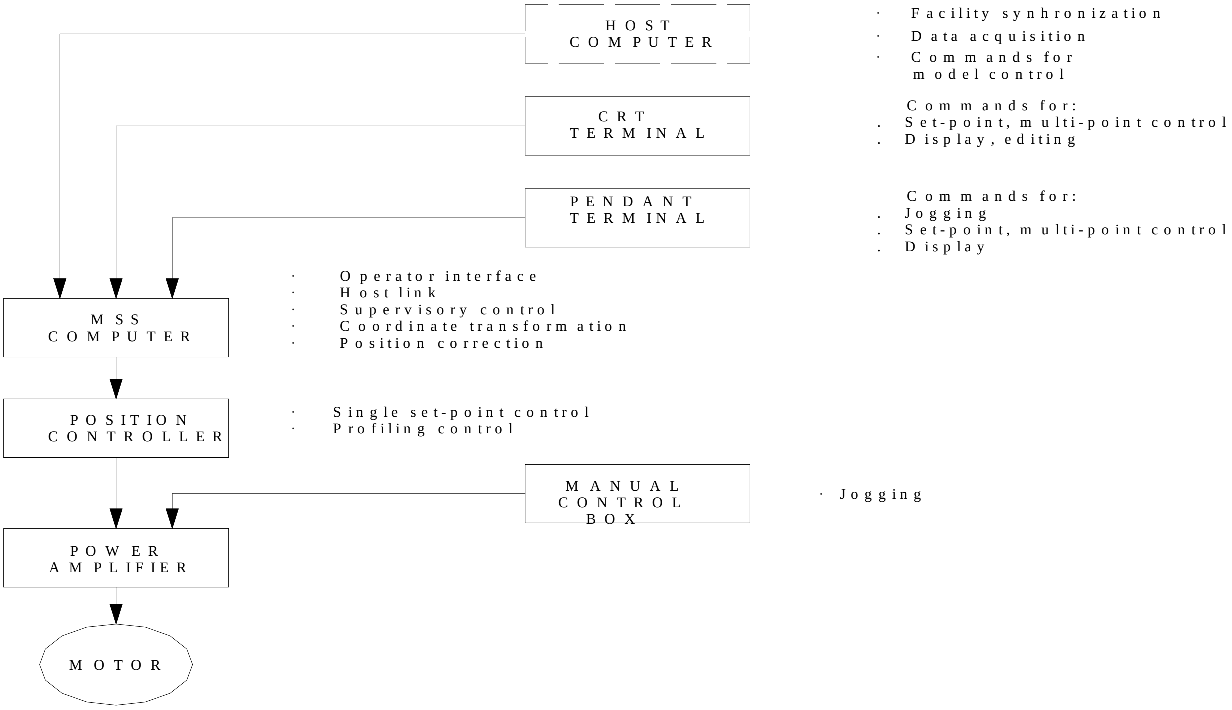


Figure 7

port system will help in the realization of the future tasks of the Military Technical Institute of the Yugoslav Army (VTI VJ). Combined supports (the TEM support and the tail support system - MSS) are bound to improve the possibilities for various development and research tasks in the area of the aircraft industry and ballistics.

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Nadgradnja novog radnog dela aerotunela T-35 repnim držačem modela

Radi poboljšanja uslova ispitivanja modela letelica i osnosimetričnih tela, urađena je nadgradnja novog radnog dela aerotunela T-35. Ovom nadgradnjom omogućava se prihvat modela i osnosimetričnih tela na repni držač. Realizacija je usledila zbog potreba za ispitivanjima u režimu visokih podzvučnih brzina. Ovaj režim rada omogućen je modernizacijom tunela 80-ih godina. Rekonstrukcijom su obuhvaćene postojeće veze na trubi aerotunela i ugradnja injektorskog sistema. Injektorski sistem omogućava da se brzina ostvarena ventilatorom, koja ide od 0.5 Maha, podigne do vrednosti 0.85 Maha.

Ključne reči: **aerodinamički tunel, rekonstrukcija, modernizacija, ispitivanje letelice.**

Modernisation de la nouvelle chambre d'expérience de la soufflerie T-35 en ajoutant le support de queue

Afin d'améliorer les conditions d'essai des maquettes aérodynamiques on a modernisé la nouvelle chambre d'expérience de la soufflerie T-35. Cette modernisation facilite le montage des maquettes et des corps symétriques par rapport à l'axe sur le support de queue. Les essais dans le domaine de grandes vitesses subsoniques sont rendus possible par la reconstruction des éléments de la tuyère de soufflerie et l'intégration du système d'injection dès la modernisation dans les années 80. La vitesse réalisée par le ventilateur peut atteindre 0.5 M mais avec le système d'injection la vitesse augmente jusqu'à 0.85 M.

Mots-clés: **soufflerie, support de queue, reconstruction, modernisation, essai de l'aéronef.**