Equipment for testing the indications accuracy of speedometers and altimeters existing on board aircraft and the tightness of the related pneumatic paths

Diana Mura BADEA*, Tudor GUTA*, Dumitru VLAD*, Constantin PETRE*

*Corresponding author
NIRDMMT - National Institute of Research and Development for Mechatronics and Measurement Technique, Sos. Pantelimon 6-8, Bucharest 021631, Romania
dianamura@yahooo.com, tudor.guta@yahooo.com, didi@cefin.ro, constantin.petre@cefin.ro

DOI: 10.13111/2066-8201.2011.3.1.1

Abstract: *The equipment is intended to testing the tightness of the catchment pneumatic system (Pitot tube), the transmission (pneumatic paths) and the total and static air pressures processing (aircraft-type instruments in order to establish the main flight parameters and checking the correctness of the operation of related aircraft instruments: the altimeter and the speedometer.*

Key Words: tests of tightness, pneumatic system, Pitot tube, aircraft-type instruments.

The equipment utilization considerably increases the flight safety enabling a quick and efficient ground checking of main aircraft-type instruments, before the actual flight. Because this checking must be performed quickly (between flights) and directly on the aircraft (without removing the on board devices), the need arose for self-checking devices working directly on site.

Why an apparatus for testing the tightness? The answer to this question arises from the constructive solutions on which the operation of the above-mentioned aircraft instruments is based on. Their operation is based on measurements taken by the pressure transducer (Pitot tube). The Pitot tube simultaneously captures and transfers the total and static pressures, to the aircraft instruments through pneumatic afferent path.

We remind that the operation of an altimeter is based on the conversion of the static pressure (detected as a vacuum with respect to the atmospheric pressure), while the speedometer operation is based on the conversion of the dynamic pressure resulted as a difference between the total pressure (detected as an overpressure with respect to the atmospheric pressure) and the static pressure.

It is easy to understand the importance of testing the tightness of the above-mentioned pneumatic system, in a whole. Any leakage will cause the distortion of the processed pressures, which in turn will lead to false indications issued by the board equipment.

We will give as example the influence of the leakages on the afferent path of static pressure, wherever they occur (Pitot tube, pipe, device).

The vacuum corresponding to the true altitude will be lower than the correct one, so the altitude indication will be wrong (smaller than the real one). The disastrous effects that may occur when crossing the mountains or at landing, especially in poor visibility conditions can be deduced.

Similar effects also occur on the total pressure path. Any escape of overpressure will distort the speed value given by the speedometer (indicated speed will be lower than the real

one). Knowing that the tightness to vacuum differs from that of the overpressure, it is normal that the tightness checking be done both for the vacuum and overpressure.

On the other hand, the testing methods internationally used and according to standards and the normative papers in force, use as indications of leakage the equivalences in dropping of altitude (for vacuum) and loss of speed (for the total pressure), registered on altimeter for vacuum, and on speedometer respectively for overpressure.

Considering these equivalences and the fact that anyway the equipment indications should be checked the logical conclusion of creating a device able to perform the leak tests and checking the indications of the board apparatus becomes obvious.

To realise this desideratum the equipment will be provided with:

- A source of vacuum with the possibility of adjustment and stabilization of the vacuum, for the static path (pump of vacuum, accumulator chamber, control valves for fine dosage and for ventilation to atmosphere).
- A source of overpressure with the possibility of adjustment and stabilization of the overpressure for the path of the total pressure (pressure pump, accumulator chamber, control valves for fine dosage and for ventilation to atmosphere).
- Absolute and relative pressure transducers compensated for thermal effects.
- Standard altimeter and speedometer apparatus for displaying the altitude, the speed and dropping of altitude and loss of speed respectively (containing converters of pressure, adder and differential blocks for signals, analogue-digital converters and digital displays), used as reference to verify the tightness and the correctness of the board apparatus indications.
- The automatic performance of the leaks test cycles (in the prescribed time, display of the pressure loss converted in altitude or speed losses).
- A variometric indicator (to measure the ascensional or descensionale speed of aircrafts), necessary for limitation of the growth rate of vacuum or the additional pressure to the prescribed rate of the builder of the aircraft instruments, in the purpose of protection of the aircraft instruments during the tests (a suddenly growth of vacuum or additional pressure can lead to the deterioration of respective instruments).
- 24 or 28 VDC supply from own source or having the possibility of coupling to the power supply of airplane
- Equipment installed in a box to enable the work in outdoor.

The equipment is composed of two sections whose configurations are represented schematically in Figure 1 and whose composition and operation are explained below:

- PITOT - section intended to test the pneumatic system tightness to overpressure and to verify the speedometer errors. The operation is based on the simulation of a required speed by creating an equivalent overpressure by means of an air pump (1) and of an accumulator chamber of pressure with embedded vent (2), its adjustment to the required value by a control valve for fine adjustment (4) and ventilation (5), pressure detected by a transducer of differential pressure (7) whose output signal is processed and transformed by the electronic block consisting in a multiplexer (8), an analogue-digital converter (9) and a control unit (10) in pressure values, leakage or speeds, depending on the operation mode introduced by the keyboard (11) and displayed on the digital display (13).
- STATIC- section intended to test the pneumatic system tightness to vacuum and to verify the altimeter errors. The operation is based on the simulation of a required altitude by creating the equivalent vacuum by means of the vacuum pump (14) and of the accumulator chamber of vacuum with embedded vent (15), its adjustment to the required value by the control valve for fine adjustment (17) and ventilation (18), pressure detected by the transducer of absolute pressure (20) whose output signal is processed and transformed by the

electronic block consisting in a multiplexer (8), an analogue-digital converter (9) and a control unit (10) in pressure values, leakage or speeds, depending on the operation mode introduced by the keyboard (11) and displayed on the digital display (13) and its operation is based on creating a valve opening forces resulting from pressure differences existing on both sides of the valve (27) by teasing the existing vacuum path between the central outlet (26) and valve seat (29) with compression spring (28), plus atmospheric pressure and to maintain the vacuum within the closed volume caused by the buffer vessel together with the circuits connected with the outlets (25) is possible by the release of the spring and its return it to its original position, combined with the already existing vacuum which maintains it in position.

The accumulator chamber of vacuum with embedded vent (15) (fig. 2) is designed to create a reserve of vacuum for vacuum variation without sudden fluctuations, and its operation is based on creating a valve opening forces resulting from pressure differences existing on both sides of the valve (27) by baffling the existing vacuum path between the central outlet (26) and valve seat (29) with spring compression (28) plus atmospheric pressure, and vacuum maintenance within the closed volume determinated by the inside of the accumulator chamber together with the circuits connected to the air fittings (25) is ensured by the release of the spring and its return to the initial position, combined with the already existing vacuum, which maintains it in position.

The accumulator chamber of pressure with incorporated vent (29) is designed to create a reserve of pressure for variation without sudden fluctuations, and its operation is similar to that of the vacuum accumulator chamber.

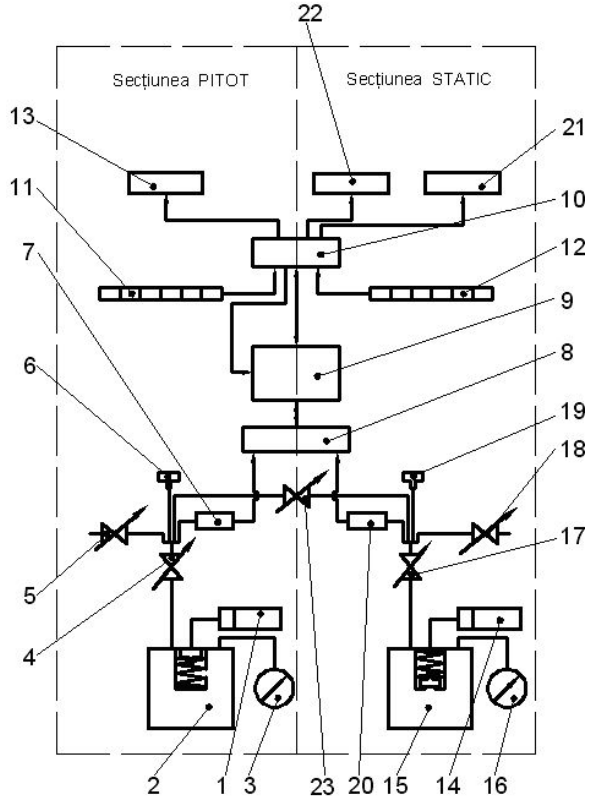

Fig. 1

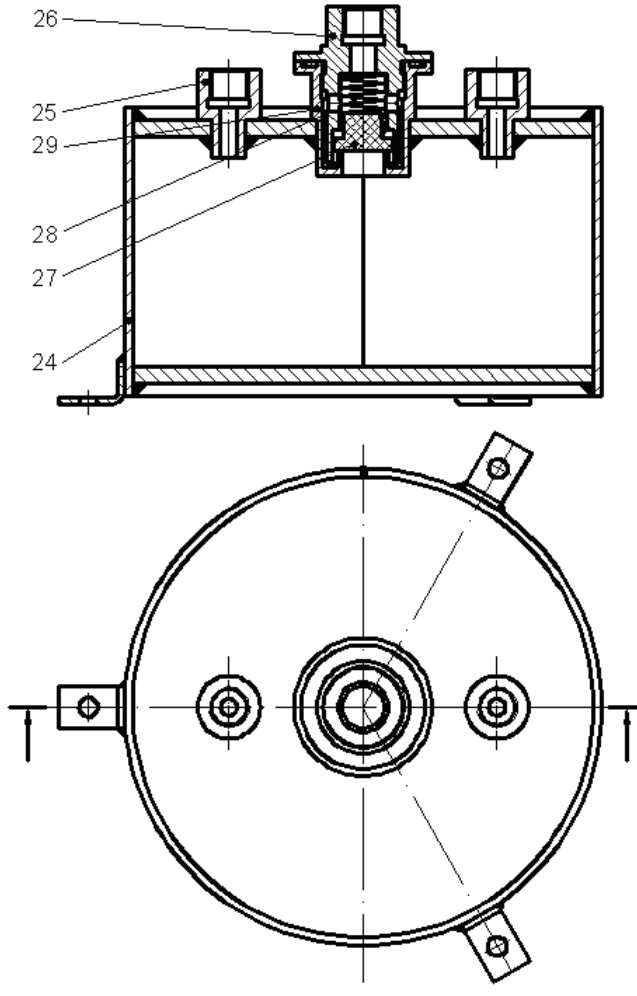

Fig. 2

TECHNICAL CHARACTERISTICS

- absolute limit pressure to STATIC connection: ≤200 mbar;
- maximal pressure to PITOT connection: 1 bar;
- Altimeter:
  - operating range: -300… + 11. 000 m against the sea level;
  - maximal error: ± 0,5 % from indicated value, ± 2 m respectively for altitudes less than 100 m;
- Speedometer:
  - operating range: 0…1.100 km/h;
  - maximal error: ± 0,5 % from indicated value, ± 3 km/h respectively for speeds less 100 km/h;
- provided with variometric indicator;
- operating temperature: + 5º… + 40ºC;
- supply: 24 VDC.

REFERENCES

[1] Aviation Publication 970.
[2] Federal Aviation Regulations (FAR 91.411; FAR 43).
[3] Prospects: Meriam (SUA), Druck (Anglia), Ruska (SUA).