A rotating multi pressure selector switch

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ABSTRACT

This paper describes the design of a rotary pressure switch for measuring differential air pressures in the range 0-1 atmospheres at twenty-four separate tapping points using a single electronic pressure transducer. The operation of the switch and pressure data acquisition is menu driven through an IBM compatible PC, the controlling programme being written in Turbo C. The pressure data is digitally recorded to a floppy or hard disc, from which it can be imported to a Lotus, Quattro or other appropriate spread sheet for further manipulation or analysis.

Introduction

Many studies in engineering particularly in university or research and development laboratories entail the recording of large numbers of pressure readings. Typical examples are the pressure distributions around aerofoil sections and other bodies for the determination of lift and drag force coefficients. This can be accomplished by proprietary pressure scanning and recording instruments (Scani-valve), or individual pressure measuring devices for each pressure tapping can be used, but the cost of these devices may well exceed the budgets of many institutions.

In conducting experiments to determine the lift and drag coefficient for any one cylinder in a group or cluster of cylinders, the time averaged static pressure at twenty-four pressure tappings around the circumference of the cylinder were required to be recorded to an accuracy of 0.025 mm of water. The first possibility was to use a single alcohol manometer and laboriously connect and disconnect each pressure tapping in turn. A second alternative was to connect each pressure tapping to its own manometer or transducer, but the zero setting and calibration time, as well as the cost, proved prohibitive.

These constraints were overcome by designing a rotary switch to which the twenty four pressure tappings were connected, and by indexing the switch, the pressure at each of the tappings was recorded using only a single recording instrument. The switch was initially indexed by hand, the individual pressures being read from an inclined alcohol manometer. This rather cumbersome and lengthy procedure was subsequently improved upon by controlling the position of, and indexing the switch through a menu driven computer programme written in Turbo C, the pressures also being recorded through the same programme via an electronic pressure transducer.

In the following sections the design of the switch is described along with the drive mechanism and its associated electronic circuit for indexing. Also described are the menu choices available from the controlling computer programme.

Switch Design

Fig. 1 shows a schematic of the switch. The two main parts are a 55 mm diameter, 45 mm high, brass body

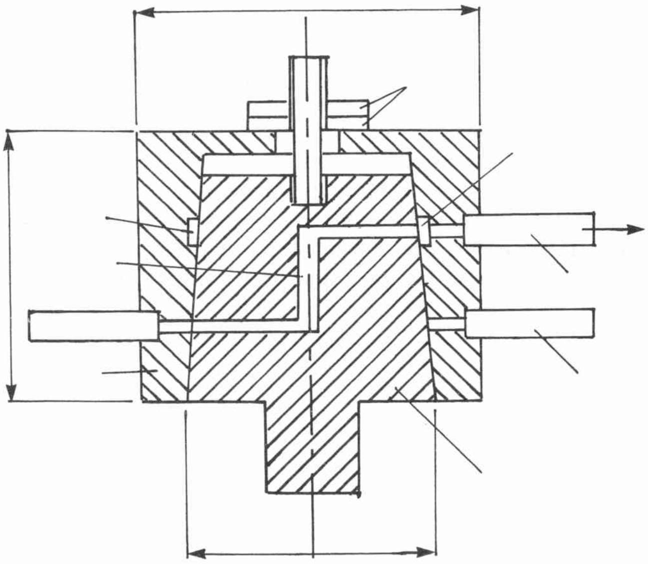

Figure 1 – Section through the switch

within which rotates a 40 mm diameter tapered phosphor bronze plug. Twenty-four pressure tappings are screwed into the input ports in the body, while a single output tapping is screwed into the output port. The problem is to transfer the pressure from an inlet port to the single outlet port without leakage to or from any of the adjacent ports. That is each port must be totally isolated from the other ports when pressure readings are taken. Sufficient time must also be allowed to elapse for the pressure throughout the connecting tubes and in the switch to reach steady state before it is recorded.

The principle of transferring the pressure from the selected input port to the output port is through the 5° taper male plug rotating in the matching body. This design was chosen since it obviates the need for 'O' rings to seal each individual input port. The input tappings are connected to twenty-four equispaced 2.5 mm diameter holes drilled through the body. A single 2.5 mm diameter 'S' shaped hole is formed by drilling horizontally through the plug, on two levels, and vertically along the axis of rotation. The vertical hole enables the transfer of the fluid from the lower input port level to an upper ring gallery level. The ring gallery, which is continuous around the full internal circumference of the body, is formed by machining a recess in the inner wall of the body at the height

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of the upper horizontal body hole. This gallery is connected to the outer face of the body through a single 2.5 mm hole. The fluid is then taken to a transducer through a suitable connector and tubing. Thus the fluid pressure can be transferred from any of the lower twenty-four tappings to the single upper tapping by rotating the plug inside the body to each input port in turn.

Leakage of the fluid is prevented by ensuring an adequate interference fit on the taper. This is varied by tightening a lock nut against the base of the body which pulls the plug into the body thereby increasing the interferences. Sealing of the pressure is further enhanced by a light smearing of grease applied to the tapered surfaces.

Manual operation is facilitated by attaching a simple handle to the bottom of the plug. It was, however, decided to control the switch position and record the pressure via a menu driven computer programme.

Rotating Mechanism

The preferred method of incrementing the switch to a desired position was by stepper motor, but expense precluded its use. A suitable inexpensive alternative, which also provides high torque to overcome the friction of the plug in the taper, was a windscreen wiper motor operating from a 12 volt DC power supply and shown in Fig. 2.

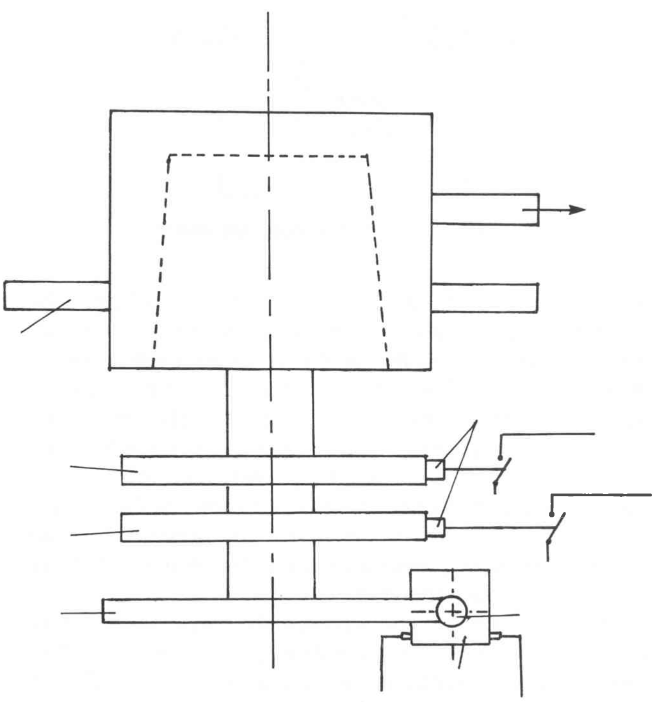

Figure 2 – Motor drive and micro switches

The output shaft of the motor is connected to the plug of the switch by an extension piece onto which is screwed two perspex discs each 55 mm in diameter and 5 mm thick. The lower disc has 24 equispaced semi circular indentations cut into its periphery, while the upper disc has a single indentation in its periphery. Around the periphery of each disc runs the wheel of a stationary cam micro switch such that when the micro switch settles in an indentation, the switch is open, but while it is lifted onto the rim of the disc, the micro switch is closed. In the closed position, the micro switch completes a 5 volt circuit which is read at the input port of an A/D (analogue to digital) card housed in the computer and which converts it into a digital signal for use in the controlling computer programme. With the micro switch in the open position, zero volts are supplied to the A/D card input port and a digital zero is then transmitted to the controlling programme. Conversely, a five volt signal may be outputted by the computer programme via the A/D card output port.

Fig. 3 shows the basic electrical circuit which controls the switching of the motor.

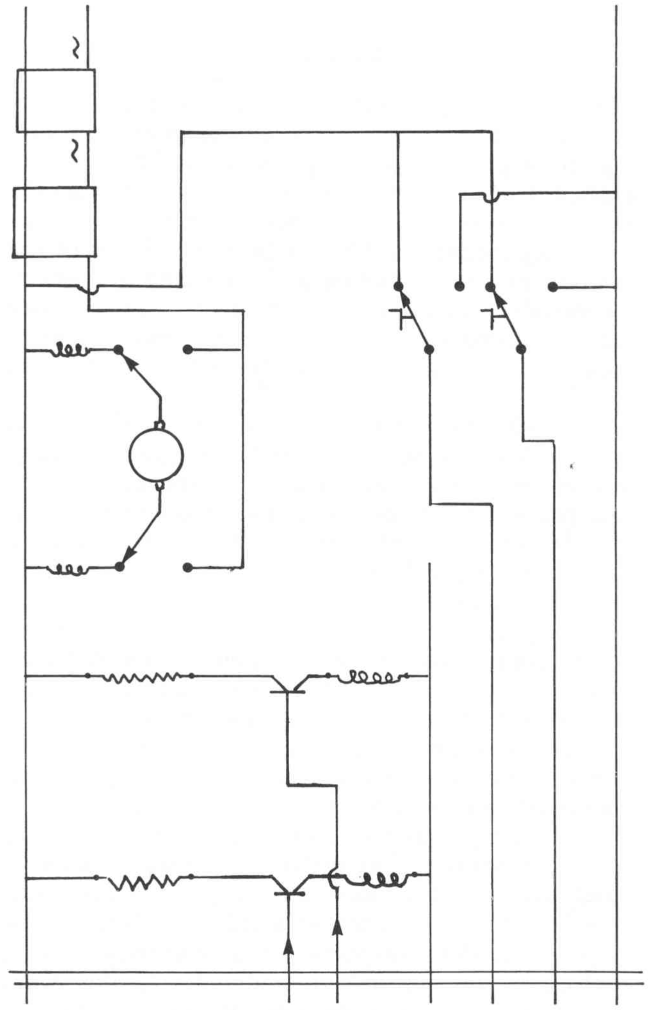

Figure 3 – Switching circuit

The electrical signals are processed in the A/D card which can read analogue voltages and provide/read TTL digital signals. Switching the motor on and off is accomplished through one of the 6 volt relay switches, the 12 volt supply being transformed from the mains supply. The relays are activated by transducers which are switched by 5 volt signals at either of the A/D data out ports, to provide 6 volts to the relay coil, and hence switch the motor to turn in the required direction. The motor, plug and discs rotate until the micro switch roller drops into an indentation. The micro switch opens and sends zero volts to the A/D card. This signal is processed by the computer and zero volts are sent out at the data out port

MAIN MENU

: Reinitialise Entire System
1: Calibrate for Pressure Conversion
2: Reset to Pressure Tapping Point 1
3: Advance Pressure Selector Switch
4: Retard Pressure Selector Switch
5: Read Current Pressure Tapping Point
6: Run Sequence
7: Draw Graph of Results
8: Write Results to Disc

E: Exit to DOS
Strike Option:

CALIBRATION MENU

Pressure Unit:
Setpoint:
Gain:

Tapping Point:
Pressure Read:

TIME/DATE

Tue Nov 19 06:51:22 1991

SYSTEM MENU

System Initialised	: No	Data Saved	: No
System Calibrated	: No		
System Reset	: No	Filename	:

Table 1 – Screen menu

to open the relay and so switch off the power to the motor, thus stopping its rotation. Therefore by judicious programming, the switch can be made to reset to a reference starting hole determined by the position of the indentation and micro switch on the upper disc, relative to the switch body; it can make a full rotation stopping for a discreet time period at each of the twenty four holes determined by the twenty-four indentations on the lower disc; or it can be indexed to any required hole. The delay time at each individual indentation is controlled through the computer's internal clock and is variable. During the delay or 'sleep' period, statistical pressure data is recorded and stored as ASCII code for direct importation into a Lotus, or other suitable spread sheet.

Computer control

The switch operation is controlled through a computer programme written in Turbo C, the options available from the menu driven programme being illustrated in Table 1. After boot up, the system is first initialised. During initialisation, the output ports of the A/D card are defined.

The calibration option 1 refers to the dedicated electronic pressure transducer which is used in conjunction with the switch. Calibration need only be carried out at the start of each work session or at any time as a check against electrical drift variations. This option sets up the pressure transducer electronics to enable the analogue pressure to be recorded and converted to the required units, and the user is prompted through each step of the calibration procedure.

Selecting choice 2 resets the switch to the reference hole determined by the angular position of the upper single indentation disc relative to the transfer holes in the plug.

Choices 3 and 4 index the switch one hole at a time in the forward or backward direction, while the selection of choice 5 and any hole causes the mean pressure at the hole to be read and stored in memory.

Choice 6 indexes the switch sequentially through all twenty four pressure tappings. It 'sleeps' at each hole for the time delay defined in the calibration section, after which the mean pressure at the hole is recorded. These pressures are also stored sequentially.

Before saving the stored data, it may be viewed graphically by selecting option 7. Selecting 8 saves the data, in ASCII code, to a specified file. This data may then be readily imported into a suitable spread sheet for further manipulation.

Closure

The drive motor and associated electronic components are contained in an aesthetically designed case through which the body of the switch, the indented discs and micro switches protrude as shown in Fig. 4.

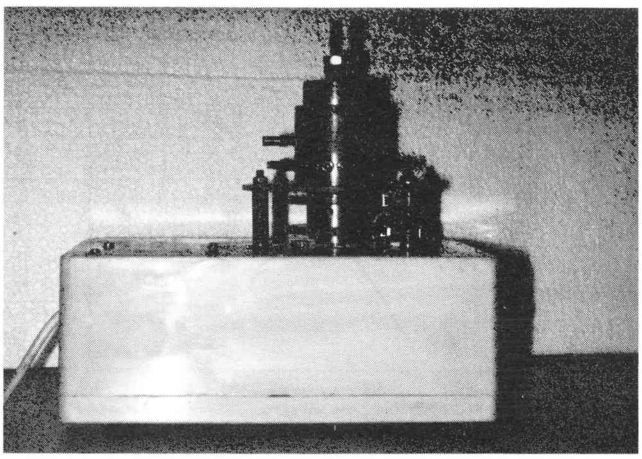

Figure 4 – The switch and its casing

A protective casing encloses the discs and micro switches when in use. The electronic pressure transducer, with its amplifier and temperature compensation circuit are separately housed, and plug into the main switch box.

The switch has been used successfully in many experimental modes and has reduced experimental time considerably especially where repetitive readings must be recorded.