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CURRENT PRESSURE MEASURING SYSTEM IN THE TRANSONIC WIND TUNNEL.(U)
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J.B. WILLIS

SUMMARY

A simple system for wind tunnel pressure measurements is described. It is intended for use with Scanivalves and a minicomputer and stagger scans at a preset, variable rate. The scan may be started and stopped under program control, and all Scanivalves are automatically homed at the end of the computer initiated scan. Scanivalve number, port number, and four digits representing the measured pressure are displayed and provided for the minicomputer.

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16\. ABSTRACT:

A simple system for wind tunnel pressure measurements is described. It is intended for use with Scanivalves and a minicomputer, and stagger scans at a preset, variable rate. The scan may be started and stopped under program control and all Scanivalves are automatically homed at the end of the computer initiated scan. Scanivalve number, port number, and four digits representing the measured pressure are displayed and provided for the minicomputer.

CONTENTS

1. INTRODUCTION

To measure the pressure at orifices in models and/or tunnel walls in the ARL Transonic Wind Tunnel, Scanivalves and a DEC 8/I minicomputer have been used for many years. Initially, a commercial data logger was used to control Scanivalve operation and to measure pressure transducer outputs, and the data logger output was interfaced to the minicomputer. Later, when the performance of the data logger became unsatisfactory the hardware described in this memorandum was quickly designed and built to avoid delaying the work in the tunnel.

The hardware has remained unchanged since its construction in 1975, and has proved completely reliable in operation. A particular feature of the equipment is its simplicity.

2. DESIGN REQUIREMENTS

The design requirement was that the new hardware should perform the same functions as those previously performed by the data logger - i.e. it should control the operation of the Scanivalves, it should operate in conjunction with the DEC 8/I, and it should measure pressure transducer outputs. The Scanivalve controllers available have "STEP" and "HOME" pushbuttons, and will accept appropriate pulses to perform the same functions. The minicomputer interface, constructed several years previously gates in data, responds to interrupts, provides pulses etc. as programmed. Actual data formats, sequence of events, and program instructions are given in Appendix A and the program details are given in Ref. 1. Consequently the hardware to be described must meet the following needs.

1. It must be possible to start and stop the scan by instructions in the minicomputer program.

2. It should be capable of controlling up to 5 Scanivalves (240 pressure points), and must put out the required pulses to "STEP" and "HOME" them.

3. It should stagger scan - i.e. after a pressure transducer output has been determined and read into the 8/I, that Scanivalve should be stepped on to its next position, and allowed to wait while the other scanivalve pressure transducers are dealt with. This gives maximum settling time for a given scanning speed.

4. Scan rate should be variable. This is necessary because total response time may vary from one model to the next, since response time is a function of transducer trapped volume, diaphragm ringing, size of pressure orifice, diameter and length of plumbing etc.

5. A pulse to cause an interrupt to the 8/I is required. This signals the operating program that data is available to be read in.

6. The output should be displayed and also sent to the 8/I interface, and the format should be:

Scanivalve number	-	1 digit
Port number	-	2 digits
Pressure transducer output	-	sign and 4 digits.

The last may, of course, be amplified before being measured.

7. Since B.C.D. Scanivalve position indicators (or port number indicators), are expensive, only one position indicator is used on Scanivalve Ø. This port number must be latched and held while a single traverse of all Scanivalves is carried out.

3. DESCRIPTION

Operation is shown schematically in Fig. 1. The pressure transducer outputs, amplified as required, are fed into the multiplexer - an AM3705, which accepts up to 8 inputs. The multiplexer address is the Scanivalve number, and the multiplexer output goes to the analog to digital converter (hereafter A-D). The A-D used is a Burr Brown ADC 100-SMD, giving out a sign and 4 B.C.D. digits and taking about 30 ms. for the conversion. Its output is actually buffered with tristate chips, which are not shown here.

Starting permits clock pulses from the electronic clock to reach the A-D, and these pulses cause conversion to start. End of conversion produces a level shift which is used to trigger pulses to step on the required Scanivalve (hereafter S.V.) interrupt the 8/I, latch the A-D output, and increment the S.V. counter. Incrementing the S.V. counter ensures that the multiplexer address is incremented so the next S.V. transducer is looked at, and the next S.V. will be stepped on at the end of conversion. The S.V. counter is compared with a thumb wheel switch, preset to the number of Scanivalves to be scanned. When coincidence occurs, the counter is reset to Ø, which causes the S.V. number to be Ø, the multiplexer address is Ø, and so the cycle for stagger scanning is produced. To ensure that scanning always starts with S.V. No. Ø, the S.V. counter is reset when the start flip flop is reset. Timing of the various pulses is shown in Fig. 2.

Considering the circuits used in more detail, Fig. 3 shows the actual clock circuit and the frequencies provided. These more than cover the range of scanning speeds found useful in the ARL Transonic Tunnel, with 12 to 14 Hz being the most commonly used.

Fig. 4 shows the main circuit details, with Fig. 5 giving details of port number and solenoid controller interface wiring. Additional details shown in Fig. 4 include the "RUN" and "STANDBY" lamps, which are useful when the Scanivalves cannot be heard running. It will be seen that the clock input is actually used as a fairly fast pulse to the A-D. Also, as shown all Scanivalves go "HOME" together when the computer stops the scan. This is satisfactory for this application, as this is the normal requirement.

The calibration setting requires some explanation. When the switch is set to CAL, the S.V. whose number is preset on the thumbwheel switch is now scanned at the chosen frequency. The intention is to permit transducer calibration, leak testing etc. to be carried out. This is achieved by using two tristate chips - DM8093, DM8094. In normal scanning, the S.V. counter output is connected both to the comparator, and via the DM8094 to the S.V. No. bus, and the thumbwheel switch setting is disconnected from the bus. In the CAL position, the switch is connected to the bus. and the counter disconnected, so the S.V. number does not change. Thus, only one S.V. may be endlessly stepped and the output observed, thus indicating transducer drift, and possibly leakage in a connection to a particular port.

The port number (Fig. 5) is inverted and brought out for checking. This is useful since the position indicator is best adjusted with the S.V. "HOME", and to latch the display steps on S.V. ø away from the "HOME" position. The standard interface circuit is required to send the necessary 6 ms pulse to the S.V. controller. One such circuit is needed for each "STEP" and "HOME" input on each controller.

As with all simple devices, there are some drawbacks. At slow scan rates, the S.V. No. changes while the A-D output is still displaying the previous S.V. output. Likewise, port number, being latched, may appear to be incorrect. If the computer print out is used as the overall check of system operation, such problems do not occur, and the print out (and input to the computer) are both always correct. Thus, if the print out displays abnormalities, they are real and due to real causes.

4. CONCLUSION

A simple system to operate in conjunction with Scanivalves and a minicomputer has been described. It provides stagger scanning at variable scanning speeds, and has proved highly reliable in operation.

REFERENCE

1. Willis, J.B. Programmes for the transonic wind tunnel data processing installations Part 9: Pressure Measurements Updated.

APPENDIX A

Fig. 6 gives the format used in 12 bit words, and the instructions actually used in the DEC 8/I. Actual operation of a pressure scan under computer control commences with the operator pressing a pushbutton. Tunnel instrumentation providing model attitude, air stream parameters etc. are read into the 8/I, and the pressure scan started. Pressure data are then read in when interrupts are received.

Mach number may drift slightly during a long slow scan, and for this reason, tunnel parameters are again read in after a preset number of pressure points have been acquired. Pressure ratios and pressure coefficients are computed using the mean values bounding the scanned pressure points, and the computed values stored. Scanning continues, another lot of tunnel parameters is read, and so on. At the end of the preset numbers of pressure points, the scan is stopped and all Scanivalves sent home. Data is displayed, printed, stored on magnetic tape, plotted etc. It should be mentioned that the computation and reading in of tunnel instruments all occur while scanning continues. The time required is so small compared with the slow rate of scanning that this causes no difficulty.

In practice, this arrangement ensures that pressure coefficients (or ratios) are displayed to the operator virtually instantly the scan is completed, and the hardware described is all designed to achieve this result.

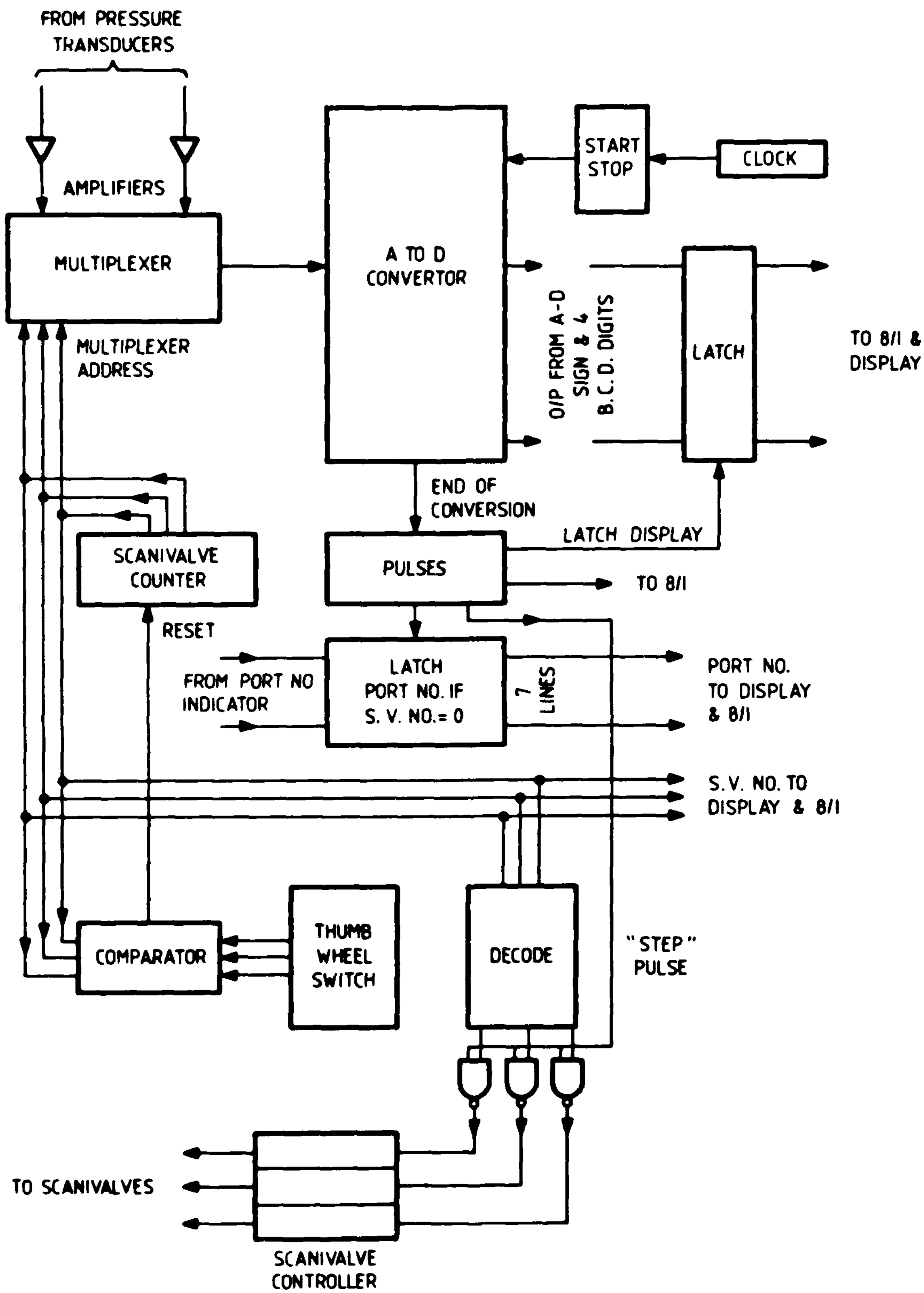


FIG. 1 SCHEMATIC DIAGRAM

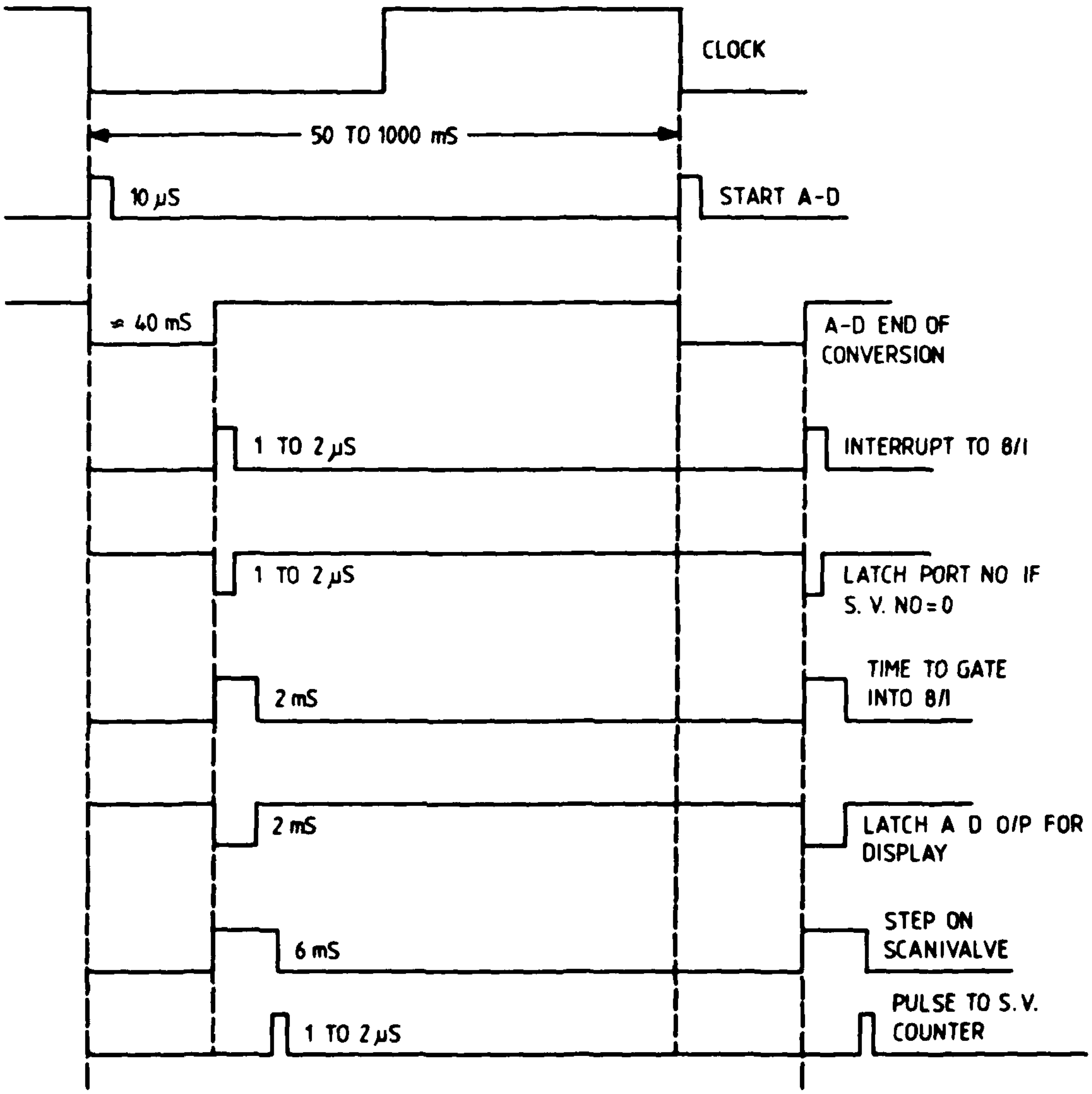
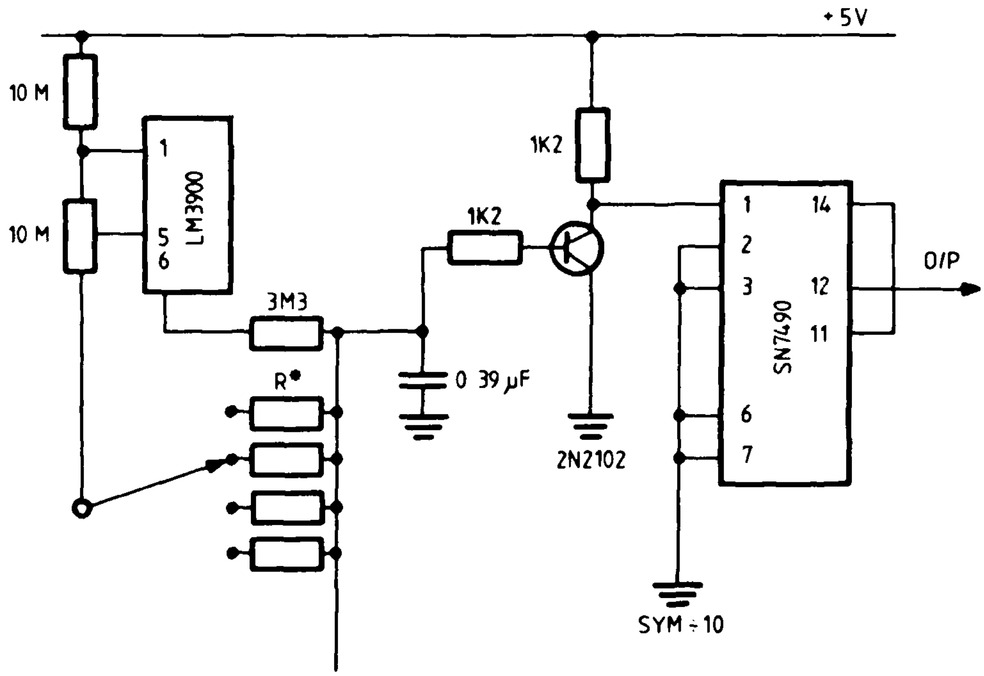


FIG. 2 TIMING - NOT TO SCALE



POS	R* (K)	f (Hz)
1	200	1
2	100	2
3	50	4
4	34	6
5	25	8
6	20	10
7	16.6	12
8	14.3	14
9	12.5	16
10	11.1	18
11	10.0	20

FIG 3 CLOCK

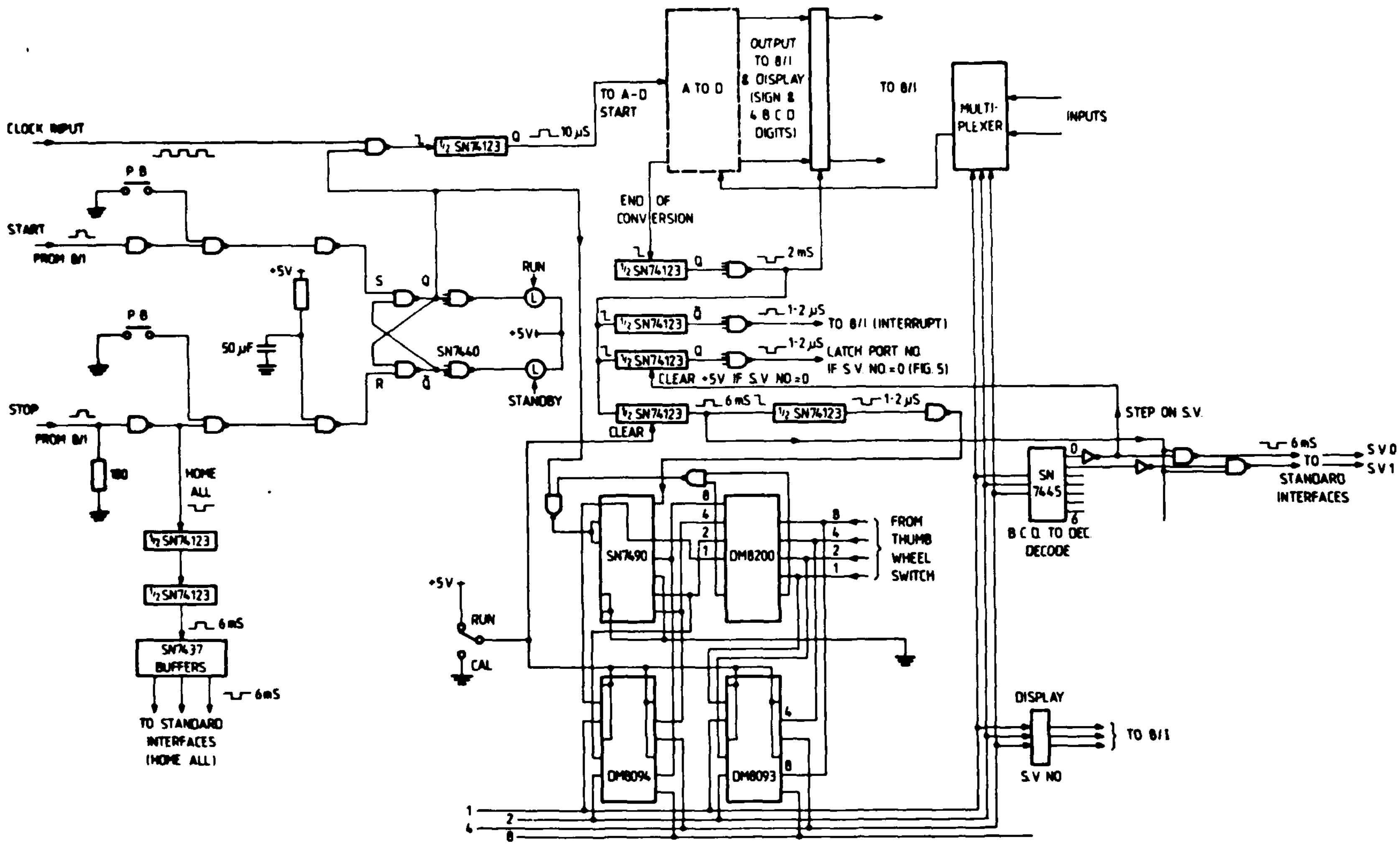
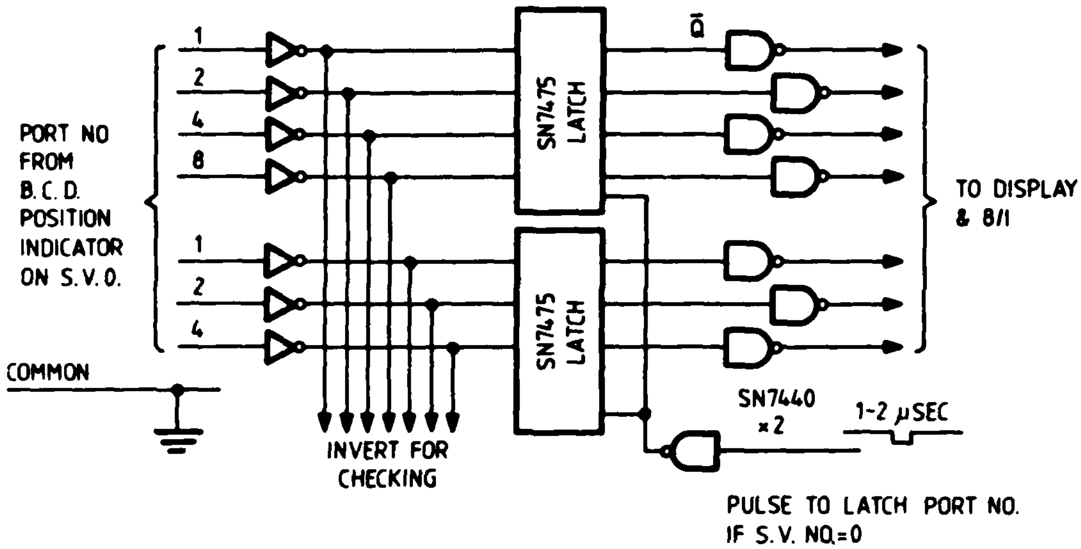
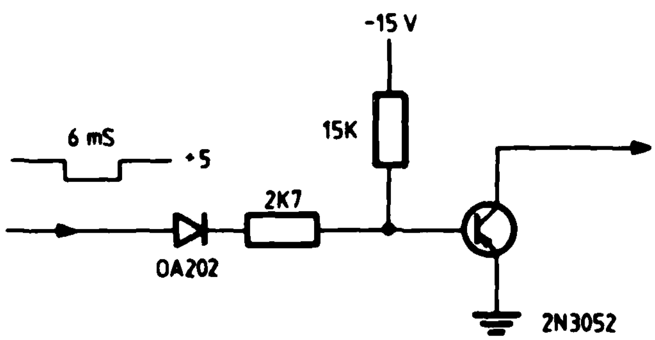


FIG 4 MAIN CIRCUIT DIAGRAM

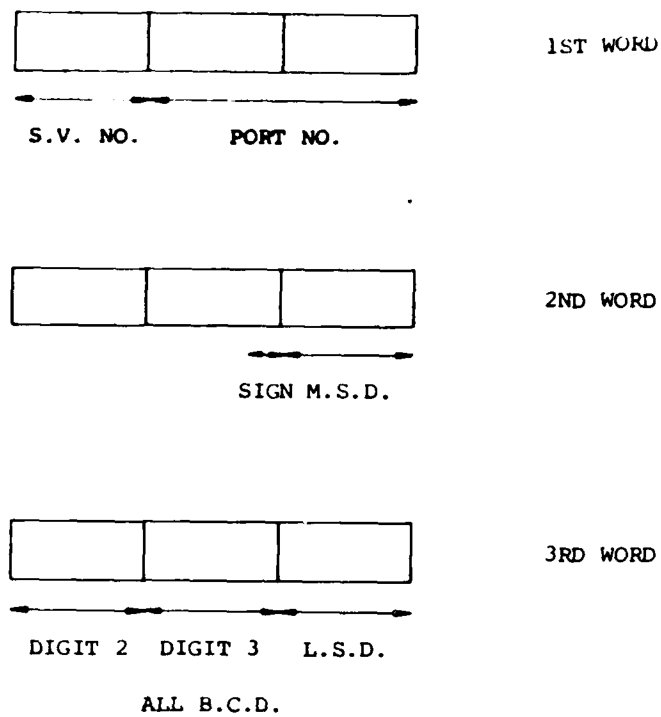


PORT NUMBER



STANDARD INTERFACE TO SCANIVALVE CONTROLLER

FIG. 5 PORT NO. & SCANIVALVE CONTROLLER INTERFACE



DATA FORMAT

INSTRUCTIONS

6346	READ IN FIRST WORD
6352	READ IN SECOND WORD
6354	READ IN THIRD WORD
6324	START SCAN
6364	END SCAN
6341	SKIP IF FLAG SET
6351	CLEAR FLAG

FIG. 6. FORMAT OF OUTPUT AND INSTRUCTIONS.

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