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An electronic mean wind speed indicator

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ABSTRACT. A digital mean wind speed indicator which displays the mean wind speed for the past two minutes with the means updated every 10 sec has been developed in the Instruments Division of the India Meteorological Department, Pune. The sensor used is a photoelectric cup anemometer with a LED source. Pulsed out-put from the sensor is split into 10 sec samples by means of a counter which is reset every 10 sec and 12 such samples are averaged and displayed as the mean wind speed. The data is updated every 10 sec as the old data in the memory is replaced by fresh data from the sampling counter. The equipment can be easily connected to a digital printer to provide a print-out of the display.

1. Introduction

The rapidly changing types of aircraft and progressively lowering landing minima have posed new challenges in surface wind instrumentation for air traffic at airports. The fluctuating character of wind speed and direction in both time and space has been brought out by the work of Giblett *et al.* (1932), Sherock and Stout (1937), Panofsky, Crammer and Rao (1958) and others. Since the pilot uses the wind information a few minutes after it is transmitted to him, the wind speed averaged over a specified small interval of time represents more realistically the wind conditions he encounters while landing or taking off than the instantaneous wind at the instruments site. Sparks and Keddie (1971) found that a wind speed averaged over a 4·5 min interval gives a reasonable estimate of mean wind over a 300 m run of wind 10 min later. Considering the requirements of many of the latest types of aircraft the International Civil Aviation Organisation (1966) had laid down that all international airports be equipped with instruments for giving average winds for two-minute periods near the touch down and take off points along the runways.

Ludwig (1960), Acheson (1969), Koren (1972) and others have investigated various averaging techniques and have suggested the use of suitable electrical filters to compute the average wind. The present paper describes a digital average-wind measuring equipment based on the measurement of the total wind run for 2 min periods continuously updated every 10 sec.

2. Description of the system

The mean wind speed indicator described here consists of a photoelectric cup anemometer for sensing the wind, an all-electronic computer for computing the mean wind speed for 2 min-intervals and updating it once every 10 sec and a seven segment numeric indicator to display the information.

The sensor which is a photoelectric cup anemometer gives 600 revolutions for every nautical mile of wind that passes it, *i.e.*, for one knot wind speed the cups will rotate 600 times per hour or 20 times in two minutes. The anemometer gives out 8 pulses per revolution, *i.e.*, 160 pulses in two minutes for every one knot in wind speed. These pulses are scaled down electronically by a factor of 160 to provide one pulse in two minutes for every one knot in wind speed.

The pulses thus derived are fed to a divide-by-10 counter which is reset every 10 sec, so as to provide samples of data every 10 sec. 12 such samples will constitute a whole two-minute data. These samples registered in the divide-by-10 counter are stored at 12 addresses in a memory. Every 10 sec these 12 samples stored in the memory are read out into an adder, added up and displayed as the average wind. Since one pulse represents every one knot in wind speed the sum presented at the output will indicate the average wind speed in knots. The data entry into the memory is regulated in such a manner that the 13th data sample replaces the 1st sample in the memory. This way the data gets updated every 10 sec.

2.1. *Sensor*

An IMD cup-contact anemometer in which the contact mechanism is replaced by a light emitter,

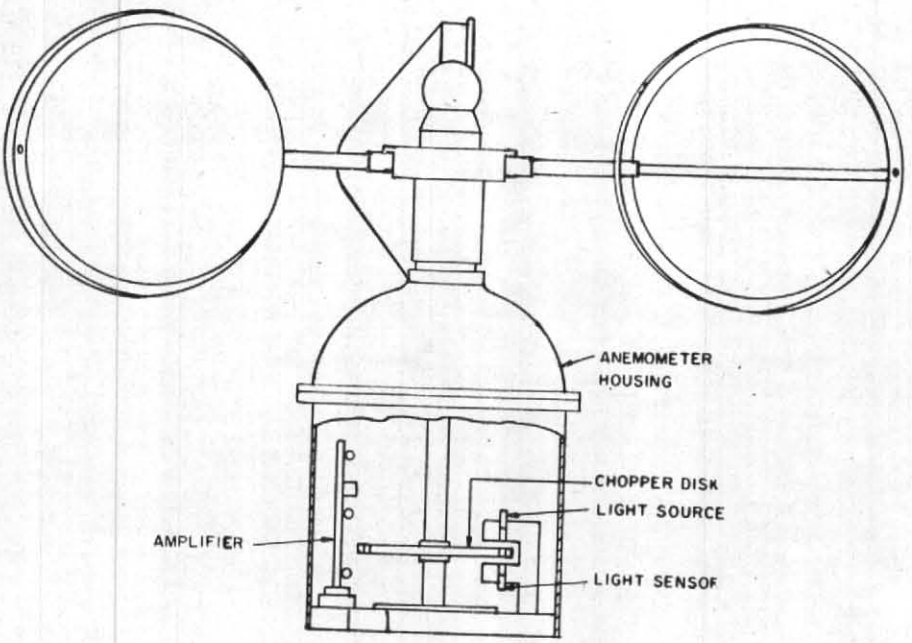

Fig. 1. Photo electric anemometer

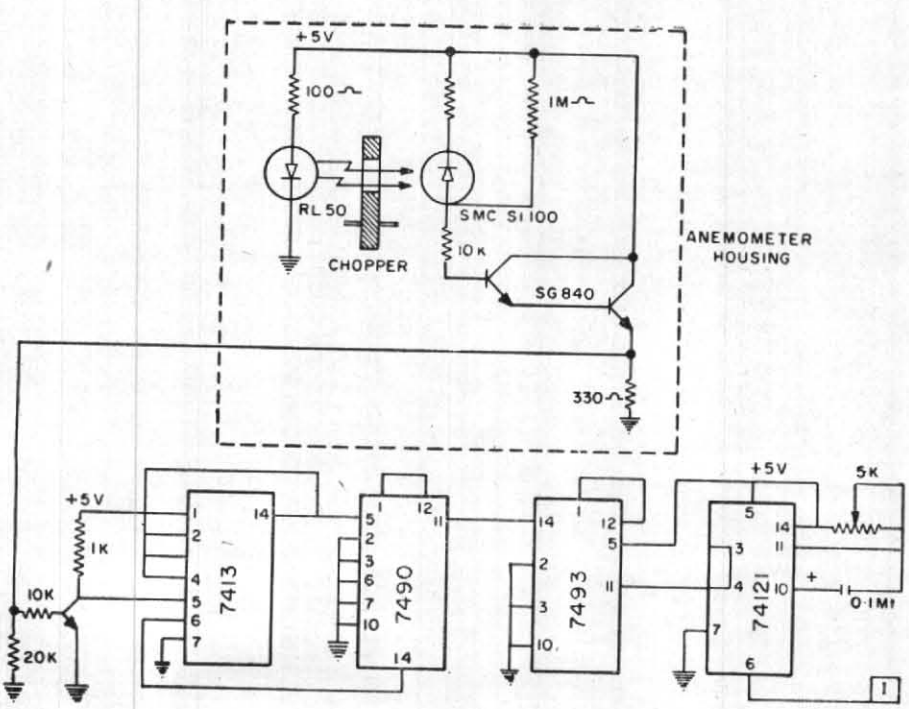

Fig. 2. Sensor and input amplifier

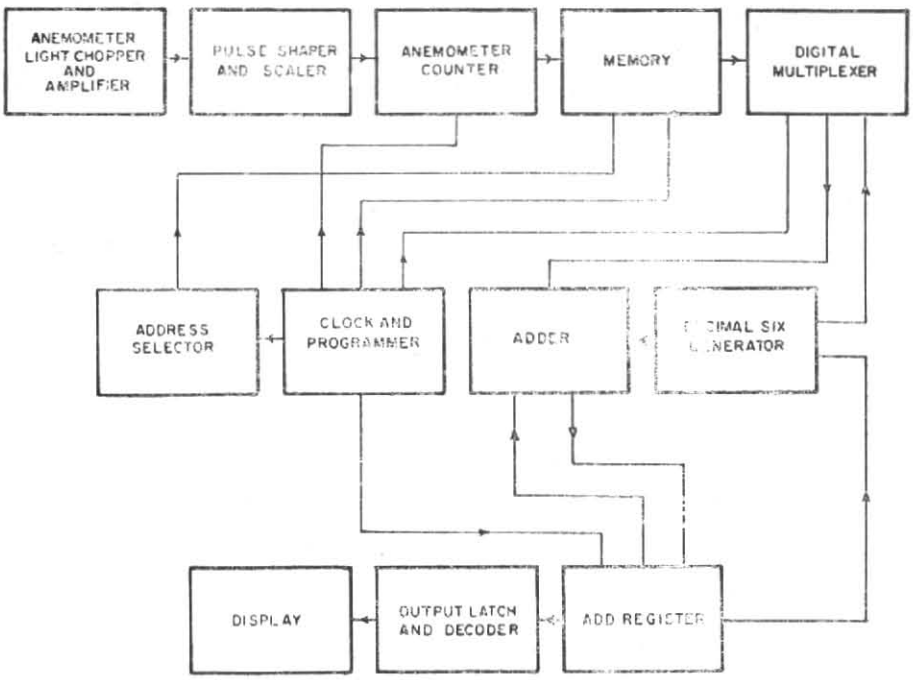

Fig. 3. Block diagram of mean wind speed computer

chopper and detector is used as the wind speed sensor (Fig. 1). The light chopper is a circular disc with 8 symmetrical holes and is mounted axially on the shaft of the anemometer. The light source is a light emitting diode (type RL 50) emitting red light and the light detector, a photo diode (type SMC SI 100). The LED and the photodiode are mounted on rigid supports facing each other with the chopper disc in between. The signal is boosted by an input amplifier (Fig. 2) mounted inside the anemometer housing using two SG 840 transistors in Darlington configuration. The amplifier works on +5 volts from the system power supply. For every rotation of the anemometer 8 pulses are produced by the amplifier. The anemometer is connected to the computing unit by means of 3 core shielded cable.

2.2. *The mean wind computer*

Fig. 3 represents the block diagram and Fig. 4 the detailed circuitry of the mean wind computer. The pulses derived from the anemometer are *further* shaped by a saturating amplifier and a Schmidt trigger (7413) so that the pulses can drive TTL counters. These shaped pulses are scaled down by a factor of 160 by a divide-by-16 counter (7493) and a divide-by-10 counter (7490) in ripple connection so as to provide one pulse in two minutes for each knot of wind speed.

The pulses thus derived are again fed to a 7490 counter which is reset every 10 sec by a pulse from the programme clock (Fig. 4). Just before reset the count registered in this counter (the data counter) is transferred into the memory. A 16×4 bits type (7489) memory is used. This has 16 addresses out of which only the first 12 are used since there are only 12 samples of data in every two minutes. Thus the data are stored in the first twelve addresses (0000 to 1100). When the first 12 samples of data have been stored, the 13th sample goes again to the 1st address, the 14th sample to the 2nd address and so on, so that the data available in the memory get updated every 10 sec. To compute the average wind speed the data registered in the memory is read out into a 4-bit adder (7483) every 10 sec. The twelve samples of the data are added serially and put into an add register consisting of two J. K. Filpflops (7473) and a 4-bit counter (7490). Since the addition is binary, to convert the output data into BCD for display, after every addition binary 0110-Decimal 6 is added to the contents of the add register, if necessary. For this at the start of the add operation the add register is reset to zero. Then the data in the first memory address is added to the content of the add register. Next, if after the addition the add register reads more than 1001 (Decimal 9) or if the adder final carry output is a logical one, binary 0110-Decimal 6 is added to the

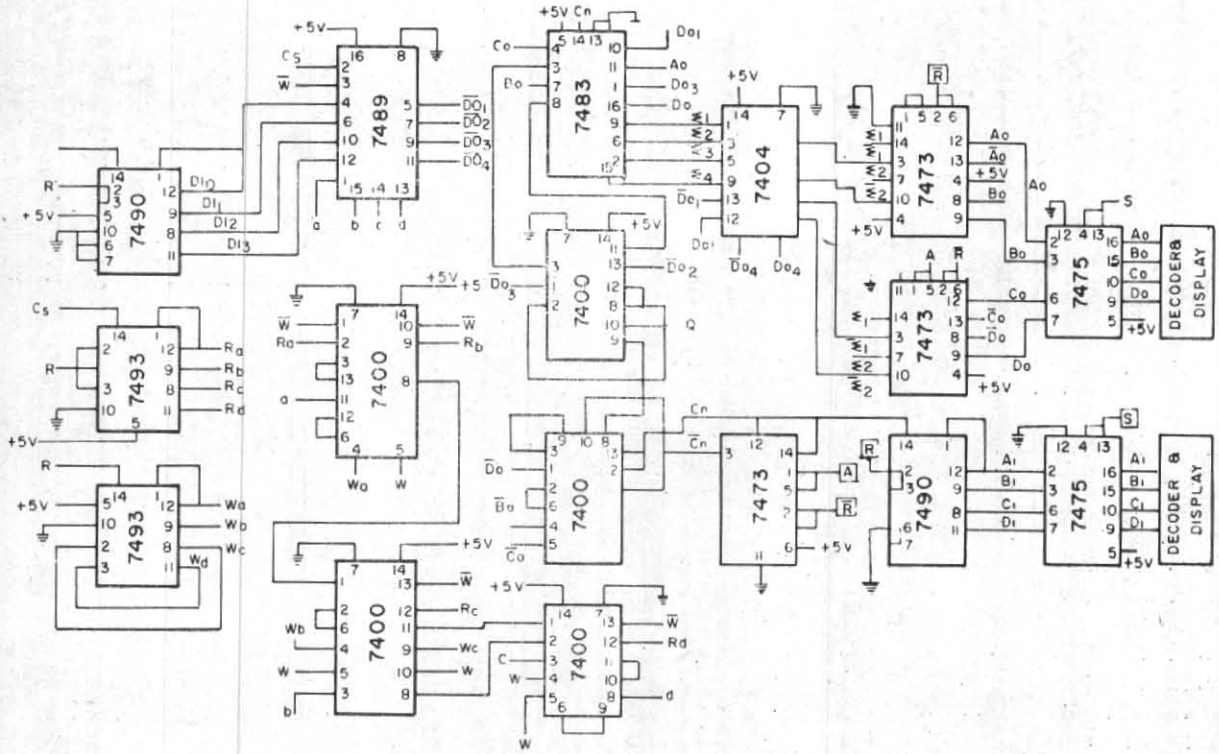

Fig. 4. Memory and adder circuit

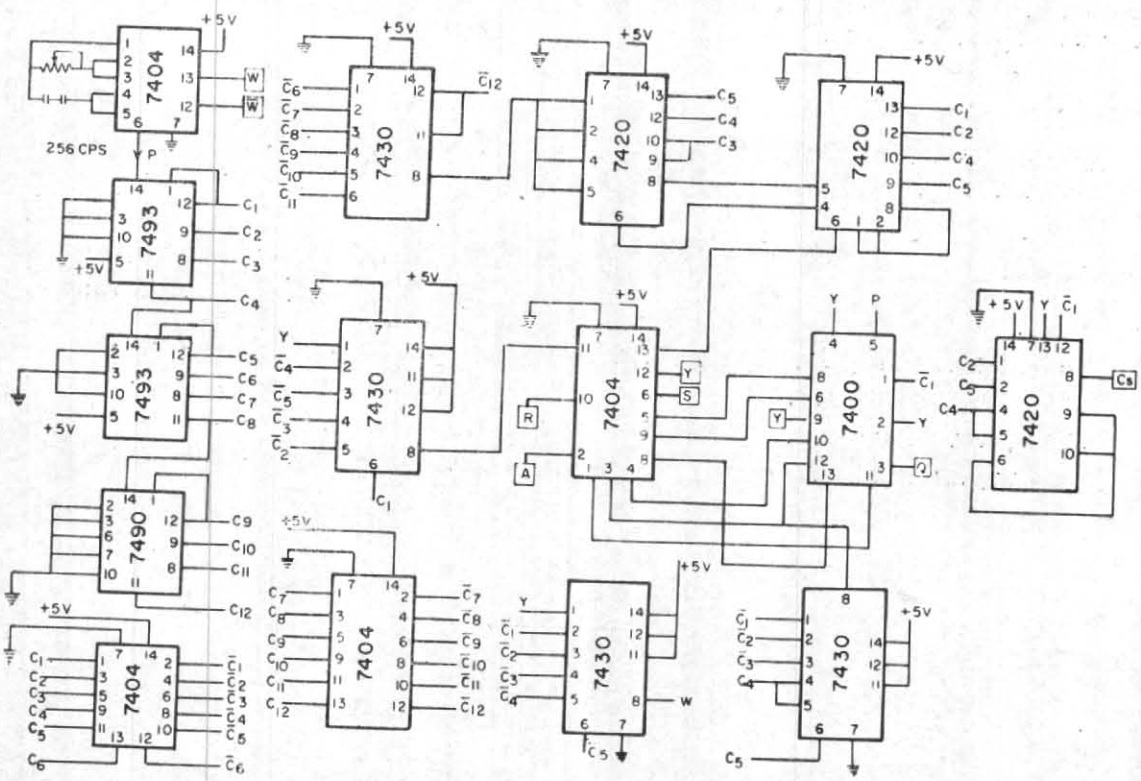

Fig. 5. Programmer circuit

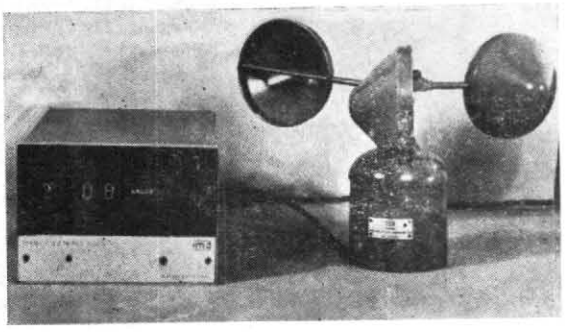

Fig. 6. Mean wind speed indicator and photoelectric anemometer

content of the add register. The carry outputs of the adder are rippled into a 7490 counter and the total number of such carries form the most significant digit of the output. Next the data in the second address is added to the add register content and after this 0110 is again added if necessary. This process goes on till all the 12 samples are added together. After the addition is over, the added output now in BCD form available in the 7473 add register and 7490 carry counter is shifted into the 4-bit 7475 output latches and displayed through the 7447 decoders in a LED seven segment display (DL 61). The memory is addressed for reading and writing by means of read, write counters and address multiplexer consisting of 7493 counters and 7400 Nand gates.

2.3. *The programmer*

The operations of the mean wind computer is controlled by a clock and associated programme circuitry shown in Fig. 5. The clock uses a 256 Hz oscillator. This is divided by a factor of 2560 to give an output of 1 pulse in 10 sec (0·1 Hz). The computing operations are done every 10 seconds by the first 27 pulses of these 2560 pulses. The photograph of the mean wind speed indicator and the photoelectric anemometer is given in Fig. 6.

3. Performance of the instrument

A proto-type of the instrument, designed and developed in accordance with the above mentioned scheme was installed in the open and field-tested in the Instruments Division, Meteorological Office at Pune for a period of 6 months and the performance was found to be quite satisfactory.

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