551.508

A telemetering current weather instrument system for use at airports

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(*Received 4 December 1961*)

ABSTRACT. With the increase in air traffic and the advent of fast jet aircraft it has become necessary to provide almost continuous information on meteorological conditions prevailing over the runway complex to the Air Traffic Control. The Current Weather Instrument Panel designed and constructed at Poona meets these requirements. The instrument displays continuously pressure, temperature, humidity, rainfall, wind speed and wind direction. The sensors are installed near the runway complex where the temperature and humidity are truly representative of the surrounding environment and the data are electrically transmitted by cables to the panel kept in the control tower. The observer in the control tower has only to switch on relevant dials to obtain the information whenever required.

1. Introduction

The provision of continuous and precise information on weather conditions prevailing over the runway complex is one of the services demanded of meteorological offices at all major airports. With the instruments now available to current weather observers at airports, it has become impracticable to take the number and type of observations required, without an inordinate increase in the strength of the observing staff. Nor are the observations recorded near the air terminal building truly representative cf runway conditions which are of vital importance in modern jet aircraft operations. The obvious solution is the installation of remote indicating instruments at appropriate locations near the runway to telemeter the required information to the control tower as and when asked for. Such a system has been designed and constructed at the Instruments Division of the Poona Meteorological office and installed at the Santacruz and Dum Dum airports on an experimental basis. The parameters measured are — station level pressure, temperature, humidity, wind speed, wind direction and precipitation amount. The sensing devices used are conventional meteorological instruments which have been modified and adapted to suit the requirments of speed and accuracy. Telemetering has been achieved by using selsyns and direct cable connections. The electro-mechanical system described below combines the reliability of sensitive and dependable meteorological elements together with the simplicity of electrical circuits, which renders servicing easy.

2. Description of equipment

The equipment consists of —

(*i*) A generator type anemometer,

(*ii*) A selsyn type windvane,

(*iii*) A tipping bucket raingauge,

(*iv*) A telemetering hygro-thermometer, and

(*v*) A display panel with 5 indicators for wind speed, wind direction, rainfall, humidity and temperature. The panel also accommodates one precision aneroid barometer for station level pressure indication.

2·1. The generator type three-cup anemometer used in this system is the standard equipment used for distant indication of windspeed in the IMD distant indicating electrical wind equipment. A cup frame consisting of three beaded conical cups drives a six pole permanent magnet rotor fixed to the rotating spindle. Alternating voltages developed are proportional to the speed of rotation which is measured by a suitable voltmeter.

2·2. The selsyn type wind vane used is likewise similar to the one used in the IMD distant indicating wind equipment. A heavy but accurately balanced rotatable arm carries an aluminium vane at one end, which makes the arm turn to align the vane in the direction of the wind. The spindle is coupled directly to a selsyn transmitter, which telemeters the position of the vane to a suitable distant repeater.

2·3. The tipping bucket raingauge resembles that used in the IMD distant indicating intensity raingauge (Venkiteshwaran *et al.* 1954) except in the diameter of the rim of the funnel; the funnel of 101 mm diameter collects exactly 8 cc of water for a rainfall of 1 mm, which pours down on a two-way tipping bucket carrying a mercury switch. As 8 cc of water collects, the bucket tips, making a momentary contact in the mercury switch. This closes an electric circuit and operates a distant indicator.

2·4. The remote indicating thermo-hygrometer (Fig. 1) has been designed to transmit temperature and humidity values to distant indicators. The instrument consists of two parts: a temperature transmitter and a humidity transmitter, mounted on a single base with cover.

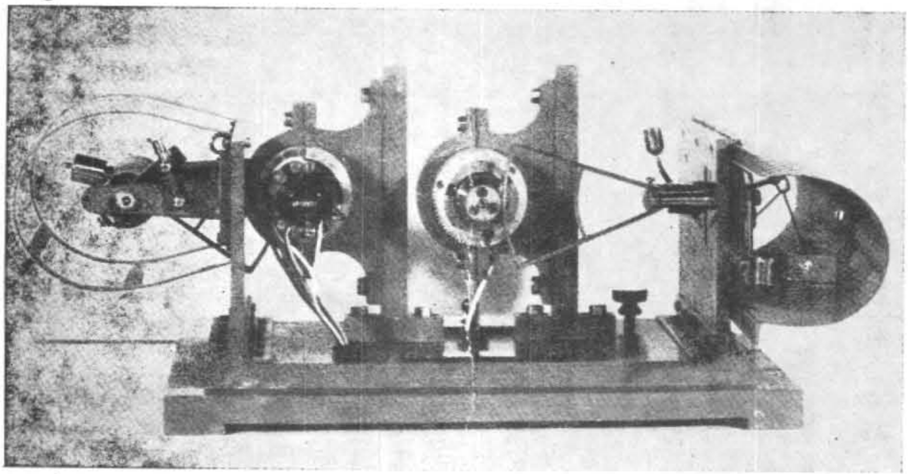

Fig. 1. Telethermohygrometer

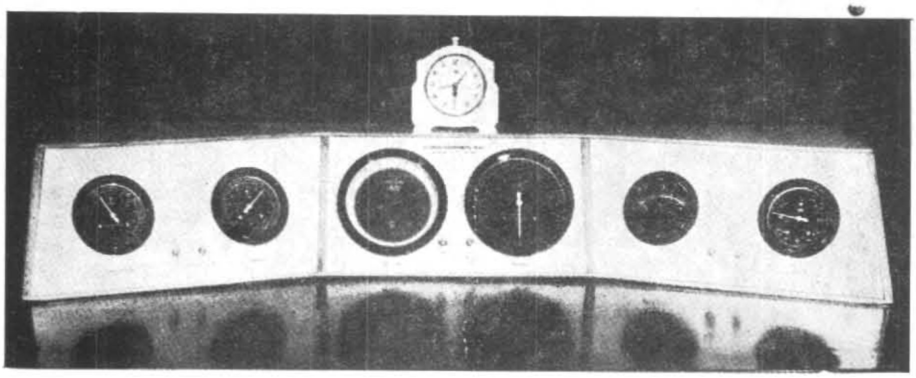

Fig. 2. Current Weather Instrument Panel

2.4.1. The temperature transmitter consists of a multiturn bimetal helix similar to one used in IMD thermographs, the free end of which carries a balanced gear-sector. The gear-sector engages the pinion on a magslip transmitter rotor spindle in a smooth meshing. The angular range of the gear sector is so chosen that the total traverse of the sector turns the magslip rotor through a complete turn. The length of the helix can be adjusted for proper magnification, by shifting a coupling pin over a number of slots provided for the purpose; this enables one to adjust the movement of the magslip rotor corresponding to a known temperature change.

The whole unit consisting of the bimetal helix, spindle and gear sector, is mounted on a brass plate which is fixed to a cast aluminium base. The magslip transmitter is mounted on this aluminium base by suitable rigid clamps. An adjustable slot is provided at the base for adjusting optimum meshing between the sector and the pinion.

The rotor and stator terminals of the magslip are taken to a terminal strip from where the cable to the distant recorder can be easily connected.

2.4.2. The humidity transmitter is composed of a humidity sensitive human hair element with a cam-lever arrangement for magnification and linearisation of movements, identical to the one in use in IMD hygrographs. A bundle of hair is held by two adjustable jaws and hooked approximately at the middle to a lever. Two properly designed cams attached to this lever movement magnifies and linearises the logarithmic variations of the hair element with changes in relative humidity. A balanced gear sector is fixed to the second cam axis, whose angular movement is proportional to the variation in humidity within certain limits. The sector meshes smoothly on a pinion on a magslip transmitter rotor spindle. The pinion-sector is so adjusted that the rotor turns through about 300° for a variation of humidity from 0 to 100 per cent.

The hair element is mounted on a brass plate and fixed to the opposite side of the temperature element on the common aluminium base. The sector and the magslip transmitter are mounted inside on rigid and adjustable mounts to ensure proper meshing. The magslip connections are

TABLE 1(a)
Station — Poona

Date	Time (GMT)	Rainfall since last observation: Recorded in ordinary raingauge (mm)	Rainfall since last observation: Recorded on panel (mm)
1-8-60	0500	3·8	4·0
2-8-60	0500	20·0	20·0
3-8-60	0500	1·2	1·0
4-8-60	0500	1·4	1·0
5-8-60	0900	2·8	3·0
9-8-60	0600	6·8	7·0
11-8-60	0500	3·8	3·0
12-8-60	0500	2·0	2·0
3-9-60	0500	3·0	3·0
5-9-60	0500	1·4	2·0
6-9-60	0500	Traces	Nil
7-9-60	0500	2·2	2·0
8-9-60	0500	6·2	6·0

TABLE 1(b)
Station — Poona

Date	Time (GMT)	Temperature: Screen reading (°C)	Temperature: Panel reading (°C)	Humidity: Screen reading (%)	Humidity: Panel reading (%)
9-6-61	0500	29·0	28·7	61	67
	0900	29·5	29·5	60	64
10-6-61	0900	30·8	30·4	59	61
	1200	27·1	27·2	69	74
11-6-61	0500	28·3	27·5	65	71
	0900	29·4	28·7	60	63
	1200	27·7	27·8	71	76
12-6-61	0500	28·8	28·8	65	71
	0900	30·5	30·5	63	62
	1200	28·8	29·8	66	67
13-6-61	0500	30·5	30·1	58	61
	0900	31·4	30·5	56	57

brought out to the common terminal strip for cable connections.

The temperature and humidity sensitive elements are mounted outside the case for proper exposure, whereas the two magslips and the sectors are covered by a metal counter casing with glass windows. The hair element is protected by a perforated metal guard against damage. The whole unit is placed inside a standard Stevenson Screen.

2·5. The display panel consists of six indicator dials (Fig. 2) arranged over an arc to ensure easy and accurate reading without parallax errors. The arrangement of dials from left to right are — (1) temperature, (2) humidity, (3) pressure, (4) rainfall, (5) wind direction, (6) wind speed.

2·5·1. The temperature indicator dial is calibrated for a range —10°C to 50°C incorporating a pointer movement over about 300°. The pointer is press-fit on the rotor shaft of a magslip repeater, which repeats the movements of the transmitter rotor of the distant temperature recorder. A switch is provided at the bottom of the dial to connect or disconnect power supply to the two rotors in parallel. Since the angular position of the transmitter is repeated to the indicator with an accuracy of $\pm 0°\cdot 25$, the maximum error likely to be introduced in the process of telemetering is equal to 0°·05 C.

2·5·2. The humidity indicator dial is similarly graduated from 0 to 100 per cent humidity over an arc of about 300°. A pointer on the humidity repeater magslip rotor shaft shows variations of humidity at the location of the transmitter unit. A switch to connect power to the rotors in parallel is also provided at the bottom of the dial. The maximum error in the transmission of humidity values is less than 1 per cent.

2·5·3. The pressure indicator is a precision aneroid barometer, set to read pressure at the runway height. The aneroid is graduated at intervals of 1 mb and is capable of recording a variation of 0·1 mb.

2·5·4. The rainfall indicator dial is graduated from 0 to 100 mm over a complete circle. The pointer is moved by a lever escapement arrangement actuated by electrical impulses produced by momentary shortages at the mercury switch in a distant tipping bucket raingauge. Each impulse moves the pointer by one division in the clockwise direction, and the total number of tips is indicated by the position of the pointer at the end of the period, to give the amount of rainfall in mm. A resetting arrangement is provided on top, by which the pointer can be brought to zero after each observation. The intensity of rainfall during any period can be obtained by dividing the amount of rainfall by the time interval. The dial can also be graduated in mm/hr and intensities read directly if the pointer is set to zero and read after the required time interval.

2·5·5. The wind direction indicator is a repeating selsyn, identical to the wind direction meter in use in IMD distant indicating wind equipment. The rotor shaft is attached to a pointer moving over a dial graduated in degrees for every 5° position of the compass and in cardinal and intercardinal letters. The mains power supply to the selsyn system is controlled by a toggle switch mounted below the dial. Wind direction can be read to an accuracy of 1°.

2·5·6. The wind speed meter is again identical to the one used in the standard IMD equipment. The meter is a rectifier type A.C. voltmeter giving full scale deflection for 5 mA D.C. The meter has got two ranges marked on the dial, one 0–20 knots and the other 0–80 knots and is controlled by a spring loaded toggle switch mounted below the meter to give either of the two ranges. Wind speed can be read to an accuracy of 1 knot.

TABLE 2

Station — Santacruz

Date	Time (GMT)	Temperature		Humidity	
		Screen reading (°C)	Panel reading (°C)	Screen reading (%)	Panel reading (%)
9-10-61	1500	27·4	27·4	87	90
	1600	27·0	27·4	89	91
	1700	26·9	27·3	91	91
10-10-61	0000	23·6	23·8	96	95
	0100	23·6	23·8	96	96
	0200	23·8	23·8	98	96
	0300	24·4	24·0	96	95
11-10-61	0300	23·5	23·4	83	87
	0400	26·3	25·7	81	82
	0500	27·1	26·7	82	82
	0700	28·0	27·4	75	80
	0900	27·0	27·4	77	76
	1200	26·7	25·8	81	84
	1300	25·4	25·8	84	86
12-10-61	1000	30·2	30·0	70	75
	1100	29·7	29·9	72	74
13-10-61	0700	29·3	29·2	74	74
	0800	29·8	29·7	74	73
	0900	29·8	29·7	73	73

2.6. Power supply to the complete equipment is located behind the panel and consists of the following units —

(*i*) Three step down transformers 230 v to 25 v for the thermometer, hygrometer and wind direction selsyn systems.

(*ii*) One step down transformer 230 v to 6 v for dial lighting arrangement.

(*iii*) One 6 v dry battery pack for the operation of the tipping bucket raingauge.

Power is fed near the repeater side of the selsyns and a cable length of 1000 m can easily be used between the repeater and transmitter. For longer cable lengths an alternate arrangement of feeding at the centre point of the cable through a suitable junction box can be made.

2·7. The panel is mounted on 5 ft × 3 ft desk at an angle of 15° to the vertical, so that for an observer sitting at the desk, the full view of the dials are presented normally. The desk is provided with drawers for keeping essential stationery articles, forms etc.

3. Discussion

The equipment was tested at the Instruments Division, Meteorological Office, Poona with the telemetering elements installed on the roof of the main building and the panel in the Weather Central. The total length of cable used between the transmitter and receiver was 150 m. Wet and dry bulb thermographs and hygrographs as well as thermometers and ordinary raingauges were used for taking comparative observations. The reliability of the wind instruments is well established and no check readings were taken.

A second model was installed at Santacruz airport in October 1961. The Stevenson Screen with the telethermo-hygrometer and the tipping bucket raingauge were installed near the main runway (distance between transmitter and repeater 800 m) and the wind instruments on the roof of the control tower. These will shortly be shifted to the centre of the runway complex and installed at heights most likely to give runway take off and landing winds. The panel was installed in the control tower.

The results of the comparison at Poona and Santacruz are given in Tables 1 and 2. It will be seen that the telemetering devices worked very well in transmitting temperature and humidity data within the limiting accuracy of the instruments. The rainfall data also compare well.

The accuracy of indication by the telemetering thermo-hygrometer incorporated in this equipment is limited by the accuracy of the elements. The bimetallic thermometer can record with an accuracy of ±0°·25 C and the hair element ± 5 per cent of relative humidity. The errors in transmission is negligible — theoretical maxima being ± 0°·05 C and 0·75 per cent of relative humidity respectively. The overall accuracy of the system is slightly better than that of the conventional recording instruments owing to decreased frictional drag on the movements of the elements.

The equipment, being a prototype model has ample scope for improvement. Electrical resistance thermometers and dewcel elements will in due course replace the conventional telethermo-hygrometer.

4. Acknowledgement

The authors are deeply thankful to the officers and members of staff of the Instruments Division, Meteorological Office, Poona for their valuable help. Particularly mention is made of S/Shri G. P. Srivastava, B. B. Huddar and R. R. Wagholikar for their co-operation during the work of constructing and testing the equipment.

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