A Remote-Reading and -Recording Instrument Board for Weather Station

by

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Abstract

An experimental remote-reading and -recording instrument board has been designed and assembled in 1951. It comprises a combination wind vane and anemometer, six thermometers with sealed carbon filaments (air, wet- and dry-bulb, and earth thermometers at three depths) and a float-actuated rain gauge, with their indicators and recorders, each of which was already reported in the preceding issues of the Papers. The instruments are incorporated in an instrument board in combination with two observation clocks, an aneroid barometer, a statoscope, an aneroid barograph and a Fortin mercurial barometer, each of ordinary make. The whole equipment was installed in December 1951 at the Maebashi Weather Station, and a preliminary test was successfully gone through in June 1952.

1. Object of the instrument board

Many attempts have hitherto been tried out to afford individual remote-reading and -recording meteorological instruments, but the recent trends are toward their combination into a single instrument board. Only such an equipment will realize the true synoptic meteorological observation, because it gives at a glance the state of all meteorological elements as a whole, and also their successive changes are constantly inspected. Instantaneous informations are available in relation to all other

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Table 1. Items of the routine equipment with their accuracies and the systems of measurement and supervision.

<table>
<thead>
<tr>
<th>Element</th>
<th>Routine equipment</th>
<th>Accuracy</th>
<th>Subdivision</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind direction</td>
<td>Continuous record</td>
<td>16 cards/pt.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind speed</td>
<td>Continuous record</td>
<td>0.1 m/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instantaneous max.</td>
<td>Continuous record</td>
<td>Daily max.</td>
<td></td>
<td></td>
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<tr>
<td>10-min. mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Forecast max.</td>
<td>Continuous record</td>
<td>Class 0, 1, 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainfall</td>
<td>Continuous record</td>
<td>0.1°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. thermometer</td>
<td>Continuous record</td>
<td>Max. temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min. thermometer</td>
<td>Continuous record</td>
<td>Depth of snow</td>
<td></td>
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<tr>
<td>Depression</td>
<td>Indicator reading</td>
<td>Max. pressure</td>
<td></td>
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<tr>
<td>Max. pressure</td>
<td>Indicator reading</td>
<td>0.1°C</td>
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</tr>
<tr>
<td>Min. pressure</td>
<td>Indicator reading</td>
<td>0.1°C</td>
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<tr>
<td>Min. pressure</td>
<td>Daily barometer</td>
<td>Max. pressure</td>
<td></td>
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</tr>
<tr>
<td>Max. pressure</td>
<td>Daily barometer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind speed</td>
<td>Same as routine</td>
<td>Instantaneous max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weather balloon</td>
<td>Daily barometer</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Rainfall</td>
<td>Same as routine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extremities</td>
<td>Same as routine</td>
<td>Daily max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>Same as routine</td>
<td>10-min. max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>Same as routine</td>
<td>24-hr. max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>Same as routine</td>
<td>1-hr. max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>Same as routine</td>
<td>10-min. max.</td>
<td></td>
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</tr>
<tr>
<td>Change</td>
<td>Same as routine</td>
<td>24-hr. max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>Same as routine</td>
<td>0.1°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainfall</td>
<td>Same as routine</td>
<td>0.1 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainfall</td>
<td>Same as routine</td>
<td>0.1 mm</td>
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<td>0.1 mm</td>
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</table>

*Also contact indication is possible.*
elements, and, as a result, exact analysis is readily possible by an observer sitting at the instrument board. The observer is relieved of most of physical labour, and need no more rush from one instrument to another, his sole task being the observation of the single instrument board.

The present equipment is, however, to be regarded as a step toward the ideal feature, and is designed according to the requirements of code (SYNOP CODE) despatching.

The items of the present routine equipments for SYNOP CODE and their accuracies are listed in Table 1, together with the system of the instrument board. The accuracies of the latter are, of course, required at least to be equal to those of the former.

2. Arrangement of the instrument board and description of the instruments

The general layout of the instrument board is illustrated in Fig. 1, and its actual aspect is shown in Fig. 2. The board consists, at present, of four sections, but additional sections can be attached at both sides as the number of instruments increases. The board sections are of wooden construction, and only their fronts

![Fig. 1. General lay-out of the instrument board.](image_url)

are covered with enamel-painted steel sheets of 1mm thickness. They rest on a desk. The illumination is provided from a fluorescent lamp hung above the desk.

The electric power source of the whole system is D.C. 12-volt except for the drive of the thermograph and the loading of its elements, for which 100-volt, 50-cycle A.C. current is applied (for driving the synchronous motor) or passed after being stepped down to 6 volts and rectified (for the elements).

The details of the instruments are as follows.

1) The combination wind vane and anemometer (Fig. 3).

The form and construction are described in References [1] and [2]. The wind speed is indicated and recorded by means of a D.C. generator coupled directly to the anemometer windmill. The wind direction is transmitted from a D.C. position motor incorporated in the vertical shaft supporting the fuselage. The equipment is installed on the tower of the Station.

2) The remote-reading and -recording mercurial thermometer with sealed carbon filament.

The details of its construction are reported in Reference [3]. For the present instrument board, six thermometers, i.e., one for air temperature, a pair as wet- and dry-bulb, three for earth 0.0m, 0.1m and 0.2m. The wet- and dry-bulb thermometers are installed in an aspirator (Fig. 4) driven by a small D.C. motor. The earth thermometers are sealed in glass sheaths filled with mercury.

The air thermometer and wet- and dry-bulb thermometers are installed within a standard screen which is about 10m apart to the east of the screen containing the
routine thermometers. The earth thermometers are put in a line on and in the earth to the east of the routine ones. The continuous recording is provided for the air and earth 0.0m thermometers, while other thermometers' readings are read off on a single indicator (a crosscoiled ohmometer) by manipulating a multipoint rotary switch. The aspirator motor is automatically put in motion and a pilot lamp is lit when the rotary switch is set to the wet- or dry-bulb temperature.

3) The rain gauge (Fig. 5).

The original design is described in Reference [4]. A minor improvement is effected in removing the electric contact from within the float to the upper compartment, to make it free from the moisture contained in the float tank. Further the total capacity is reduced from the original value of 1,000 mm to 250 mm, while the minimum reading of 0.1 mm is secured. In case of cold season an electric lamp is to be lit inside the wooden muffle box enclosing the tank to keep the rain water well above its freezing point. The rain gauge is placed within a hut on the observation field, the rain receiver being equipped on its roof top.

4) The clocks and the drive of recorders.

Two electric clocks are installed to give the Greenwich Civil Time (GCT or Z time) and the Japanese Mean Time (J time). They are actuated by the electric pulse at each 1 minute transmitted from a standard clock placed in a separate room. The standard clock also feeds the recorder chart of the combination wind vane and anemometer. The thermograph is driven by A.C. current as stated above and time marks are dotted on the recorder chart at each 10 minutes by means of the electric pulse of the standard clock to avoid the power-line cycle fluctuations.

5) Additional features.

To meet the demands of observers, three signal lamps are provided on the instrument board to record the time of commencement and finish of rainfall, the duration of sunshine and the occurrence of earthquake. The rainfall signal is communicated by a tiny tipping bucket of a separate rain receiver. The sunshine signal is transmitted by the contacts incorporated in a Robitzsch type actinograph. The earthquake signal is given by a pendulum detector. These additional features are realized in the second instrument board installed at the Tokyo District Central Meteorological Observatory.
All these installations at the Maebashi Weather Station were completed in December 1951. The leads are gathered from the tower and observation field to the instrument board in the observation room where the meteorological telegraphs are despatched. The whole instrumentation is so designed as to be easy to handle and robust enough for weather station use.

3. The comparison of the instrument board results with the routine observations

The comparison was commenced at once after the installation, between the instrument board results and the routine observations, and continued until the end of June 1952. It was found to be almost satisfactory, interruptions being hardly experienced. The whole equipment is still in use now that it is regarded as a powerful implement in relieving the observers' physical labour and in affording prompt and exact informations on the other hand. The test on the second instrument board which was completed in March 1952 was started in September 1952 at the Tokyo District Central Meteorological Observatory. The number of installations will no doubt be increased in the coming year, and, we hope, the time will not be long in coming when the present instrument board with probable improvements will be seen as a standard equipment at the weather stations in Japan.

The opinions of the personnel who utilized and maintained the present equipment are summarized with necessary remarks on our side in the following.

a. Wind speed

1) The comparison with the Robinson cup-anemometer shows generally somewhat smaller values of wind run. The difference becomes larger as the wind speed increases. This is due to the larger over-estimation of the cup type.

2) The comparison with the Dines pressure tube gives also smaller values of indication. The difference seems to be nearly independent of wind speed. This is probably due to the good peak response of the pressure tube in the region of low wind speed. The errors due to the positions of both anemometers seem to be negligible, as they are placed close enough to each other. This is also confirmed by a wind tunnel test carried out in advance.

3) The comparison of gustiness defined by

\[ \text{gustiness} = \frac{V_{\text{max}} - V_{\text{min}}}{V_{\text{max}} + V_{\text{min}}} \]

where \( V \) means the speed given by the instrument board and Dines pressure tube, manifests much larger values for the former for the whole wind speed range (0~20 m/s). This fact will probably testify to a better total response (smaller over-estimation factor) of the instrument board anemometer than the pressure tube.
b. Wind direction

Good coincidence is found in general between the mean indications of the instrument board wind vane and the routine one. Further the amplitude of the former is much smaller than the latter, showing higher damping and shorter period of oscillation which are the most desirable features for the purpose.

c. Dry-bulb temperature

The comparison of the instrument board and routine observation shows discrepancies not exceeding ±0.2°C, the general tendency being a little higher for the former in cases of temperatures lower than 10°C, and a little lower in cases of temperatures higher than 10°C. The discrepancies will probably have arisen partly from observation parallax due to the curved glass cover of the indicator, and also from the difference of time of both observations, especially in the daytime when the temperature changes rapidly.

d. Wet-bulb temperature

The discrepancies from the routine observation are somewhat large, reaching about 2°C in extreme cases for the instrument board. The thermometer itself seems to be correct as it is confirmed from the tests conducted as a dry-bulb thermometer. Further it shows acceptable indication as a wet-bulb with no ventilation. Therefore the cause should be sought in the unsatisfactory ventilation. The aspirator used for the instrument board thermometer is the same type as that used for routine observation. The instrument board thermometer bulb, however, is much larger and, in addition, it has a long wick along the ventilating duct to the water pot suspended below, while the routine wet bulb has a short muslin wicking covering it. Thus the shortage of ventilation is quite possible and also actually observed by the feeling of the hand at the inlet port.

e. Earth temperature

1) Surface temperature.

The discrepancies from the routine observation are larger than these between the instrument board dry-bulb temperature and the routine one. And they are large in the daytime and small by night. These facts are considered to be due to the positions of setting and also to the difference in heat capacities of the exposed portions of both thermometers. The instrument board thermometer has a larger stem and bulb which receives and emits more radiation.

2) Underground temperature at 0.1m and 0.2m.

The tendencies due to the effect of setting positions are the same as those of the surface thermometers, but the radiation effect is reversed. The latter is attributed to the adverse relation due to nearly buried instrument board thermometers and largely exposed stems of the routine thermometers. The larger the earth depth, the smaller are the discrepancies.
f. Rainfall

The discrepancies are the smallest of all the instrument board system. They are of the order of a few fractions of mm.

4. Trends of further improvement

After the preliminary test described above, the following requirements are presented to us for improvement.

1) Standardization of electric source.

The present thermograph utilizes A.C. current for its drive and loading, while the other instruments are all of D.C. type. This problem will be solved by employing either of the two currents exclusively. An electronic thermograph using A.C. current which will give powerful and linear recording is now under construction. To fit it for the complete D.C. current system, an inverter will be inserted between the batteries and instruments.

2) Barometric pressure.

An instrument is under construction to record barometric pressure and its minor changes, employing the same principle as that for the thermometer with sealed carbon filament.

3) Rainfall intensity.

For exact knowledge and analysis of rainfall, the rainfall intensity is indispensable. An instrument has been completed to record it by means of a tipping bucket and sliding resistance set by the pulses emitted from the bucket contacts.

4) State of the sky.

A sky projector will be the solution but is not yet realized.

References