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Recent developments in meteorological instruments and techniques in India

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1. Introduction

In a previous article (Agarwala 1949) the author had given a review of the work done on the development and designing of meteorological instruments in India upto that time. In this article an attempt has been made to review briefly the work done in the subsequent eight-year period.

Work on the design and construction of meteorological and other necessary instruments has been undertaken mainly at the laboratories and workshops of the India Meteorological Department at New Delhi and Poona and at the Solar Physics Observatory at Kodaikanal. Besides the Meteorological Department, the National Instruments Factory (formerly Mathematical Instruments Office), Calcutta, which has been considerably expanded and modernised in recent years by the Government of India has made significant contribution in this direction.

2. Instruments for upper air measurements

Mention had been made in the previous article of two inexpensive and simple radio-meteorographs—the Chronometric type designated as the C-type radiosonde developed at New Delhi (Mathur 1946, 1948) and the other, the Fan operated type known as the F-type radiosonde developed at Poona (Venkiteshwaran, Thatte and Keshavamurthy 1947, 1948). Major improvements have been effected in both these instruments during the past few years for securing greater accuracy, lightness and cheapness and also equipment for calibration of these radiosondes has been improved (Venkiteshwaran 1950). These two types of radiosondes have been in use at Indian stations for about a decade now for determining the pressure, temperature and humidity in the upper layers of the atmosphere. They have completely replaced the improved type of the Dines sounding balloon meteorograph with enlarged pressure and temperature scales, which was constructed in India and which was so widely being used in this country for upper air soundings in the past. India took part in the Second World Comparisons of Radiosondes which took place at Payerne (Switzerland) during May-June 1956, under the auspices of the World

Meteorological Organisation and both types of radiosondes used by the India Meteorological Department were sent in for comparisons. The Indian delegation headed by Dr. S. Mull made a large number of successful soundings at Payerne and obtained valuable data. An analysis of the data of the radiosonde comparison flights in which fourteen sondes were used in train has been made and an assessment of the comparative performances of the sondes from different countries has been given in a paper recently published by Satakopan and Mull (1957).

In order to be able to supply accurate high level wind data required by aircraft flying at very high altitudes such as jet airliners, the India Meteorological Department set up a programme for the installation and operation of radio-wind equipment at a number of major observatories. This programme is at present being executed under the direction of Shri S. Basu, Director General of Observatories. Keeping in view the ever-growing needs of aviation, Shri Basu has also set up a further programme for the development of radio-meteorology, modernisation of equipment used at aerodrome observatories and designing and local construction of meteorological instruments under the country's Second Five Year Plan (1956—61). The work is now being pursued energetically at the Instruments Divisions at New Delhi and Poona under the supervision of Dr. S. Mull, Deputy Director General of Observatories (Instruments).

A technique by which both radiosonde and radio-wind data could be obtained from the same transmitter borne by one balloon resulting in very considerable decrease in the cost was an obvious line of development which suggested itself from the experience gained in the use of the radiosonde and the radio-theodolite in India. The investigation of this problem was undertaken at New Delhi as well as at Poona. At New Delhi, Mathur and his associates (1956) have evolved a technique for telemetering the chronometric radiosonde data on the F-M channel of the receiver of the radio-theodolite (Fig. 1). In this method a squegging oscillator is used in conjunction with the chronometric radiosonde to obtain F-M signals from the 400 Mc/s rawin transmitter at each contact of the meteorologically sensitive pens with the contacting helix of the radiosonde. With the ground-based rawin receiver an auxiliary unit is used to work the radiosonde receiver whenever the F-M signals are picked up by the radio-theodolite receiver. At Poona also, a technique has been developed by which the rawin and radiosonde circuits are successfully adopted for obtaining both wind and radiosonde data with a single valve transmitter on 400 Mc/s. The details of this technique have been published in a paper by Ramachandran and Mani (1956). The advantages of this method are that (*i*) simultaneous measurements of all the data necessary for computing winds and plotting a tephigram are made with a single valve transmitter and (*ii*) the "fading" of the signals for high angles of elevation found in the radio receivers is very much reduced due to the proper alignment of the receiving aerial.

A technique has also been developed by Venkiteshwaran and his associates (1953) for the measurement of the electrical potential gradient in the upper air with the audio-frequency modulated type of radiosonde. This method has also been successfully extended by Venkiteshwaran, Gupta and Huddar (1954) to the measurement of electrical conductivity in the upper air.

The C-type and the F-type radiosondes as well as the rawin transmitters are now being manufactured on a large scale at New Delhi and Poona workshops respectively and the technique of making the various components, *e.g.*, clock movements, high tension batteries etc, has also been improved considerably. In this connection mention may be made of a modified scheme of contacts for the C-type radiosonde devised by Yacob (1956). A simple arrangement for seasoning aneroids and bimetals used in radio-meteorographs has also been evolved (Venkiteshwaran, Mani and Huddar 1956); the system is automatic for subjecting the aneroid elements to a number of cycles of pressure changes from the pressure

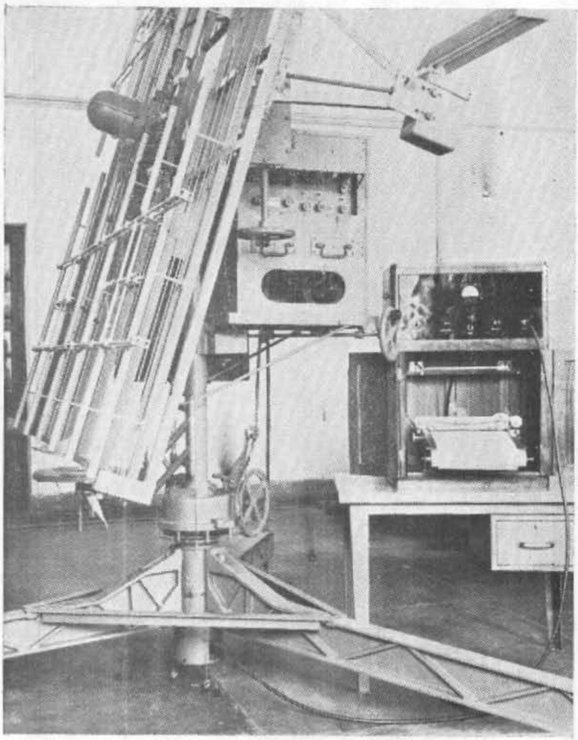

Fig. 1. Radio-theodolite with modified type of radiosonde ground equipment set

of one atmosphere to 50 mb and can also be adapted for seasoning the bimetal temperature elements. In order to test the performance and also to effect improvements, the lag coefficient of the bimetal thermometer used in the chronometric radiosonde was determined experimentally at New Delhi by Mitra and Datta (1954) and found to be of the order of 8 seconds for an ascentional rate of 18 to 20 km hr^{-1}. Work on the determination of the radiation error of the C-type and F-type radiosondes as well as on the evaluation of the temperature effect on the aneroids of these instruments is also in progress.

3. Instruments for recording surface observations

Reference had been made in the previous article (Agarwala 1949) to the Sil Intensity Raingauge which is an autographic instrument designed by Shri J. M. Sil for recording the intensity of rainfall. The work on the design of intensity raingauge has been continued and another instrument which gives at a distance the record of the intensity of rainfall has been designed and constructed by Venkiteshwaran, Mani and Amritham (1954). This instrument (Fig. 2) uses a tipping bucket mechanism and a Bibby type electric impulse recorder and is very useful at aerodrome stations where heavy rainfall warnings have to be issued at short notice. Another instrument which records rain continuously for six months without attention has also been designed and constructed at Poona. This instrument (*Adm. Rep.*, 1948-49, India met. Dep.) is suitable for installation at stations which are difficult of access such as some of the Himalayan stations. Besides the "I.Met.D." cyclometer-

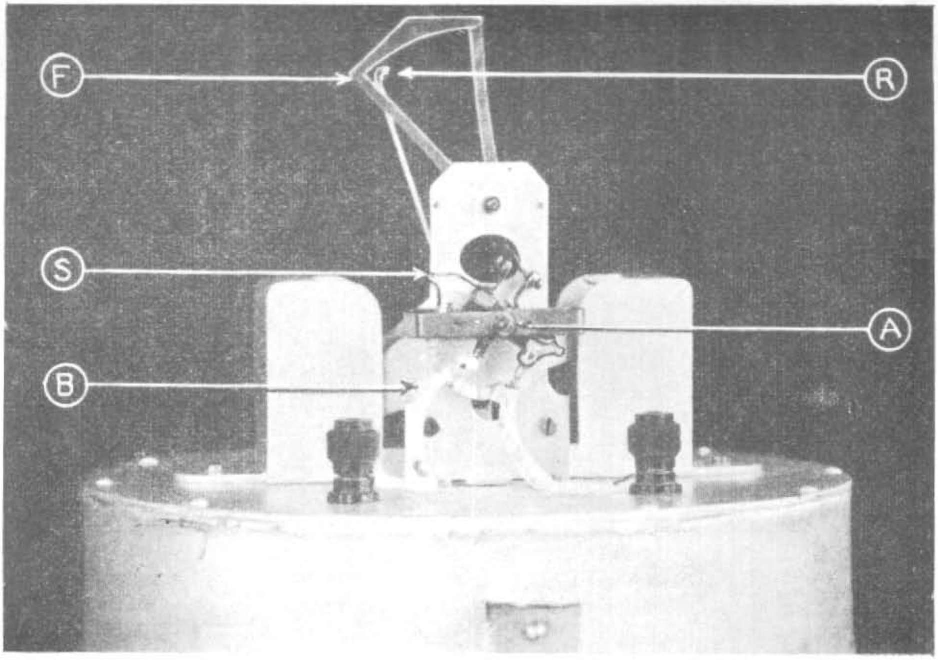

Fig. 2. Distant recording intensity raingauge using a tipping bucket mechanism and a Bibby type impulse recorder

Rain collected in a 8″ diameter funnel is led to the tipping bucket B coupled to a mercury switch S through the fork F. The rod R, rigidly attached to the bucket, engages one arm of the fork F. The bucket, when full, tips to one side and the lower end of the fork tilts in turn one of the two arms of the mercury switch which is capable of oscillation about the axis A

type cup anemometer and "I.Met.D." windvane with splayed tail referred to in the author's previous article, an electronic distant recording anemometer and a Selsyn operated windvane have been designed and constructed (Keshavamurthy and Venkiteshwaran 1950) for use at aerodromes and other observatories. A suitable snowgauge with wind shield and tower has also been designed for use at observatories on the Himalayan range in connection with the various river valley schemes. In connection with evaporation measurements, an evaporigraph to record automatically the level of water in a U.S.A. type open pan evaporimeter has been devised and constructed (*Adm. Rep.*, 1953-54, India met. Dep.). Mention may also be made of an improved type of bucket designed by Mani (1952) for the measurement of sea surface temperature.

The technique for the manufacture of instruments for surface observations has been developed by meteorologists in this country and now most of these instruments such as anemometers, windvanes, Kew pattern barometers, ordinary raingauges and snow gauges, sunshine recorders (except the glass sphere), barographs, thermographs, hair hygrographs, Dines anemographs, recording raingauges and small type Assmann psychrometers are being manufactured in the departmental workshops.

Necessary arrangements for the calibration and standardisation of all types of meteorological instruments have been developed. Standard instruments are being carefully maintained which are required for periodical comparisons. It may be added that the Regional Association II (Asia) of the World Meteorological Organisation at its session held in February 1955, set up a programme for the comparison of national standard barometers in the Asian Region with a single standard and designated Calcutta as the main centre at which such Regional comparisons should be made from time to time with the Indian standard barometer maintained there. Steps have already been taken for the implementation of this programme under the guidance of Shri S. Basu, President RA-II, and Dr. S. Mull, Chairman of the Standing Working Group for the comparison of barometers. Detailed procedure for making the comparisons has been issued to all the member-countries of the Region.

Established in 1830 under its original name of the Mathematical Instruments Office, the National Instruments Factory, Calcutta, sponsored by the Government of India, has now grown up into a large industrial undertaking, producing various types of instruments. This factory has also now developed the technique for the manufacture of thermometers in addition to other instruments such as standard ordinary raingauges, measure glasses etc which it has been manufacturing and supplying to the India Meteorological Department as well as to the State Governments for many years. It also occasionally meets the demands of neighbouring countries like Afghanistan, Burma, Pakistan and Iraq.

The laboratories and workshops of the India Meteorological Department have also devoted considerable attention to the design and construction of various types of appliances required for research work in addition to those required for test and calibration. Mention may be made here of the following appliances (*Adm. Rep.*, 1952-53, India met. Dep.)—

(*i*) D.F. calibrator for calibrating the output of the amplifiers of the radiogoniograph

(*ii*) Absorption wavemeter and field strength indicator for Baby Maggie radar

(*iii*) Thyratron controlled thermostat

(*iv*) Lecher wire wavemeter for 400 megacycles

(*v*) Rack assembly for an airborne radar set suitably modified to be used as a static ground installation for storm-detection work

4. Spectrographs and seismographs

A number of instruments which belong to the field of astrophysics have been developed at the Solar Physics Observatory, Kodaikanal, under the direction of Dr. A.K. Das. A noteworthy contribution is a recording photo-electric photometer devised by Das and his associates (1951). This instrument is designed specially for use in solar line-contour work. At the Kodaikanal observatory a "Radio Telescope" for the 100 Mc/s region for the study of "solar noises" (*Adm. Rep.*, 1951-52, India met. Dep.) has also been constructed by making necessary modifications in an old army radar. A prism-spectrograph has also been constructed at this observatory for the observation of the total solar eclipse; this instrument has been so designed that it is capable of rotation about its optical axis (*Adm. Rep.*, 1952-53, India met. Dep.)

Reference may also be made of an instrument for the measurement of infra-red radiation during day and night designed by Kale (1952) of the Agricultural Meteorology Branch. Also, Momin (1953) of the same Branch has developed a new high-speed recording technique for use with infra-red spectrograph. Both these new designs have been patented.

In the course of the last eight years or so, the India Meteorological Department has also done further work on the development and construction of seismological instruments suitable for Indian conditions. A simplified model of Wood-Anderson seismograph and a quick run recording drum employing a governor controlled weight drive have been evolved by Tandon (1951). Instruments of this design have been constructed at the Poona workshops and are now in use at some of the Indian seismological stations. These instruments have been found suitable for study of strong earthquakes. The programme of local construction of seismographs has been further pursued in the Poona workshop and a good number of seismographs of Milne-Shaw type have been made and these have given as good a performance as the imported instruments (*Adm. Rep.*, 1949-50, India met. Dep.). Sprengnether type horizontal component electromagnetic seismographs have also been made and tried. Clocks driven with weight and with automatically wound springs for use with seismological and other instruments have also been constructed with notable success; an account of this work is given in a paper by Venkiteshwaran and Narayana Iyer (1951).

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