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A tipping bucket type of distant recording intensity raingauge

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1. Introduction

A suitable instrument for recording rainfall intensities should satisfy the following requirements —

(*i*) It should be capable of recording rates of rainfall either instantaneously or in very short time intervals

(*ii*) The range of the instrument should be adjustable since the rates of rainfall vary widely from place to place and at various seasons in the same place

(*iii*) It should be preferably distant recording, this being particularly necessary at aerodrome stations where heavy rainfall warnings to aircraft have to be issued at short notice.

The records of the standard syphon raingauge available at many stations in India can be used to calculate the rates of rainfall as was done for Poona, Madras and Bangalore (Krishnaswamy 1951, 1952, 1954). He calculated rainfall intensities for 15-minute intervals from the rainfall records and found that intensities of the order of 3 to 4 inches per hour are not uncommon. For shorter intervals of time the intensity of rainfall shows very different features and hence there is a need for intensity records for shorter duration.

2. Types of intensity recorders

There are two main types of rainfall intensity recorders in use. In one, the instantaneous rate is recorded, usually by making use of the fact that the rate at which water flows through a restricted orifice depends on the pressure or head of water producing the flow. The rain is allowed to escape through a hole and the head of water produced is measured. The Ramon Jardi (1922) and Nell (1939) rate of rainfall recorders are of this type.

In the second type, the amount of rain which has actually fallen in a short period of time is recorded. A float mechanism or one which counts the number of drops formed by an orifice at the base of the collecting funnel is normally used. The Sil Intensity raingauge (1945) and the Bibby rate of rainfall recorder (1944) are of this type. In the Sil Intensity raingauge, the rainfalls collected in a funnel of 8″ diameter for duration of one minute each are led in succession into a series of three identical receivers. Each receiver has a light float which operates a common pen arm. The displacement of the float due to the collection of rain in the receiver for any one minute is proportional to the mean intensity of rainfall during that minute interval, the continuity of the record is maintained by the use of the three receivers which are filled and emptied in cyclic order every three minutes by a clock-work mechanism. The record formed is in practice, a continuous curve giving the rate of rainfall in inches per hour.

In the Bibby rate of rainfall recorder, rain entering the funnel of the raingauge falls from a carefully made circular orifice in a succession of drops of equal size (corresponding to 0·01 mm of rain for a 5-inch diameter funnel). The falling drop hits a lightly balanced paddle, causing the latter to tip

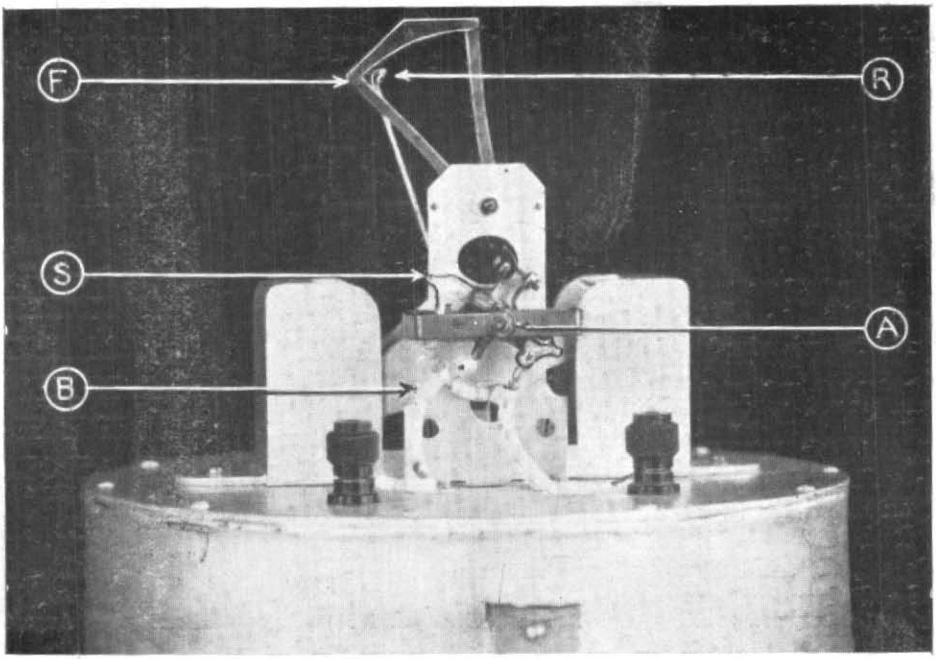


Fig. 1

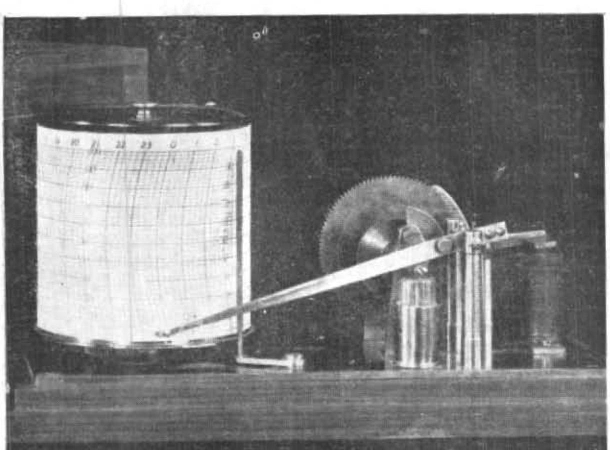
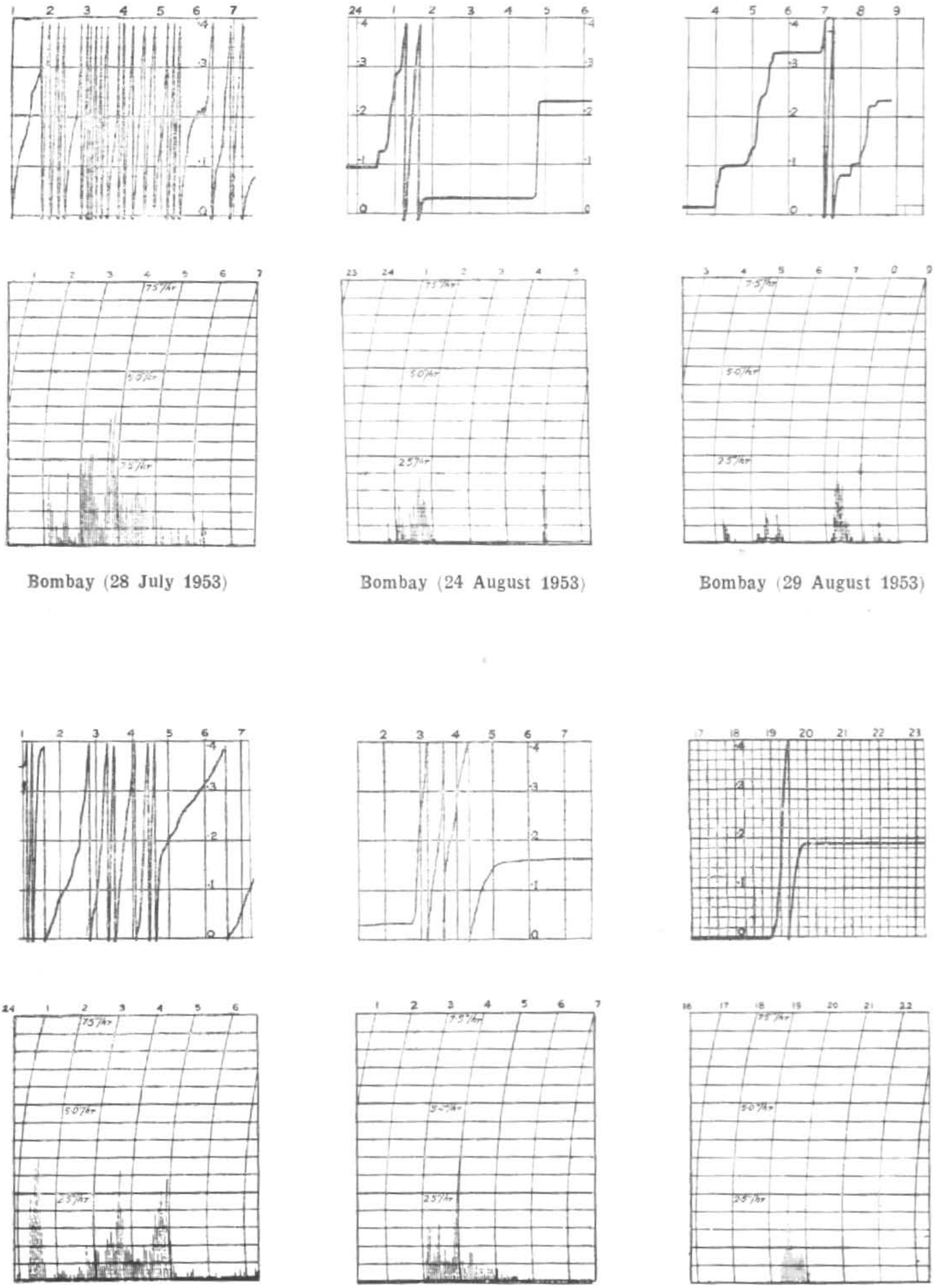


Fig. 3

Fig. 4



Bombay (28 July 1953) Bombay (24 August 1953) Bombay (29 August 1953)

Bombay (4 September 1953) Poona (13 September 1953) Poona (30 September 1953)

Fig. 2

momentarily. A momentary contact is made in an electrical circuit for each drop and the pen of the impulse recorder raised a short distance up the chart. The pen is returned to zero by a time switch at fixed time intervals of 1 or 3 minutes and the chart drum also advanced by a small amount. The record, therefore, consists of a series of nearly vertical lines close together, whose tops indicate the number of contacts in the fixed time interval. The rate of rainfall in millimetres per hour is read directly on a suitably graduated chart.

3. Description of the instrument

In the present note, a distant recording intensity raingauge using a tipping bucket mechanism and a Bibby type impulse recorder constructed in the workshops of the Meteorological Office, Poona is described. Rain collected in a funnel of diameter 8″ is led to the tipping bucket B (Fig. 1) coupled to the 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. As the switch passes its central position, a momentary contact is made in an electrical circuit of which the impulse recorder forms a part. The recorder pen is raised up the chart for every impulse received and returned to zero every three minutes. Since the bucket tips for every cent of rain received from a funnel of diameter 8″, the height of the trace gives the number of cents of rain recorded during three minute intervals. The height of the chart corresponds to 75 impulses and the instrument will thus record 75 cents, during the three minutes interval before the pen returns to zero. A maximum intensity of 15 inches per hour can thus be recorded with this arrangement. The bucket can be made to tip for every half cent of rain by fitting a funnel of 11.31″ diameter. This will reduce the total range to 7½ inches per hour. Using one-minute intervals, the range of the instrument can be increased to 22½ inches per hour. The range can thus be conveniently adjusted by changing the receiver funnel diameter or the time interval in which the rain is recorded. The receiver is usually installed in the observatory enclosure and the recorder at any convenient distance from it.

Two distant recording intensity raingauges of this type have been in regular use since July 1953 at the Meteorological Office, Poona and at the Airport at Santa Cruz, Bombay. Fig. 2 shows sample records obtained at Bombay on 28 July, 24 and 29 August and 4 September 1953 and at Poona on 13 and 30 September 1953. Corresponding records obtained with the automatic syphon raingauges are also shown. The amount of rainfall recorded in the syphon raingauge in 15-minute intervals, and the corresponding amount in 5 spells of 3 minutes each on the impulse recorder are tabulated in Tables 1 and 2. Though no meteorological conclusions can be drawn, it is observed that intensities recorded in 3-minute intervals often exceed those calculated for the 15-minute intervals.

The chief drawback in an intensity raingauge of this type is that the amount of rain falling in any given time interval cannot be directly obtained from the instrument records except by evaluating the areas under the curves. This can be overcome by using a second recorder of the well-known type illustrated in Fig. 3. The pen is moved up the chart for every cent of rain by means of an electro-magnet and ratchet wheel arrangement and on reaching the top is returned to zero by means of a cam fixed on the same axis as the pen arm. If, however, only the total amount of rain is required a dial indicator shown in Fig. 4 can be connected in parallel to the impulse recorder. A similar electromagnet and ratchet wheel arrangement moves the hands of the indicator every time the bucket tips and the mercury switch closes. It can be set to zero when desired. The tipping bucket raingauge with the impulse recorder, total rain recorder and indicator can thus give at a distance both the intensity and the amount of rainfall. Since the bucket will not tilt until half a cent has

TABLE 1

Intensity of rainfall (in. hr^{-1}) from the recording and intensity raingauges at Poona

Date	Time	Natural syphon raingauge, 15-minute intervals	Intensity raingauge					
			3-minute intervals					Mean
13-9-1953	0245-0300	0·84	0·70	1·70	1·50	0·60	0·80	1·06
	0300-0315	0·80	0·70	1·10	1·65	0·60	0·60	0·93
	0315-0330	0·60	1·00	0·60	0·60	0·50	0·70	0·70
	0330-0345	1·40	1·70	3·40	2·25	0·40	0·60	1·66
	0345-0400	0·40	0·40	0·25	0·50	0·90	0·80	0·56
	0400-0415	0·40	0·40	0·50	0·25	0·40	0·40	0·40
	0415-0430	0·32	0·25	0·10	0·40	0·40	0·40	0·31
	0430-0445	0·24	0·20	0·40	0·40	0·15	0·30	0·29
	0445-0500	0·16	0·15	0·15	0·15	0·15	0·15	0·15

TABLE 2

Intensity of rainfall (in. hr^{-1}) from the recording and Intensity raingauges at Santa Cruz

Date	Time	Natural syphon raingauge, 15-minute intervals	Intensity raingauge					
			3-minute intervals					Mean
29-8-1953	0400-0415	0·36	0·75	0·50	0·50	0·30	0·00	0·51
	0445-0500	0·13	0·10	0·30	0·30	0·20	0·20	0·22
	0500-0515	0·44	0·50	1·00	0·70	0·20	0·20	0·52
	0515-0530	0·24	0·20	0·30	0·80	0·50	0·40	0·44
	0645-0700	0·28	0·20	0·30	0·90			0·47
	0700-0715	1·60	1·70	3·00	1·75	1·50	1·70	1·90
	0715-0730	0·32	0·70	0·70	0·60	0·30		0·58
	0800-0815	0·48	0·50	0·40	0·25	0·60	1·20	0·60

been received, very light rainfalls will not be recorded. This is, however, not a serious error in India where the rates of rainfall are usually very high.

Another disadvantage is that the tipping bucket takes a finite, though short time while the bucket is going through the first half of its tipping and water is still falling into the emptying half of the bucket. Assuming this period to be 1/10th of a second, there will be an error of about 1/50th cent with a rate of rainfall of 7½ inches per hour, that is, an error of about 0·2 per cent which is negligible.

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