ROYAL OBSERVATORY, HONG KONG

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COMPARISON OF JARDI AND WORKMAN RATE-OF-RAINFALL GAUGES

by

T. Y. CHEN

Contents

List of Figures

Comparison of Jardi and Workman

Rate-of-Rainfall Gauges

1. Introduction

Hong Kong occasionally experiences heavy rain associated with the passage of weather disturbances at low levels and in the upper air, including the passage of tropical cyclones. In order to measure heavy rainfall rates of which a knowledge is needed in connection with the economical design of catchwaters and drains, a Jardi rate-of-rainfall gauge was first installed at the King's Park Meteorological Station in June 1952. Three more of these gauges were installed several years later at the Royal Observatory and at other stations. In August 1972 a Workman rate-of-rainfall gauge was received from the Cloud Physics Observatory, University of Hawaii at Hilo, and was installed at the Royal Observatory. Since then, simultaneous readings have been taken from both the Jardi and Workman gauges. This report presents the response characteristics to a sudden burst of rain by these two types of instruments and comparison of data collected by them during 1972-73.

2. Jardi Rate-of-Rainfall Gauge

Fig. 1 shows the essential parts of a Jardi rate-of-rainfall gauge [1]. The water from a large collecting funnel falls through the tube A into the float chamber B. The float C has an appendix of diminishing cross-section extending through an aperture into a lower chamber D. The water can flow into D only through the annular space between the bottom of B and the tail of the float. The higher the float rises, the larger this space will be, and the float will continue to rise until as much water flows out of B as enters at A. The motion of the float is transmitted to a pen by a system of levers. By Torricelli's principle, the volume of water flowing out per second is proportional to the area of the opening and to the square root of the depth of water in the chamber B. The tail of the float is given a shape that will produce a linear relationship between the rate of flow and the height of the float[2][3].

3. Workman Rate-of-Rainfall Gauge

The essential features of the Workman rate-of-rainfall gauge are shown in Fig. 2[4]. Rainwater from a collecting funnel is led into a small cup and flows out a V-shaped trough. The cup and trough are free to rotate on ball bearings about a horizontal axis through the base of the cup. One end of a flat leaf clock spring is fixed to a wooden bracket and the other to the end of the trough through a piece of string to hold the cup-trough in the normal "dry" configuration. When water flows along the trough, a torque is produced and a strain results in the spring. Two strain gauges (BLH, type SR-4) are glued to the spring at the area of greatest bending with one directly underneath the other. These strain gauges together with two other fixed resistors form a simple Wheatstone bridge (Fig. 3). The output from the bridge is fed into a millivolt recorder.

4. Method of calibration

Running water is fed into a container which is installed at a fixed height above the gauge to be calibrated. The container is provided with an overflow pipe so that a constant water head can be maintained inside the container. The water from the container flows through a pipe with a regulating tap to the collecting funnel of the gauge under calibration. The flow can be adjusted to various constant rates by means of the regulating tap and the rate is calculated by measuring the time required for a given volume of water to flow through the gauge.

5. Response Characteristics

Cheng[5] studied the response of Jardi rate-of-rainfall gauge and concluded that rainfall of any intensity will have to persist for a period of at least 15 seconds before it can be fully registered.

Similar study on the response of Workman gauge has been carried out and it has been found that although it still takes at least 15 seconds before a full registration can be made, the Workman gauge responds much faster to a sudden burst of rain than the Jardi gauge. The Workman gauge takes 0.3 second to reach 63% of the maximum rainfall rate compared with 3.5 seconds for the Jardi gauge.

Response times from the experimental results for two types of gauges are shown in Table 1 and plotted in Fig. 4.

Table I. Response Time in Seconds of Jardi and Workman Gauges from Experimental Results

	Percentage of Maximum Rate											
	10	20	30	40	50	60	63	70	80	90	95	%
Jardi	0.4	0.9	1.4	1.8	2.4	3.1	3.5	3.9	5.1	7.2	9.3	s
Workman	0	0	0	0	0.1	0.2	0.3	0.6	1.2	3.0	6.0	s

As pointed out by Cheng[5] some time is required for rain drops to run from the funnel into the gauge. This time delay is not constant but depends on the rate of rainfall and the state of the collecting surface. For moderate rain and a wet collecting funnel surface, it takes about 2 seconds for the gauge to respond after rain falls into the funnel. No such time delay has been included in Table 1 and Fig. 4.

6. Installation for Field Comparison

The Workman gauge was installed on the top of the Jardi gauge (see Fig. 5). The output water from the Workman gauge went directly into the Jardi gauge. It took about 1 second for the rain to run from the Workman gauge to the Jardi gauge. A funnel of 22-inch diameter was used above the Workman gauge.

For the Jardi gauge, record was made on a daily chart wrapped on a revolving drum inside the gauge. For the Workman gauge a roll-chart recorder was installed inside the Central Forecasting Office so that the duty weather forecaster could read the rainfall rate immediately or compare its rate with that observed from the weather radar. In 1972, an Elliott milli-ammeter recorder was used and an electronic amplifier was inserted between the Workman sensor and the recorder. In 1973 a new transistorized potentiometer-type milli-volt chart recorder was obtained and the output from the Workman Wheatstone bridge was connected directly into the recorder without the necessity of using an electronic amplifier.

7. Comparison of Records

The comparison started on August 24, 1972. During the comparison period in 1972, three tropical cyclones moved across the northern part of the South China Sea, bringing showers and periods of heavy rain to Hong Kong. Cold fronts and troughs also caused disturbed weather in the Colony. A total of 74 occasions were recorded simultaneously during 1972.

The comparison continued throughout 1973 which was a wet year with the greatest annual rainfall recorded since 1884 at the Royal Observatory. During the year, seven tropical cyclones came close enough to cause heavy rain in Hong Kong. However, a majority of the wet situations were associated with the passages of troughs of low pressure. A total of 590 such occasions were recorded by both gauges in 1973.

All the data recorded in 1972 and 1973 were plotted in Fig. 6. There are altogether 664 cases and the points cluster together at low rainfall rate region where one point may represent more than 10 cases. The highest rate was recorded during the early morning on September 3, 1973 when a trough of low pressure lay across southern China. The rate recorded by the Jardi gauge was 260 mm/hr compared with 446 mm/hr by the Workman gauge (Fig. 7).

Fig. 6 indicates that the Workman gauge generally records higher rates than the Jardi gauge when the rainfall rates are high. For rates less than 30 mm/hr, the points are scattered on both sides of the 45^{o} line. For higher rates, they tend to incline to one side of the 45^{o} line. When the rate is higher than 100 mm/hr, the Jardi gauge never recorded a rate higher than the Workman gauge during the two-year period.

If a freehand line is drawn through the most clustered area on Fig. 6, it shows that the Workman gauge records, on the average, about 20% higher at a rate of 50 mm/hr recorded by the Jardi, 40% higher at 100 mm/hr, and 70% higher at 200 mm/hr.

8. Maintenance Problems

Both gauges need constant care and regular maintenance if satisfactory records are to be obtained from them.

The most common type of faults with the Jardi gauge is due to the entry of solid matter into the float chamber. Periodic flushing is therefore required to keep the gauge clean. It is also necessary to reduce the friction in the moving parts to a minimum in order to obtain reliable records of small rates of rainfall.

There is less mechanical friction associated with the Workman gauge. The instrument is very sensitive, and direct heavy rain on the collecting cup must be avoided. Otherwise the trough and the spring vibrate, resulting in a fluctuating recording. In addition, it is difficult to maintain the base line at a fixed position. It drifts from time to time as the temperature changes. Frequent adjustments have therefore to be made. When rain has stopped, some rain drops usually adhere to the trough end and thus prevent the recording pen from returning to the base line. Some device is required to drain the rain drops away. It has been found helpful to stick a piece of cotton thread at the end of the trough so that rain drops can drain away through the thread.

9. Conclusions

Unless the rainfall rate remains constant, neither the Jardi gauge nor the Workman gauge is able to record the true instantaneous rainfall rate especially when the rain is of showery type. However, due to its quicker response the Workman gauge would indicate a rate which is much closer to the true rate than the Jardi gauge.

10. References

(1) Handbook of Meteorological Instruments, Part I (Her Majesty's Stationary Office, 1956) pp. 280-282.

(2) W.E.K. Middleton and A.F. Spilhans, Meteorological Instruments (University of Toronto Press, 1953) pp. 125-126.

(3) W.E.K. Middleton, Invention of the Meteorological Instruments (Johns Hopkins Press, 1969) pp. 165-166.

(4) C.F. Fullerton & D.J. Raymond, Rainfall Intensity Instruments and Measurements, Technical Report No. 67, Water Resources Research Centre, University of Hawaii, 1973.

(5) T.T. Cheng, Response of a Jardi Rate-of-Rainfall Recorder, Royal Observatory Technical Note (Local) No. 13, 1971.

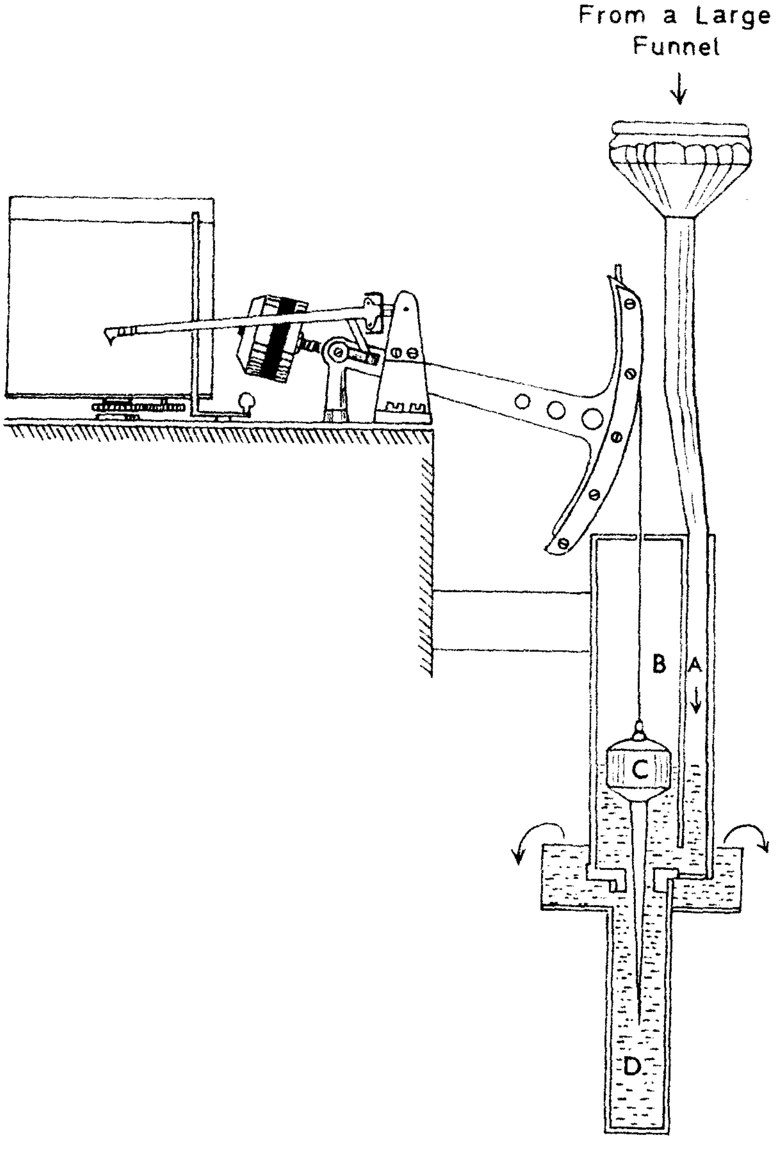


Fig. 1 JARDI RATE-OF-RAINFALL GAUGE

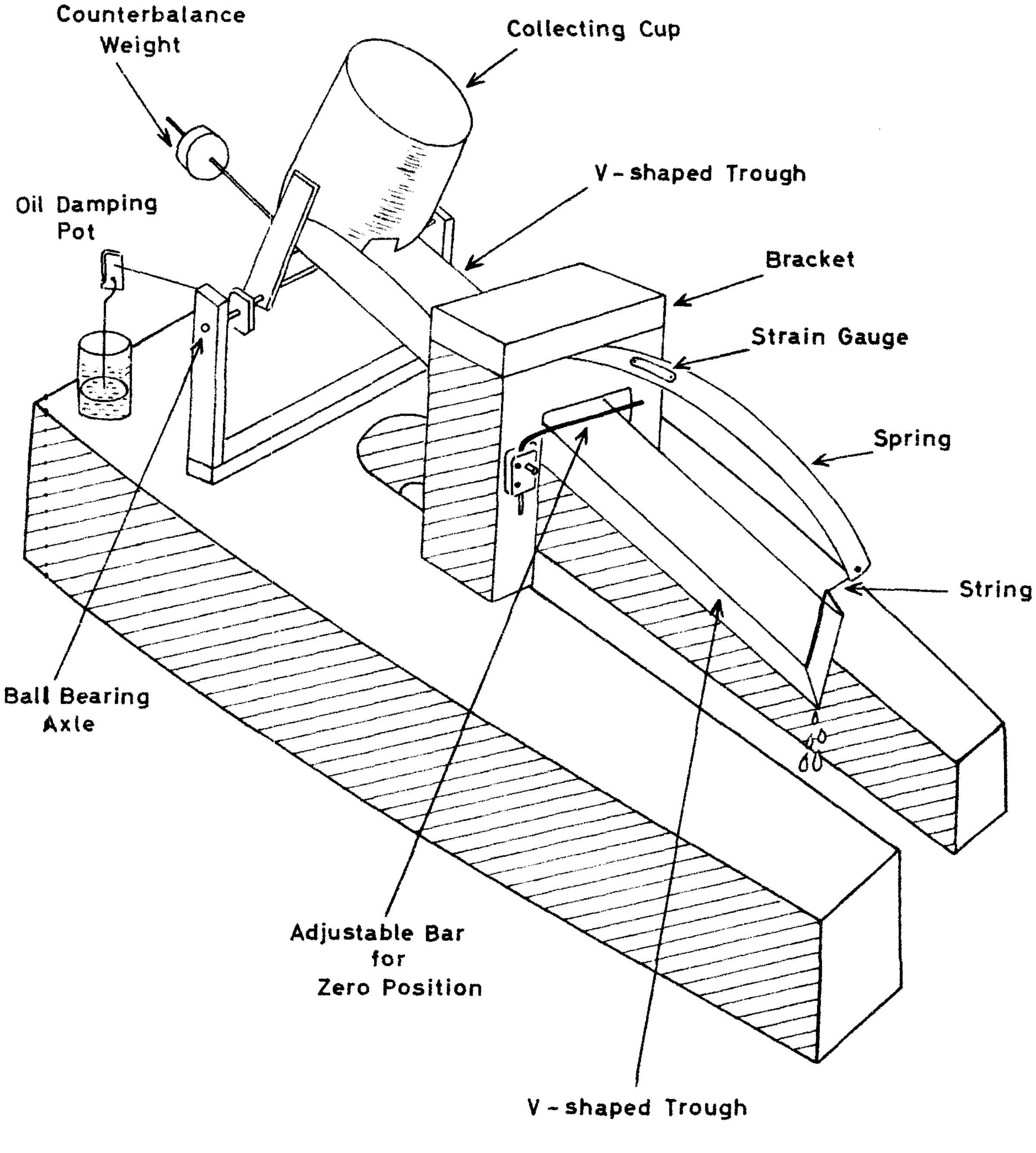


Fig. 2 WORKMAN RATE-OF-RAINFALL GAUGE

Fig. 3

A WHEATSTONE BRIDGE OF

WORKMAN RATE-OF-RAINFALL GAUGE

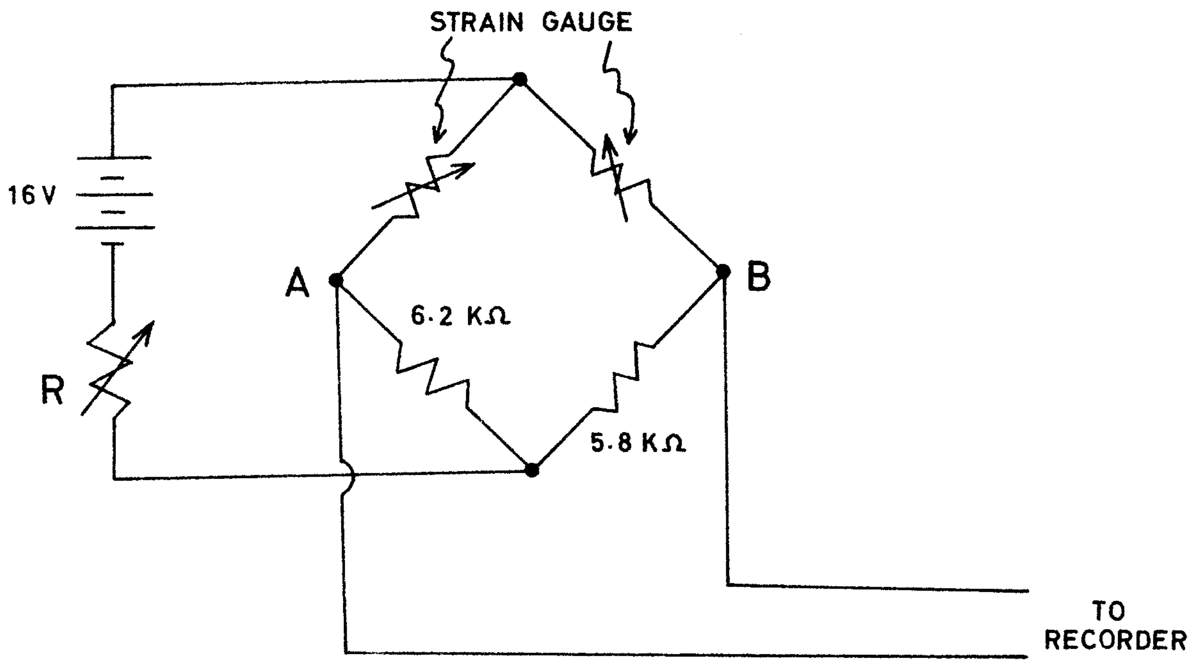
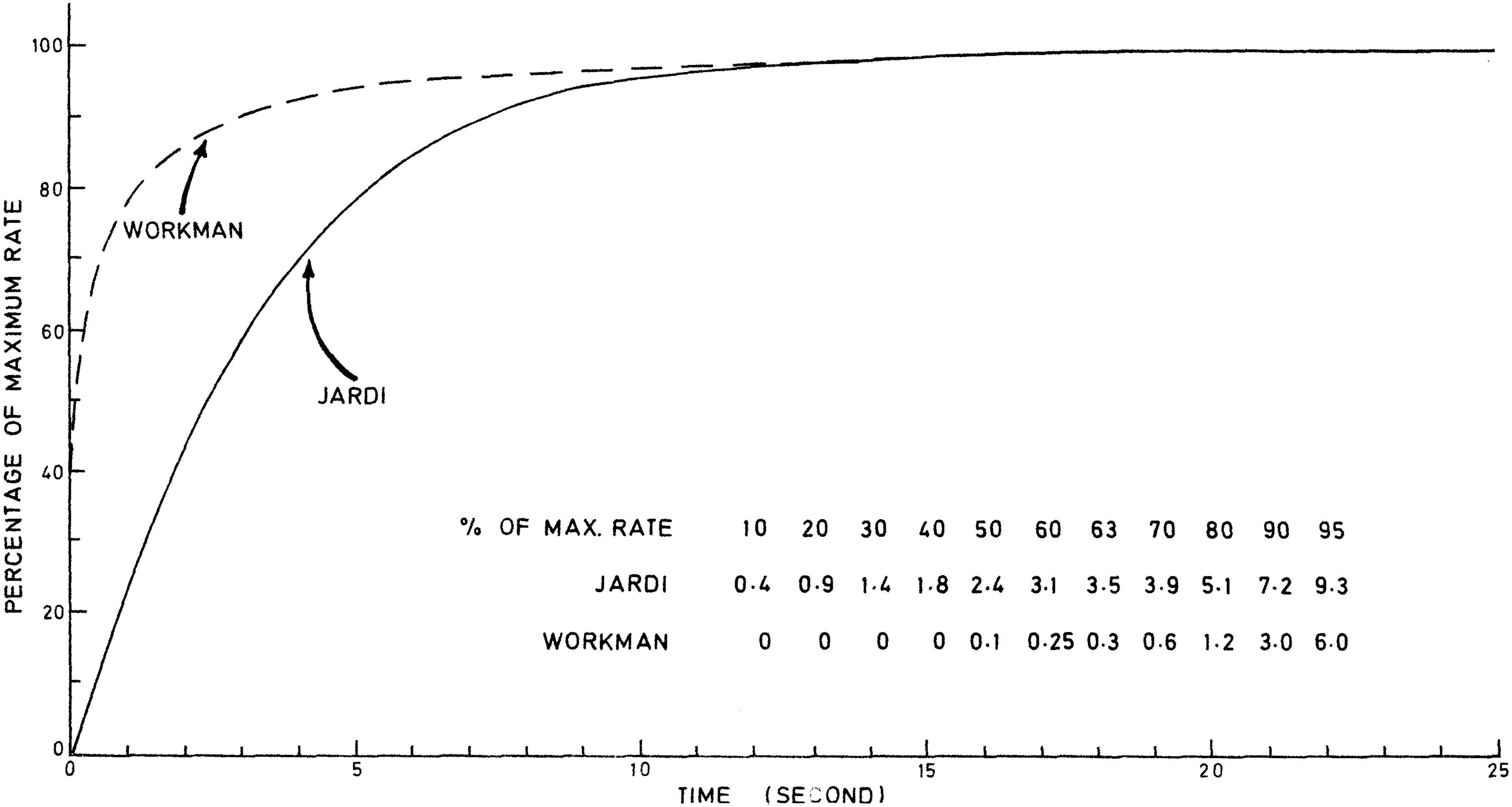


Fig. 4

RESPONSE CURVES OF JARDI AND WORKMAN

RATE - OF - RAINFALL GAUGES



% OF MAX. RATE	10	20	30	40	50	60	63	70	80	90	95
JARDI	0·4	0·9	1·4	1·8	2·4	3·1	3·5	3·9	5·1	7·2	9·3
WORKMAN	0	0	0	0	0·1	0·25	0·3	0·6	1·2	3·0	6·0

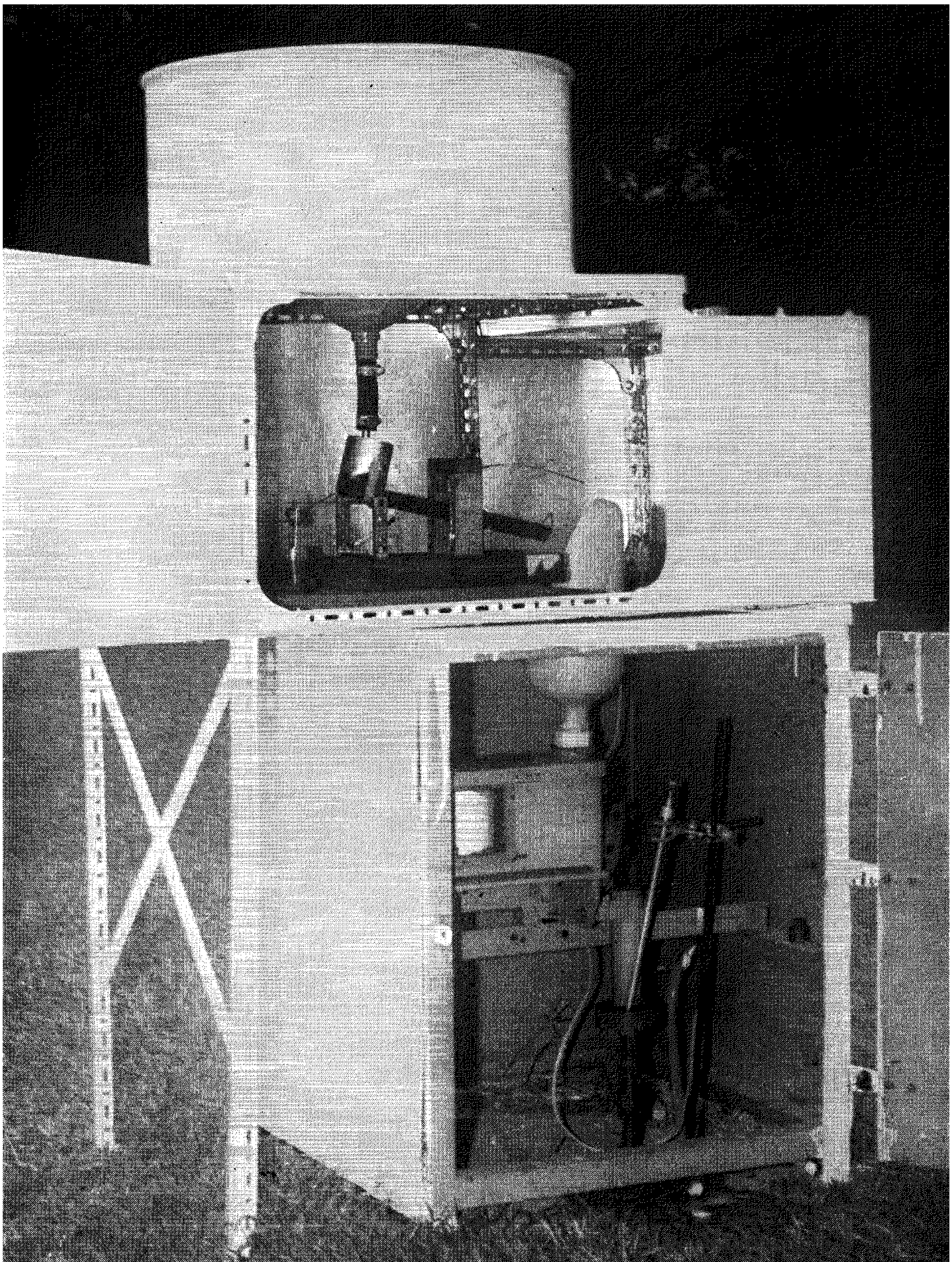
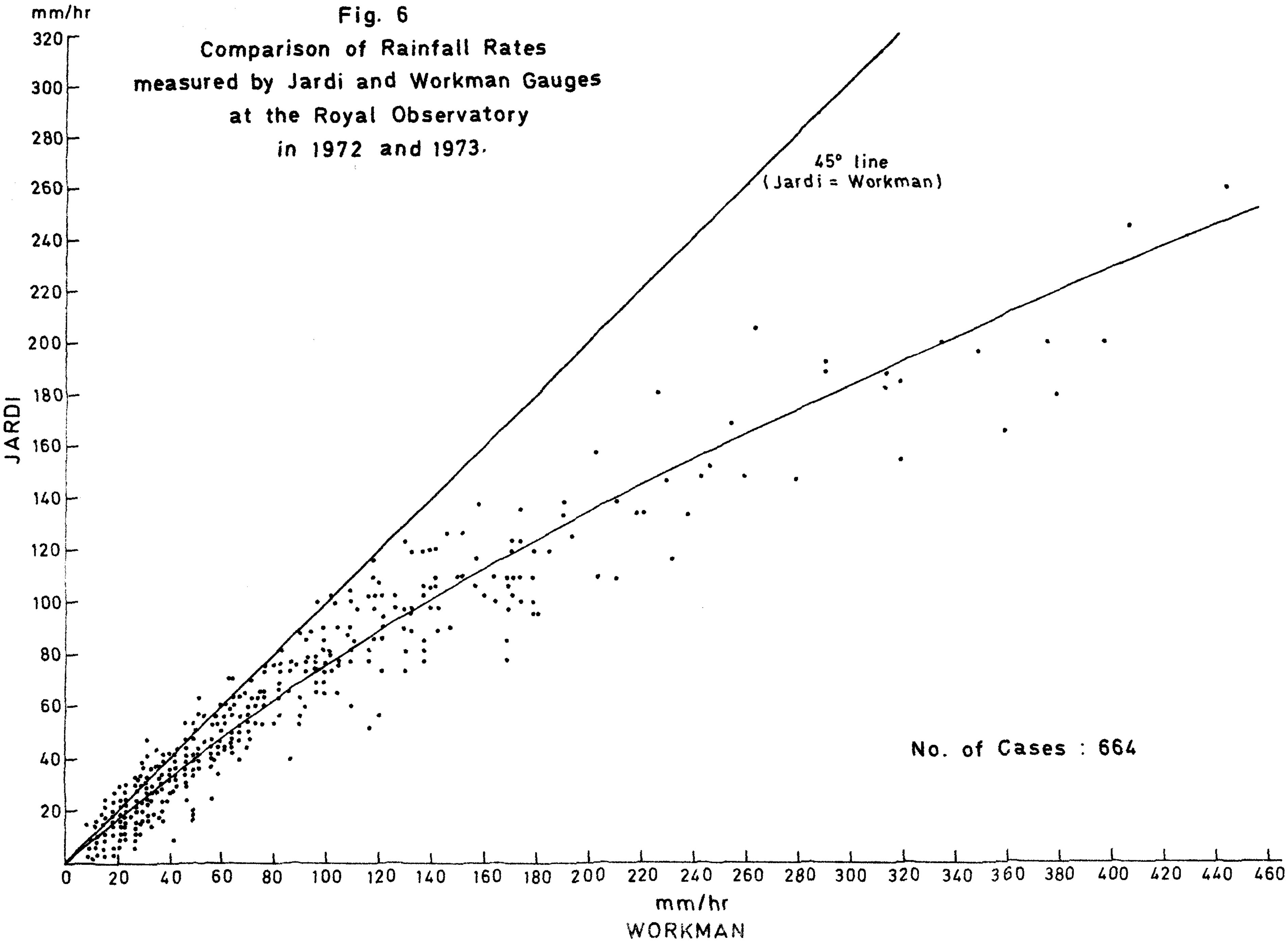


Fig. 5 FIELD INSTALLATION FOR COMPARISON

Fig. 6

Comparison of Rainfall Rates measured by Jardi and Workman Gauges at the Royal Observatory in 1972 and 1973.



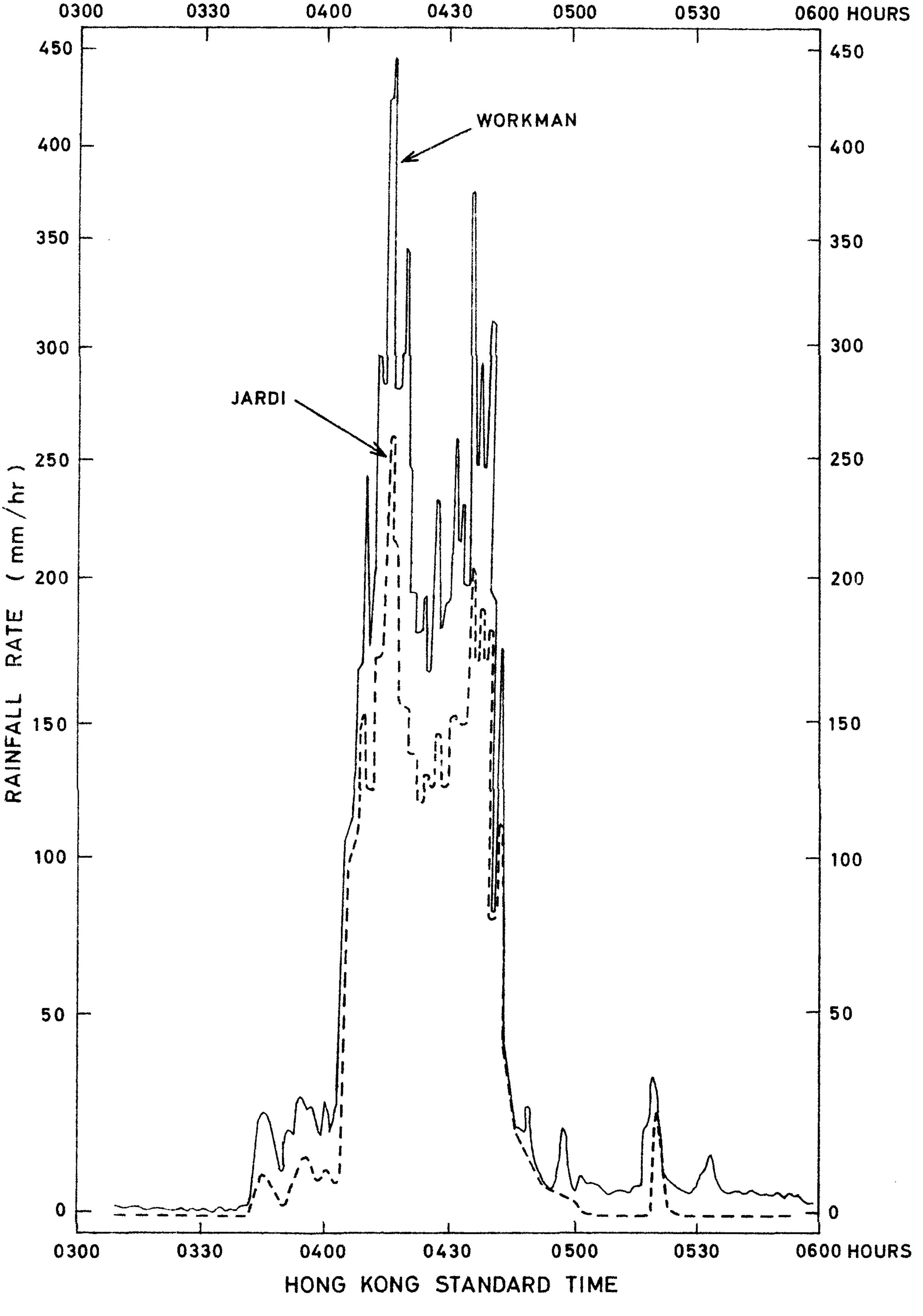


Fig. 7 RAINFALL RATES RECORDED ON SEPT. 3, 1973