DISDROMETER RD-80

INSTRUCTION MANUAL

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CONTENTS

1. CHECKLIST FOR OPERATING THE DISDROMETER

(for complete operating instructions read chapter 5 :INSTALLATION and chapter 6 : OPERATING INSTRUCTIONS)

(1) Make sure the styrofoam cone is mounted properly on the sensor. It should not be loose and not overly tight, to avoid cutting the plastic foil cap, and it should not touch the protecting cylinder.

(2) Be sure the styrofoam cone is free of grease, to avoid the formation of puddles on it's surface.

(3) Check if all connections are made:
  - between sensor and processor
  - between power source and processor
  - between processor and PC.

(4) Turn on the power.

(5) Check the operation of the system by depressing the test signal button of the processor. While the button is depressed the sensor should produce a faint 1000 Hz sound; and LED Nr. 4 on the processor should light.

2. GENERAL

The RD-80 disdrometer for raindrops is an instrument for measuring raindrop size distributions continuously and automatically. It was developed because statistically meaningful samples of raindrops could not be measured previously without a prohibitive amount of work. The instrument transforms the vertical momentum of an impacting raindrop into an electric pulse whose amplitude is a function of the drop diameter. A conventional pulse height analysis yields the size distribution of the raindrops.

3. DESCRIPTION OF THE INSTRUMENT

The RD-80 disdrometer for raindrops (Fig.1) consists of three units:

- the sensor which is exposed to the rain,
- the processor and
- a plug-in power supply for powering the processor

A cable, 10 meters long, is used to connect the sensor and the processor.

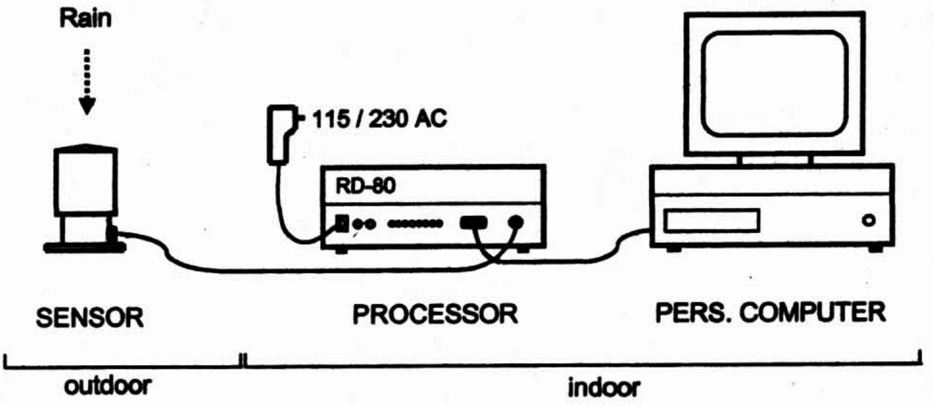

Fig.1 Disdrometer for Raindrops Type RD-80

The sensor transforms the mechanical momentum of an impacting drop into an electric pulse. The amplitude of the pulse is roughly proportional to the mechanical momentum. The sensor consists of a cylindrical metal housing, containing an electromechanical transducer and an amplifier module. The processor contains circuitry to eliminate unwanted signals, mainly due to acoustic noise and produces a 7-bit code at the output for every drop, hitting the sensitive surface of the sensor.

4. SPECIFICATIONS

Range of drop diameter	0.3 mm to 5 mm
Sampling area	50 cm2
Accuracy	+/- 5% of measured drop diameter
Resolution	127 size classes distributed more or less exponentially over the range of drop diameters (ref. to table in Chap. 10)
Output format	according to RS-232-C standard, 7 data bits, even parity, 1 stop bit
Baud rate	9600 Baud
Handshake	DCD and DTR signals
Display	8 LED's for 8 groups of 16 channels each
Power requirements	Plug-in power supply included in delivery: 115/230 Volts AC, 5.5 VA, 50/60 Hz (9 to 18 Volts DC; 3.3 Watts, also possible)
Operating temperature range	0 to 40 degree Celsius for processor 0 to 50 degree Celsius for sensor
Dimensions of the sensor	10 cm * 10 cm * 17 cm high
Dimensions of processor	12 cm * 26 cm * 27 cm deep
Weight	Sensor: 2.9 Kg ; Processor:2.2 Kg
Standard length of sensor cable	20 meters

5. INSTALLATION

When choosing a site for the sensor the following conditions should be observed. It is advisable to set up the sensor in quiet surroundings, as high acoustic noise levels will impair the measurement of small drops. Signals caused by acoustic noise are suppressed by the instrument, but drop signals not exceeding the level of the noise will be suppressed together with the noise signal. Drop signals exceeding the noise signal will be measured with full accuracy. The presence of acoustic noise therefore causes a reduction in the number of small drops measured.
A similar effect is caused by strong winds, producing turbulence at the edges of the sensor. Mounting the sensor with it's top even with the surrounding surface will reduce this effect.

Care must be taken to prevent the sensor from getting flooded.

No objects which can resonate when hit by raindrops and no hard surface, where the drops can splash, should be in close vicinity of the sensor. A cable of 20 meters length is supplied with the sensor for connecting it to the processor.

A longer cable with a total length of up to 100 meters can be used, provided that it is of similar construction. Do not ground the sensor housing to avoid ground loops, which might increase the noise level and thus cause the measurement of small drops in the absence of rain. The processor, like other laboratory instruments, should be placed anywhere in a well sheltered location.

To avoid interferences from external sources of electromagnetic fields the sensor should be placed away from equipment, generating such fields
(transformers, electric motors, RF-transmitters).
Transients propagating along the power line to which the processor and/or the computer is connected can also cause the registering of some small drops in absence of rain. Such transients may be caused by surge currents in the power line, when electrical equipment is switched on and off in the vicinity of the processor and the computer.

6. OPERATING INSTRUCTIONS

6.1. Mounting the Styrofoam Cone (see Fig.3)

Care should be exercised when mounting the styrofoam cone onto the sensor.

- Remove the protecting cylinder sliding it upwards. Inspect the plastic foil for any defects that might impair it's water tightness. It is the only sea between the outside and the electromechanical unit. Any leakage of water may have grave consequences for the instrument. If there is any doubt about it's integrity, it should be replaced. A rubber O-ring is used to hold the edge of the plastic foil to the upper end of the sensor housing. Make sure the plastic foil seals tightly along the whole circumference and that the O- ring is seated in the groove. If the plastic foil needs replacement, apply some silicone grease in the groove at the upper edge of the sensor housing as well as on the rubber washer before mounting the new plastic foil.

- Replace the protecting cylinder and slide it down all the way. Make sure the rubber washer is in place.

- Mount the styrofoam cone. Do not over tighten but make sure it seats well (turn the styrofoam cone lightly with the tips of your fingers until you feel that it is getting into contact with the plastic foil cap; then make about another quarter of a turn).

- Slide the protecting cylinder upwards until it's upper edge is level with the outside edge of the styrofoam cone. Make sure the styrofoam cone does not touch the protecting cylinder.

CAUTION:

Do not try to disassemble the electromechanical unit of the sensor; to do so without the necessary know-how may cause serious damage.

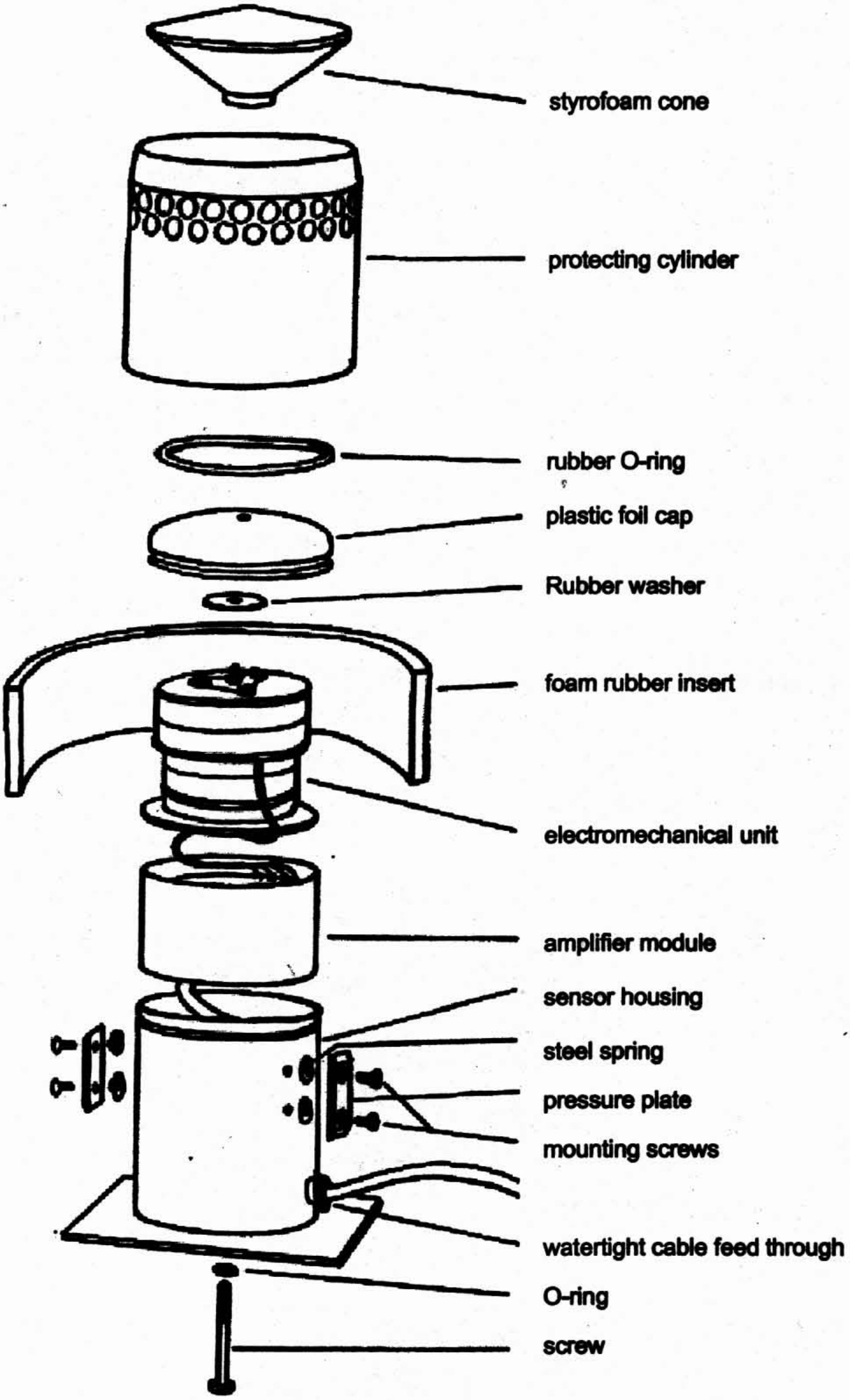

Fig. 2 Sensor Exploded View

6.2 Recording Data

To operate the system as shown in Fig. 1 proceed as follows:

- connect the Sensor to the Processor.
- connect the processor to a free and usable serial input (COM1 to COM4) of the PC using the standard 9 pin D-sub cable.
- connect the plug-in power supply to the Processor DC power connection
- turn on power of the processor and of the PC.
- then start the program. See separate "User's Guide for Disdrodata"

6.3 Testing the Performance of the Disdrometer

A very sensitive method of testing the performance of the disdrometer in the field is to make a comparison of rainfall amounts measured with the disdrometer and with an accurate rain gauge. An event with a continuous rain rate of between 1 and 10 mm/h lasting for several hours, such that evaporation from the rain gauge can be neglected and with light winds only, is best. If the disdrometer is in good condition and the total amount of rain is more than about 5 to 10 mm, the difference of the measured rain amounts should not be more than about 15%.

6.4 Maintenance

The instrument needs little maintenance. It is recommended though that the plastic foil cap of the sensor be replaced from time to time. Due to the solar UV-radiation the polyethylene material of which the plastic foil cap is manufactured deteriorates with time. If the sensor is exposed to the weather continuously, replacement of the plastic foil cap about twice a year is advisable.

7. OUTPUT SIGNAL

The digital output signal of the processor follows the RS-232 standard with a Baud rate of 9600 Baud. The interface is brought out on a female 9-pin sub-D connector on the front panel of the processor.

8. TEST SIGNAL

A circuit for generating a test signal is incorporated in the processor. The test signal consists of a train of pulses with a frequency of 1000 Hz. The test signal provides a quick way to test the proper functioning of the processor and the presence of the sensor.

It can be actuated by hand. When the pushbutton on the front panel of the processor is depressed with the sensor connected to the processor, LED Nr. 4 on the processor front panel should light and the sensor should produce a faint sound of 1000 Hz. If Nr. 4 LED does not light or a different Nr. LED or no LED lights, the sensor may be not properly connected or the processor may be not working properly, and further investigation is needed.

9. THE DISDROMETER SYSTEM

A block diagram of the whole system is given in Fig.3. An exploded view of the sensor is shown in Fig.2

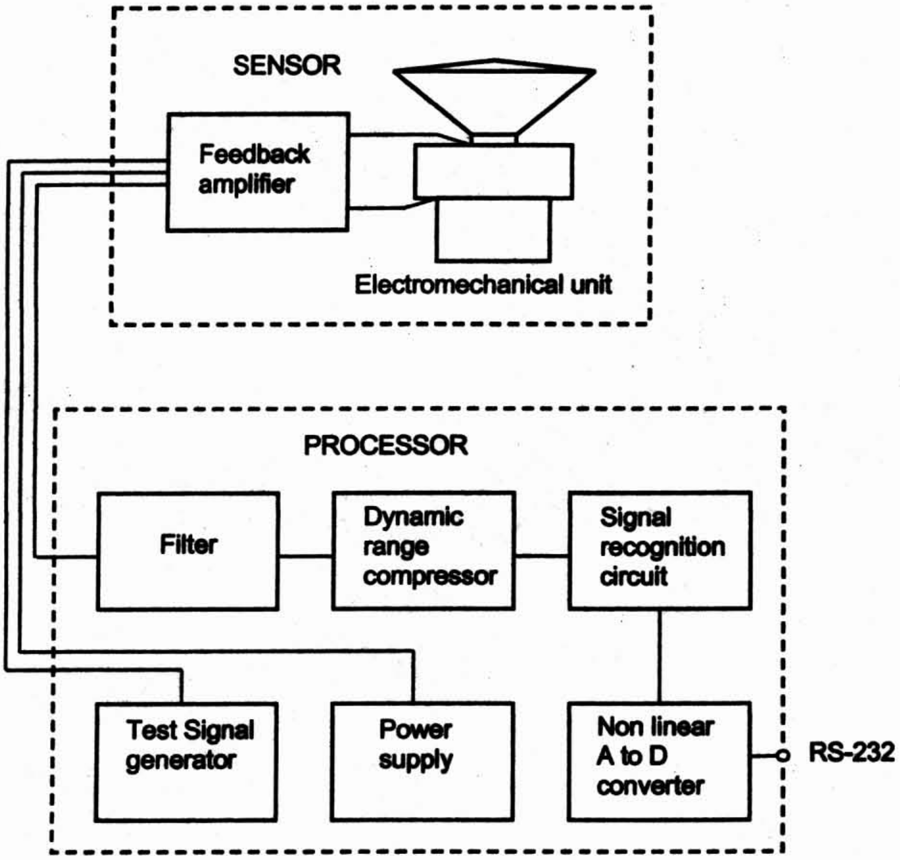

Fig.3 Block Diagram of the Disdrometer

9.1. The Sensor

The sensor (Fig.4) consists of an electromechanical unit and an amplifier module in a common housing. A conical styrofoam body is used to transmit the mechanical impulse of an impacting drop to a set of two moving coil system in magnetic fields. The styrofoam body and the two moving coils are fixed together rigidly

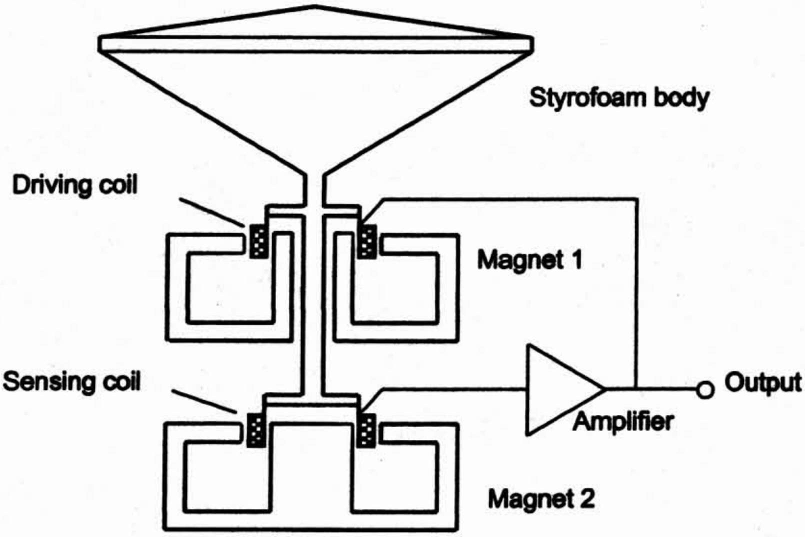

Fig.4 Construction of the Sensor

At the impact of a drop the styrofoam body together with the two moving coils moves downwards and a voltage is induced in the sensing coil. This voltage is amplified and applied to the driving coil such that a force counteracting the movement is produced. As a consequence the excursion is very small and it takes very little time for the system to return to it's original resting position and therefore to get ready for the next impact of a drop.

The amplitude of the pulse at the output of the amplifier is a measure for the size of the drop that caused it.

9.2. The Processor, Fig. 3

The processor serves three functions:

- it supplies power to the sensor
- it processes the signal from the sensor
- it contains circuits for testing the performance of the instrument.

The built in power supply generates regulated DC voltages of +15 V and -15 V for powering the sensor and the circuits of the processor.

The signal processing circuit consists of a noise reduction filter, a dynamic range compressor, a signal recognition circuit and a non-linear A-D-converter.

The noise reduction filter is an active band pass filter, whose frequency response is designed to give an optimum ratio between the signal from raindrops and the signal from acoustic noise affecting the sensor.

The dynamic range compressor consists of an amplifier with a voltage dependent feedback network to adjust the amplitude response of the system to the desired characteristic.

The signal recognition circuit can distinguish between the signal pulses caused by drops hitting the sensor and the more uniform oscillations caused by acoustic noise.

It is of course necessary that the pulses caused by raindrops exceed the oscillations caused by acoustic noise. If this is the case, a gate passes the pulses to the analog to digital converter.

The analog to digital converter has an exponential conversion characteristic. It generates a 7-bit code at the RS-232 interface of the processor for every drop measured by the sensor.

The test circuit consists of an astable multivibrator whose output is fed directly into the driving coil of the sensor. If the sensor is not properly connected or if any part of the processor is not working properly, LED Nr. 4 will not light or a different Nr. LED will light.
While the test signal is actuated the signal recognition circuit is disabled, in order not to suppress the test signal. The test signal is actuated with a pushbutton on the front panel of the processor.

10. THRESHOLDS OF DROP SIZE CHANNELS

Standard values used in the disdrometer program

Drop Diameters at the RD-80 Channel Thresholds

CH	mm	CH	mm	CH	mm	CH	mm	CH	mm
1:	0.313	2:	0.318	3:	0.324	4:	0.331	5:	0.337
6:	0.343	7:	0.350	8:	0.357	9:	0.364	10:	0.371
11:	0.379	12:	0.387	13:	0.396	14:	0.405	15:	0.414
16:	0.423	17:	0.433	18:	0.443	19:	0.453	20:	0.464
21:	0.474	22:	0.484	23:	0.495	24:	0.505	25:	0.515
26:	0.526	27:	0.537	28:	0.547	29:	0.558	30:	0.570
31:	0.583	32:	0.596	33:	0.611	34:	0.628	35:	0.644
36:	0.662	37:	0.679	38:	0.696	39:	0.715	40:	0.735
41:	0.754	42:	0.771	43:	0.787	44:	0.806	45:	0.827
46:	0.845	47:	0.862	48:	0.879	49:	0.895	50:	0.912
51:	0.928	52:	0.944	53:	0.960	54:	0.978	55:	0.999
56:	1.024	57:	1.051	58:	1.080	59:	1.110	60:	1.140
61:	1.171	62:	1.202	63:	1.232	64:	1.262	65:	1.289
66:	1.318	67:	1.346	68:	1.374	69:	1.402	70:	1.429
71:	1.456	72:	1.483	73:	1.509	74:	1.533	75:	1.558
76:	1.582	77:	1.606	78:	1.631	79:	1.657	80:	1.683
81:	1.715	82:	1.748	83:	1.793	84:	1.841	85:	1.897
86:	1.955	87:	2.013	88:	2.077	89:	2.139	90:	2.200
91:	2.262	92:	2.321	93:	2.381	94:	2.441	95:	2.499
96:	2.558	97:	2.616	98:	2.672	99:	2.727	100:	2.781
101:	2.836	102:	2.893	103:	2.949	104:	3.011	105:	3.080
106:	3.155	107:	3.230	108:	3.306	109:	3.385	110:	3.466
111:	3.545	112:	3.625	113:	3.704	114:	3.784	115:	3.864
116:	3.945	117:	4.028	118:	4.127	119:	4.231	120:	4.340
121:	4.456	122:	4.573	123:	4.686	124:	4.801	125:	4.915
126:	5.030	127:	5.145						

11. LITERATURE RELATED TO THE DISDROMETER

Joss J. and Waldvogel A., 1967: Ein Spektrograph fuer Niederschlagstropfen mit automatischer Auswertung. Pure Appl. Geophys., 68, 240-246.

Joss J. and Waldvogel A., 1969: Raindrop size distribution and sampling size errors. J. Atmos. Sci., 26, 566-569

Waldvogel, A., 1974: The No jump of rain drop spectra. J. Atmos. Sci., 31, 1067-1078

Kinnell, P. I. A., 1976: Some observations of the Joss-Waldvogel rainfall disdrometer. J. Appl. Meteor., 15, 499-502

Joss, J. and Waldvogel, A., 1977: Comments on "Some observations of the Joss-Waldvogel rainfall disdrometer" J. Appl. Meteor., 16, 112-113

Kreuels, R., 1977: Strukturanalysen und Statistik des Niederschlages auf einminuetiger Kurzzeitmessbasis und das Problem der indirekten Niederschlagsbestimmung mittels Radar. Diss. Meteor. Inst. University of Bonn, Germany

Tohma, K. et al., 1982: A performance test of a raindrop sizemeter of microphonic type by artificial waterdrop and photographing of the drop shapes. J. Radio Research Lab., 29, 27-52

Donnadieu, G., 1982: Observations de deux changements des spectres des gouttes de pluie dans une averse de nuages stratiformes. J. Rech. Atmosph., 16, 35-45

Seliga, T. A. et al., 1986: Disdrometer measurements during an intense rainfall event in central Illinois: Implications for differential reflectivity radar observations. J. Climate Appl. Meteor., 25, 835-846

Rosewell, C. J., 1986: Rainfall kinetic energy in eastern Australia. J. Climate Appl. Meteor., 25, 1695-1701

Steiner, M., 1988: Bericht Ueber Vergleichsmessungen mit verschiedenen Niederschlagsmessinstrumenten. LAPETH, 28, Swiss Institute of Technology, Zurich, Switzerland

Mc Farquhar, G. M. and List, R., 1993: The effect of curve fits for the disdrometer calibration on rain drop spectra, rainfall rate and radar reflectivity. J. Appl. Meteor., 32, 774-782

Sheppard, B. E. and Joe, P. I., 1994: Comparison of raindrop size distribution measurements by a Joss-Waldvogel disdrometer, a PMS 2DG spectrometer, and a POSS Doppler radar. J. Atmos. Oceanic Tech., 11, 874-887

Sauvageot, H., and M. Koffi, 2000: Multimodal raindrop size distributions. J. Atmos. Sci., 57, 2480-2492

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