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Rain Gauge Calibration and Testing

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Abstract

Rain Gauge Testing

Prior to TOGA-COARE, 42 Model 100 series optical gauges were tested in the rain simulator facility at Wallops Island before shipment to the field. Baseline measurements at several rain rates were made simultaneously with collector cans, tipping bucket and a precision weighing gauge and held for post-COARE evaluation with a repeat set of measurements that were to be recorded after the instruments were returned. This was done as a means of detecting any calibration changes that might have occurred while deployed (Figure 1). Although it was known that the artificial rain in the simulator did not contain the required exponential distribution for accurate optical rain gauge rate measurements, use of the facility was necessary because it was the only means available for taking controlled observations with instruments that were received, tested, and shipped out in groups over a period of months. At that point, it was believed that these measurements would be adequately precise for detecting performance changes over time. However, analysis of the data by STI now indicates that this may not be true. Further study of the data will be undertaken by Short and Wilkerson to resolve this.

During the pre-COARE period, there were two short intervals when the opportunity existed for checking the manufacturer's calibration accuracy in natural rain. Ten gauges were set up to monitor rainfall simultaneously with the precision weighing gauge. Results, presented at last year's workshop by Wang showed that above 10 mm/hr and for rates up to 100 mm/hr, these optical gauges agreed to within 20% of the weighing gauge. It was also shown that if recalibrated using the weighing gauge as a standard, agreement could be improved to within 10 %. Further, by this normalization process, measurement differences between optical gauges could be held to 5% At present, this method of determining a calibration correction factor for each instrument is all that is available for dealing with the inaccuracies of the STI calibration and for the subsequent reprocessing of the TOGA CARE data set. Natural rain data for this purpose now exists at Wallops where over 400 rain events have been recorded since the return of instruments. Still lacking, however, are sufficient events above 100 mm/hr. Since the probability of heavy rainfall is greater in south Florida, 4 gauges from Wallops are being transferred to AOML for monitoring events there during the next six months.

The distribution of TOGA COARE optical gauges by platform is shown in Table 1. Gauge mountings on ships were typically well clear of superstructure when not located on a bow mast forward of all obstructions (Figure 2). Those on TOGA buoys were located 4 m above the ocean surface and clear of the other instruments. However, at the remote island site on Kapingamarangi, rain gauge and disdrometer were placed on the beach as no other area was properly cleared of vegetation. This location proved disastrous when storm surge caused

flooding at the site and damage to the instruments. The gauge was later replaced but no substitute for the disdrometer was available.

Of the 42 optical gauges used in COARE, sixteen were returned inoperative (4 of these were unrepairable). Causes of failure were corrosion of electronics due to water leaks (8); parts failure (6), and on buoys, vandalism (2). Some of the corrosion failures appear to have been caused by field technicians who opened the instrument for inspection. Lid seals, once broken, do not remain water tight when reused in all cases, even when tape or sealant is applied. While field personnel had been instructed not to attempt repairs, it was not always practical. Replacements for defective gauges were dispatched from Wallops immediately to ports of call when connections could be made in time. But that was not always possible and those in the field were faced with the choice of attempting a repair or missing an installation. The STI redesign of the gauge housing should eliminate leaking seals, but the problem still remains for those units we have. A better seal needs to be found.

Based on a report by Nystuen prior to the workshop, that background noise levels of the AOML optical gauge (100 series #2234) exceeded 1mm/hr in the absence of rain (see his Figure 2), it was decided to test a number of instruments at Wallops to determine if this was a common condition. Seven 100 series Wallops gauges were monitored for 450 minutes during no-rain periods with the result that none recorded rates higher that about 0.2 mm/hr (see Figure 3). This suggests that if dew on the receiver lens was the cause, as Nystuen believes, differences in local weather conditions at the times of monitoring is the explanation. Gauge #2234 is now being shipped back to STI for examination and a calibration check. The planned transfer of additional Wallops gauges to AOML will allow this tests to be repeated there with these instruments.

Disdrometer Manufacture

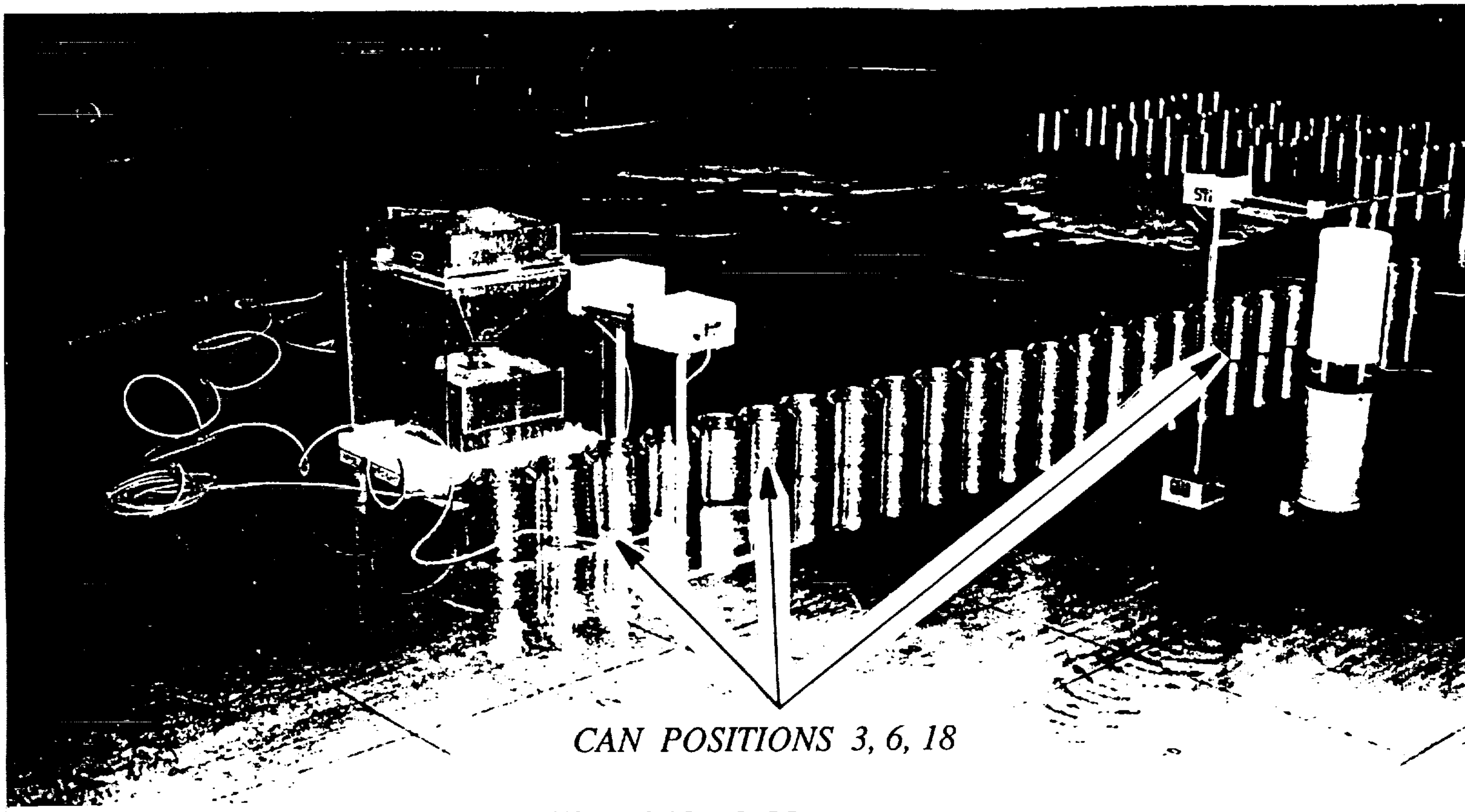
The need for drop size distribution measurements in the study of underwater sound generated by rain resulted in the purchase of a Joss-Waldvogle disdrometer from Distromet Ltd. This instrument, known worldwide, is the only commercially available disdrometer in its class considered reliable. Its cost of $15,000, however, limits the number that could be considered for TRMM. So with funding from TRMM, NESDIS began the manufacture of disdrometers of an APL design. The APL disdrometer consists of a 3-inch diameter plastic block housed in a brass cylinder with base plate (Figure 4). The impact of drops falling on the beveled surface of the plastic are sensed by a piezoelectric transducer fixed to the bottom of the block. The output analog signal is amplified and digitized using two circuit boards. The digital data is then feed to a PC. This rugged sensor appears much less prone to corrosion and subsequent failure - a problem experienced with the Joss instrument.

To date, fourteen disdrometer sensors have been assembled at NESDIS and one set of circuit boards for testing has been fabricated at Wallops. One of the fourteen sensor and the set of boards were sent to AOML for calibration and checkout. Calibration was achieved by monitoring sensor output voltage levels while water drops of known size struck the sensor head at terminal velocities. But before monitoring rainfall, AOML implemented design changes in one of the boards for enhanced performance. These changes are now being tested for expected improvement using the Joss disdrometer as a standard.. When testing is completed, the remaining electronic board components will be built and the instruments assembled. APL distrometers will be provided to Wallops, KSC, PMEL, and AOML.

NESDIS is also investigating a second disdrometer sensor concept. Because of their size, the Joss and APL sensors require 1- minute sampling for stable distribution estimates. For monitoring underwater sound level changes during rainfall however, a 6-second sampling rate is required. Since the acoustic signal levels are directly proportional to the drop size distribution, a sensor capable of higher sampling is needed. Pressure-sensitive foils appear to offer a solution. The piezoelectric foil transforms the mechanical force of drop impacts to electrical impulses that are an order of magnitude greater than the responses of the APL disdrometer and produce almost no ringing. By using an area 10 times that of the APL and Joss 3-inch diameter sensor, sampling rates of 6-seconds should be possible. For testing this concept, foil sections with 3-inch and 9.5 inch diameters have been purchased for mounting as shown in Figure 5. The mounting plates are adjustable so that optimum pitch of the surface to accommodate runoff during rainfall can be determined. A separate circuit design is not required as the signal processor boards for the APL disdrometer can be used with this sensor. Once proven, this instrument should be highly suited for buoy use because of its physical simplicity. Used as a rain gauge at sea, it should also be capable of differentiating between convective and stratiform rain by keeping count of periods when sampled distributions contain drops no larger than about 2 mm in diameter. Field testing will be carried out at the AOML facility as soon as the ongoing circuit board study is completed and production of boards is resumed at Wallops.

Artificial Rain Facility Measurements

NASA, WALLOPS



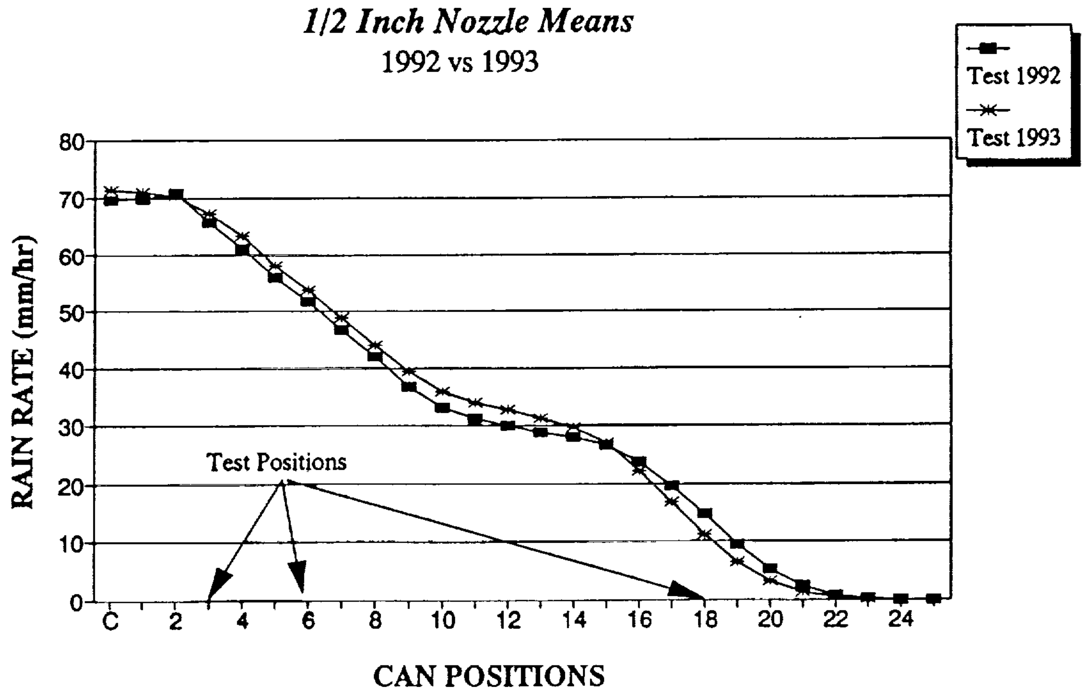


Figure 1. Measurement setup at the NASA, Wallops, rain simulator. Optical gauges were placed at three locations under the nozzel spray to record measurements at three separrate rain rates. The spatial variation of rain rates with collector can separation is shown in the lower figure.

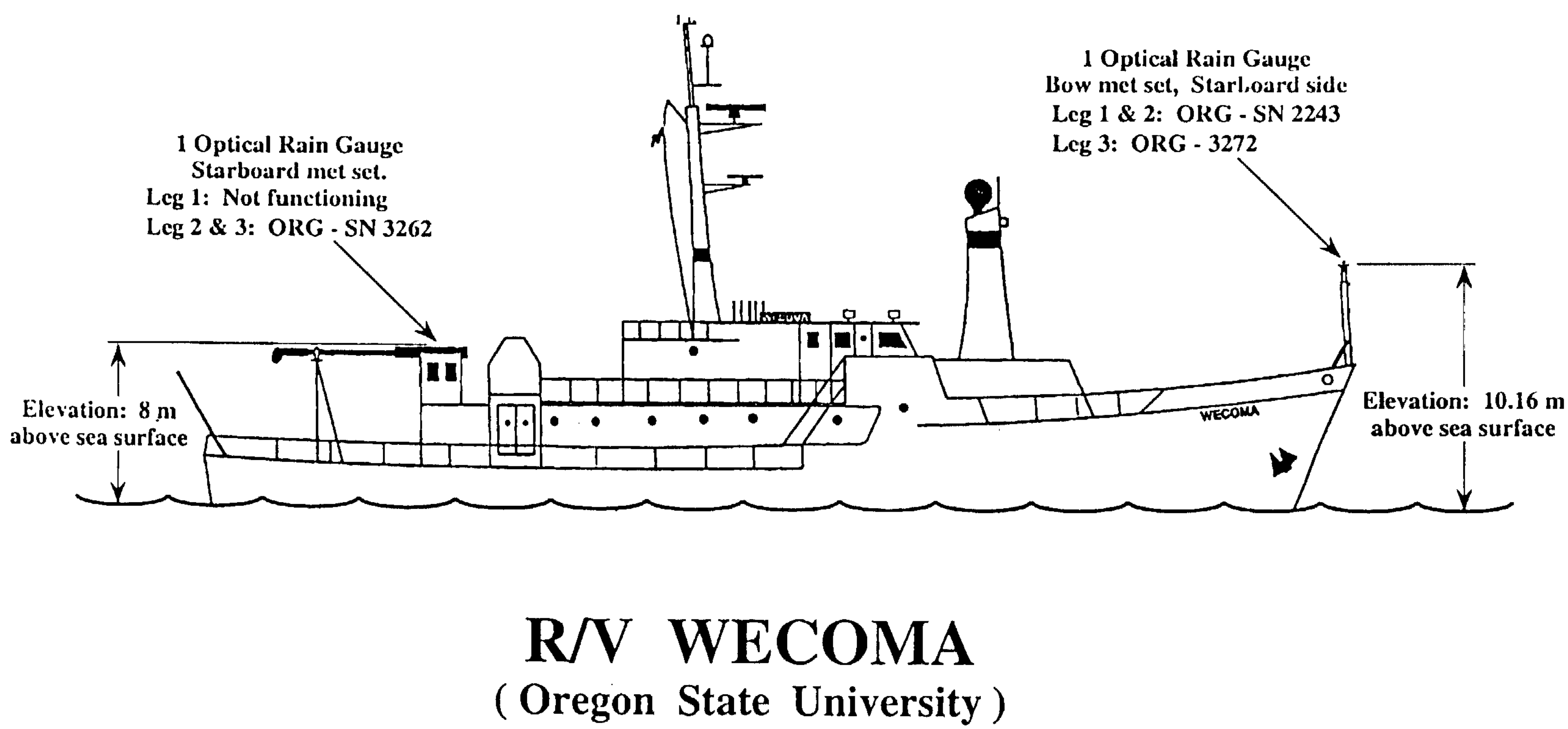


Figure 2. Typical optical rain gauge installation on ships participating in TOGA COARE.

TABLE 1. STATUS OF SHIP/BUOY RAINGAUGES FROM TOGA COARE

April 1, 1994

SHIPS	Rain Gauge Serial#	Number Shipped	Number Returned	Not Returned	Number Returned Damaged	Pre and Post Calibration Performed	Pre or Post Calibration Performed	Sent to STI For Repair
VICKERS	(3260)(3261)	2	2		2	**(3260)	**(3261)	(3260)(3261)
WECOMA	(3272)(2243)	2	2		1		(2243)(3272)	(2243)
M. WAVE	(3268)(3269)	2	2			*(3268)*(3269)		
NOROIT	(2121)(2241)(3286)	3	2	(3286)	1	(2121)		(2241)
ALIS	(3266)	1	1			(3266)		
KIEFU	(3264)	1	1			(3264)		
HAKUHO	(3265)	1	1			(3265)		
NATSUSHIMA	(3267)	1	1			(3267)		
FRANKLIN	3271)(Darwin)	1	1			(3271)		
KE #1	(2236)(2251)(3289)	3	2	(3289)	2		(2236)(2251)	(2236)(2251)
SH #3	(2237)(2252)(2238)(3290)	4	3	(3290)	2	(2238)	(2237)(2252)	(2237)(2256)
XI #5	(2239)(2253)(3291)	3	2	(3290)		(2239)(2253)		
MALAITA	(3273)(3274)	2	2		1		(3273)(3274)	(3273)
BUOYS								
0°, 157.5°E	(3258)	1	1			(3258)	(3258)	
0°, 165°E	(2245)	1	1		1			(2245)
0°, 156°E	(2113)	1	1		1		**(3303)	(2113=3303)
2°N, 156°E	(3256)	1	1		1		**(3256)	(3256)
2°S, 156°E	(3257)	1	1				(3257)	
0°, 154E	(3259)	1	1				(3259)	
SPARES	(2254)(3281)3282) (3285)(3262)	5			1		(3262)	(2254)
Unrepairable (Vandalized)	(2244)(2246)				2			(2244)(2246)
SHORE SITES								
KAPINGA	(2255)(3270)	2	1	***(3270)	1		(3270)(3308)	(2255=3308)
WALLOPS	(2235)(2240)(3263)	3					(2240)(3263)	
TOTALS		**42**	**29**	**5**	**16**	**13**	**21**	**16**

OTHER TRMM OPTICAL GAUGES

WALLOPS (100159)****(100165)****
KFC (2242)(3262)(3288)
NDBC (2108)(2109)(2123)
AOML (2234)(2252)(100117)****
NWS (Melbourne) (3274)

* Sent to KSC. Gauge 3268 was struck by lightning and replaced by 3288 which failed shortly thereafter. It in turn was replaced by 3269.
** Sent to PMEL as spares to replace gauges returned for post-COARE calibration checks.
*** Lost during return shipment from Kapingmarange
(ser#1=ser#2) Repair of ser#1 was not possible so new rain gauge ser#2 replaced it

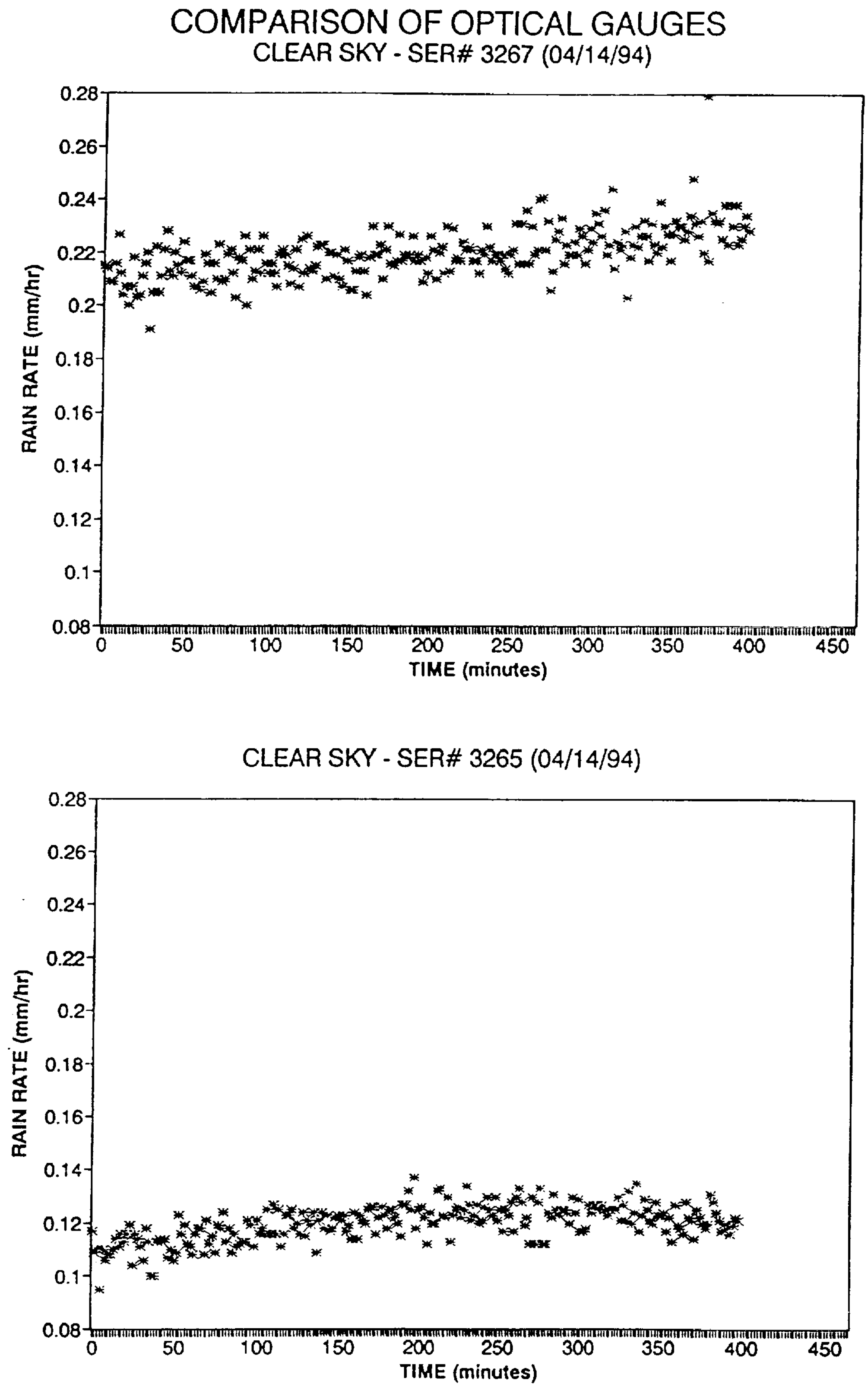


Figure 3. Typical examples from tests of seven gauges showing temporal variations in backgroumd noise levels during periods of no rain.

Figure 4. The APL disdrometer sensor dismantled, left, and assembled, right.

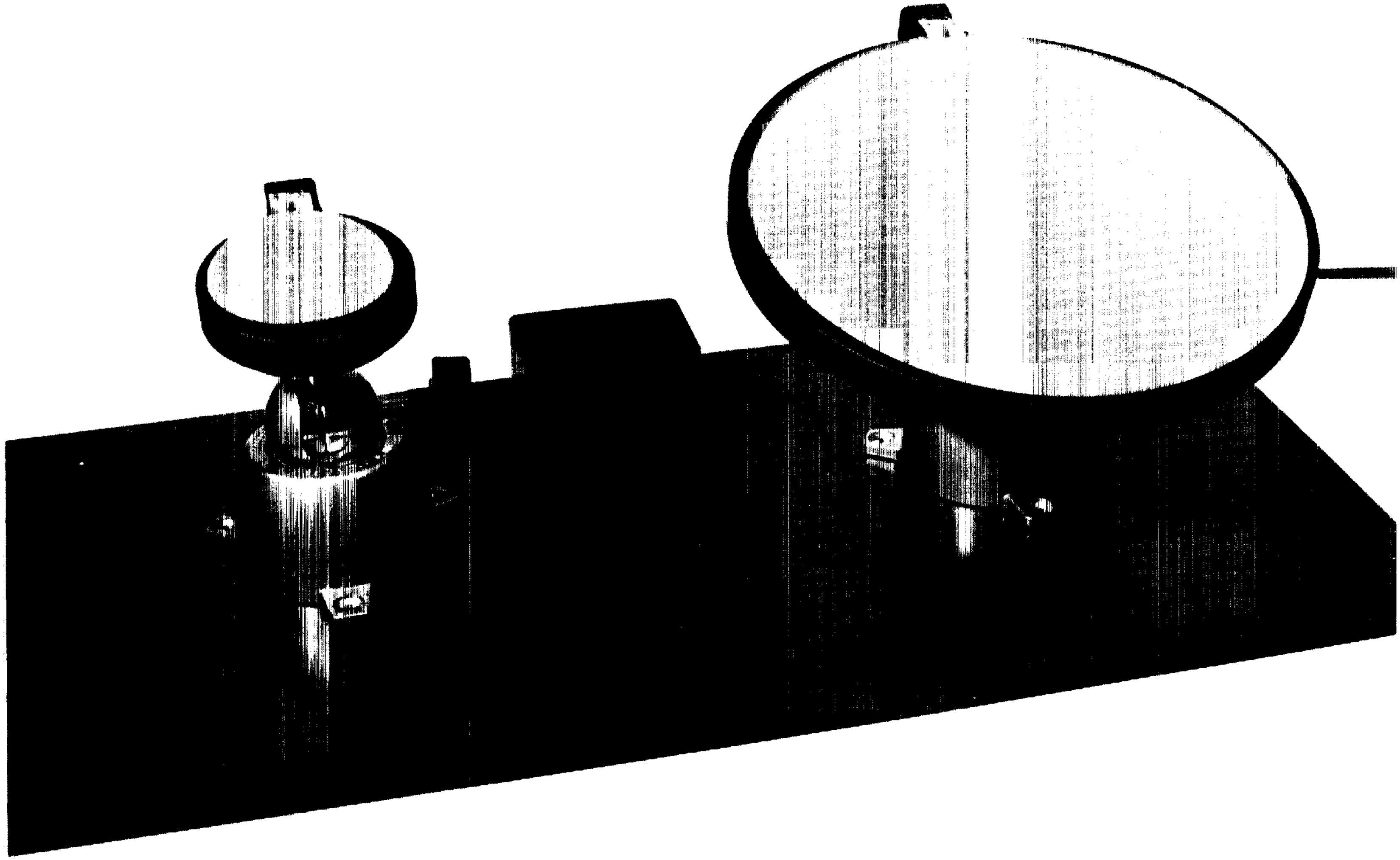


Figure 5. The NESDIS foil disdrometer sensors of 3-inch and 9,5-inch diameter mounted for testing. Mounting plates are adjustible to permit the correct pitch for water runoff.