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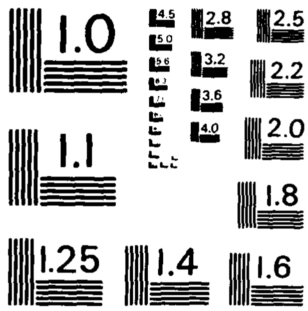

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Snow Characterization Instruments

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1 March 1983

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METEOROLOGY DIVISION PROJECT 6670
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HANSCOM AFB, MASSACHUSETTS 01731

AIR FORCE SYSTEMS COMMAND, USAF

This report has been reviewed by the ESD Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS).

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Alva T. Stair, Jr.

DR. ALVA T. STAIR, Jr
Chief Scientist

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This report details the design, fabrication, and operation of three new instruments that were developed at AFGL to define some of the physical characteristics of naturally falling snow. Two are devices for the measurement of fall velocity and high-resolution snow rate. The other was conceived for the documentation of the ice-crystal composition of the prevailing snow. Problems that surfaced during the first year of operation are discussed along with the plans to correct the deficiencies. Examples of the data supplied by these instruments are shown.

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Preface

The authors wish to express their appreciation for the assistance given by the AFGL machine and sheet metal shops in the construction of these instruments and to Steve Jones for his work on the optical systems. A special tanks to Carolyn Fadden for the typing of the report.

Very important contributions, both in the construction and operation of these devices, have been made by SMSgt Stephen D. Crist, SSgt Dennis L. LaGross and CMSgt Donald J. MacDonald. Without the great effort put forth by these individuals, these instruments would still be in the initial stage of development.

The conscientious effort provided by SMSgt Thomas Moraski, now retired, on the 1980 prototype Fall Velocity Instrument deserves special recognition. We thank him for helping to pave the way.

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1. INTRODUCTION

In the recent past one of the principal responsibilities of the Cloud Physics Branch of the Air Force Geophysics Laboratory (AFGL) has been to investigate and characterize hydrometeors along the trajectories of reentry vehicles and correlation of these data with simultaneous reflectivity measurements made by ground-based radar. Initially these investigations relied heavily on in-situ aircraft measurements of particle size, type, distributions, and number densities along with the more conventional parameters of pressure, temperature, and dew point (Barnes, et al;[1] Metcalf et al;[2] Plank;[3,4] Plank, et al;[5] Barnes, et al[6]). Currently, our efforts to solve this problem have concentrated on developing models to forecast the various hydrometeor parameters. This inclination has, in turn, increased our interest in measuring and characterizing rain and snow via ground-based instrumentation.

During the winter of 1980-1981, the Atmospheric Optics Branch of AFGL requested the Cloud Physics Branch to characterize and measure the snow falling at Hanscom AFB during those periods when they were conducting simultaneous infrared attenuation studies. At the outset, we simply combined standard measurement

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(Received for publication 24 February 1983)

Because of the large number of references cited above, they will not be listed here. See References, page 31.

techniques with cloud physics relationships to provide estimates. Later, we experimented with a high-resolution weighing system, as well as with the video recording of snowflakes to determine fall velocities and crystal type. Eventually this involvement led to the design, construction, and use of three new instruments: the Fall Velocity Indicator (FVI), the Snow Rate Meter, and the Belt Reader. The purpose of this report is to provide a detailed description of each of these devices.

All three instruments were deployed to Camp Ethan Allen, Jericho, Vt (see Figure 1) from December 81 through February 82. This was the site of a joint service, multinational field experiment called SNOW ONE-A (Scenario Normalization for Operations in Winter Observation and the National Environment), which was sponsored by the U.S. Army's Cold Regions Research and Engineering Laboratory (CRREL). Included in this report are samples of the data collected there by our instruments (Berthel[7]), as well as plans for future instrument refinements based on lessons learned. To the best of our knowledge, these instruments are unique in concept and patent disclosures have been filed for all.

Figure 1. Photograph of Instruments at Camp Ethan Allen, Vt. The FVI is at the extreme left, in front of car. The Snow Rate Meter is the center instrument surrounded by the snow fence. The stand for the Belt Reader is in right foreground. At the time of this photograph the Belt Reader was not in operation

7. Berthel, R.O. (1982) Snow characterization measurements at SNOW-ONE-A, CRREL SNOW-ONE-A Data Report, pp. 421-437, AFGL-TR-82-0003, AD A118140.

2. FALL VELOCITY INDICATOR (FVI)

The purpose of this instrument is to record the physical characteristics of individual flakes of naturally falling snow and to provide a means of measuring their fall velocities. The initial version of this device was conceived, designed, and built at AFGL in 1980. It turned out to be a cumbersome affair that lacked sufficient lighting and optical magnification. In addition, it proved highly susceptible to wind effects and was virtually inoperable in winds above the 5 to 8 knot (2.6 to 4.1 m/s) range. This was, to the best of our knowledge, the first instance where video cassette recording was used in an attempt to measure some of the microphysical properties of falling snow.

2.1 Description

The present version of the FVI was completed just in time for field testing and use during SNOW ONE-A at Camp Ethan Allen, Vt, in late 1981. The device (see Figures 2 through 4) is essentially composed of three sections: the camera, a sampling chamber, and a connecting tunnel. The camera is pointed horizontally through the tunnel and into the sampling chamber. The vidicon camera is zoom-lens equipped and housed in an environmental enclosure that is electrically heated to maintain a proper operating-temperature range. The distance from the camera lens to the 3 cm^2 sample viewing area is 75 cm. This distance restricts the optical depth of field to 1.5 cm with the equipment used and provides a 4.5 cm^3 sampling volume.

The sheet-metal connecting tunnel between the camera enclosure and the sampling chamber prevents ambient light and wind from degrading the quality of the data. A 3 × 11 cm mirror is mounted at the sampling chamber end of the tunnel and is angled so that the camera sees a top as well as a front view of snowflakes transiting the sample viewing volume. The interior surfaces of the tunnel, as well as those of the sampling chamber, are painted flat black to reduce the scattered light within the sampling chamber.

The sampling chamber is actually composed of a square inner chamber with 15.24 cm sides surrounded by a larger outer housing. A portion of two of the walls of the inner chamber are plexiglass and situated at the inner chamber bottom is a removable snow-collection tray. Two high-intensity strobe lights mounted in the bottom corners of the outer housing are angled to shine through the plexiglass and onto the sample viewing volume. Parts of the beams reflect off two mirrors mounted at an angle at the top of the inner chamber. Thus, reflected as well as direct light combine to provide more uniform illumination of the snow sample.

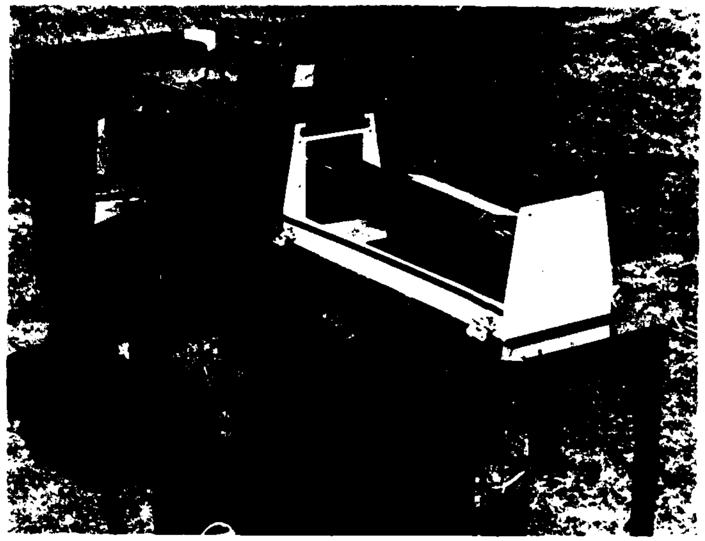


Figure 2. Photograph of FVI. The cover of the heated chamber has been removed to show the vidicon camera and zoom lens. The field-installed secondary baffle surrounding the entry port is shown in the upper left

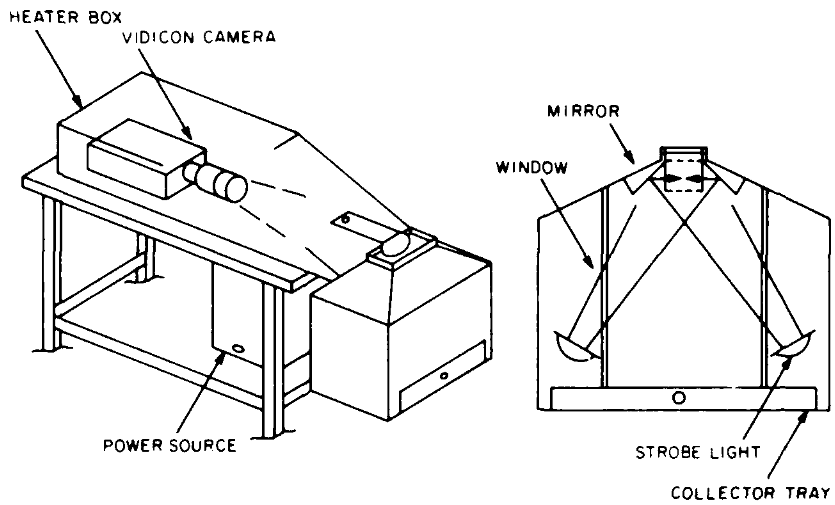
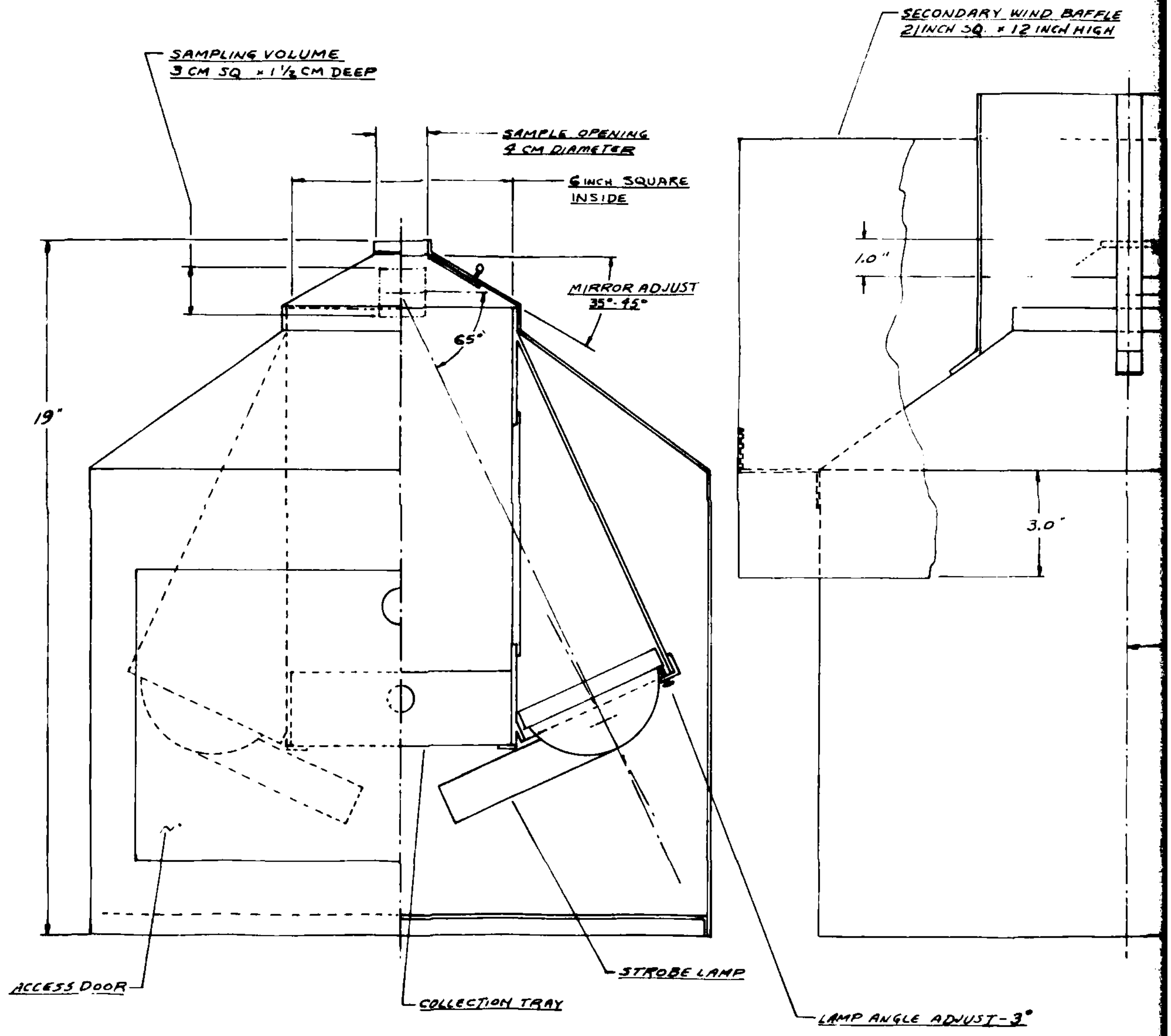


Figure 3. Diagram of FVI


SAMPLING VOLUME
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4 CM DIAMETER
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INSIDE
MIRROR ADJUST
35°-45°
65°
19"
SECONDARY WIND BAFFLE
21 INCH SQ. × 12 INCH HIGH
1.0"
3.0"
ACCESS DOOR
COLLECTION TRAY
STROBE LAMP
LAMP ANGLE ADJUST - 3°

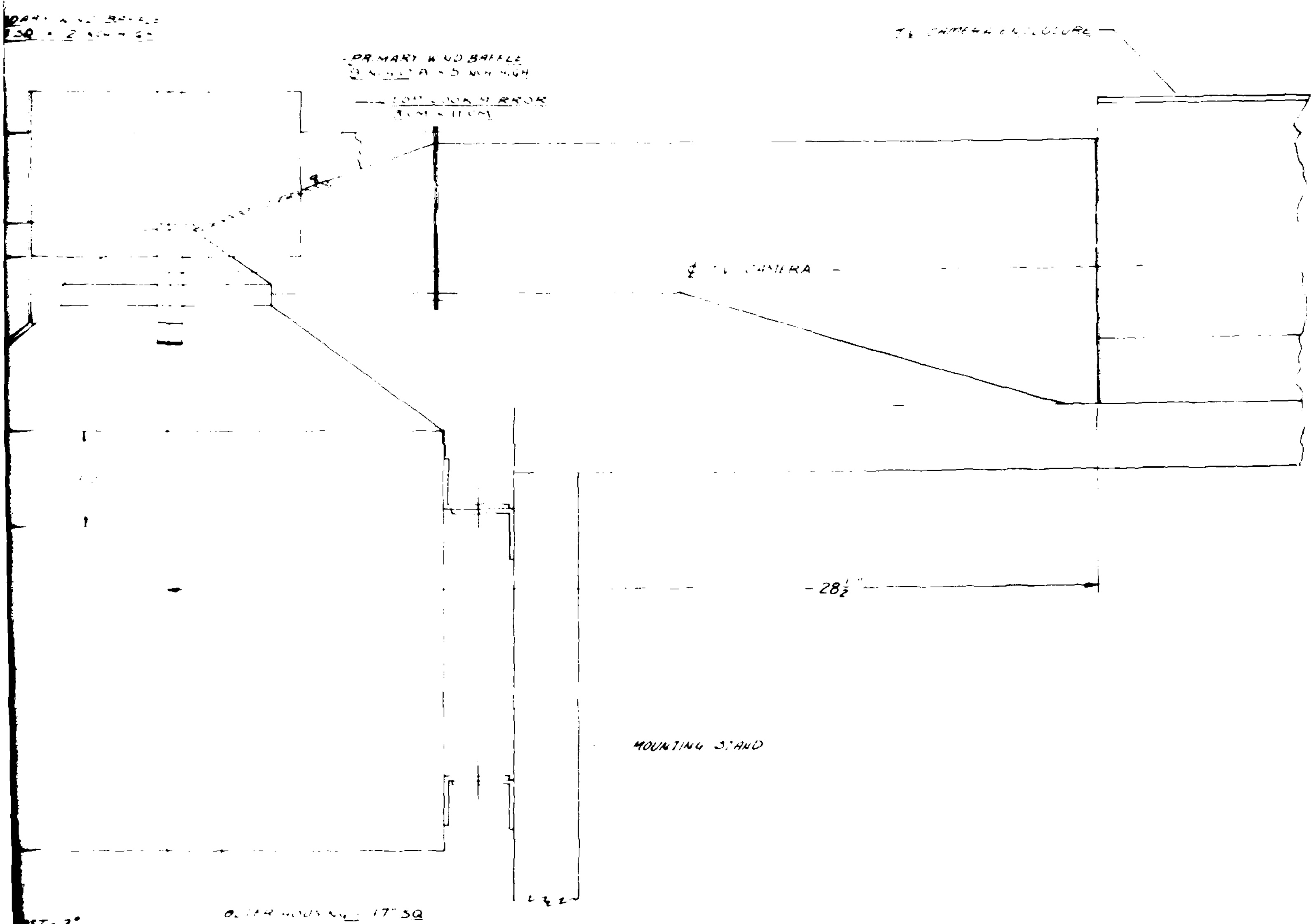

Figure 4. Schematic of FVI

Since the concept of the FVI is to monitor naturally falling snow, the instrument's design requires that a wind baffle be attached to the top of the sampling chamber to allow entry of only those flakes whose trajectories are within 45^{o} of vertical. Larger angular trajectories could conceivably be sampled by increasing the viewing area and redesign of the sampling chamber. However, winds of sufficient velocities to cause such angular deviations tend to produce turbulence as they pass over the instrument. This situation causes a "pumping" effect, which results in erratic snowflake movement. During the initial field tests, a second outer baffle was added to minimize these wind pumping effects.

The FVI is connected to the following auxiliary equipment: function generator, frequency counter, TV monitor, video cassette recorder (VCR), and a counter/timer. The adjustable function generator is used to externally trigger the strobe lights. The frequency counter visually displays the precise strobe rate. The counter/timer provides the video frame count to both the TV monitor and the VCR.

Snow falling in the sample viewing volume can be detected by the camera only when illuminated by the strobe-light flashes. Since the selected strobe rate always exceeds the camera's video scan rate, multiple images are produced and retained by the vidicon. The TV monitor and VCR are then able to display and record multiple images of a snow particle on a single frame as it transits the sample viewing volume. Thus, a recorded video frame may show top views of a snow particle (reflected by the top look mirror) associated with two or more frontal images. Comparing top and frontal images can provide information on particle orientation, tumbling, or oscillation. Then, by measuring the distance an individual particle travels between images and knowing the strobe rate or time between images, the fall velocity can be computed. In addition, the recorded video data also provides particle type and size information. These data are currently being analyzed by photographing the recorded video images and hand measuring the particle sizes and fall distances. Particle typing and fall characteristics are thus determined by observation. Mechanized, computer-controlled methods could be used to measure sizes and distances with the particle type being determined by pattern recognition techniques. See Dyer and Glass,[8] and Hunter, Dyer, and Glass[9, 10] for AFGL's recent advances in computer recognition of various snow types.

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8. Dyer, R.M., and Glass, M. (1982) Observed changes in ice crystal type in thick stratiform clouds, Conference on Cloud Physics, 15-18 November 1982, Chicago, Ill.

9. Hunter, H.E., Dyer, R.M., and Glass, M. (1982a) Comparison of human and machine classification of poorly defined patterns, IEEE Trans. on Pattern Analysis and Machine Intelligence (to be published).

10. Hunter, H.E., Dyer, R.M., and Glass, M. (1982b) A 2-D hydrometeor machine classifier derived from observed data, submitted for publication to J. Appl. Meteorol., also in ADAPT Report 82.3.

Figures 5 and 6 show examples of recorded snow particles photographed from a TV monitor. Table 1 gives some specifications for the purchased components. Table 2 shows selected computed fall velocity data.

2.2 Future Development

Field tests and operational use of the FVI have prompted consideration of several modifications to enchance the instrument's efficiency. First, the mirror mounted in the connecting tunnel to give a top view of the snow crystals needs to be repositioned. Presently, its field-of-view is too small and the amount of light it reflects is too great. Second, a circuit is being designed that will furnish a display of the strobe frequency and time directly to the VCR and the TV monitor. This will give the operator, as well as the person who subsequently analyzes the data, an accurate record of these crucial parameters since logbook entries of these parameters kept during field tests can be time-consuming and sometimes imprecise. Third, the angle of the strobe lights should be changed to provide more uniform lighting from the camera side of the sample volume. Originally, the FVI was conceived to provide fall velocities of both rain and snow, thus the strobes were angled to produce the maximum amount of refracted light while sampling liquid precipitation. Experience dictates that this angle is not optimum for snow crystals. Lastly, impelled by a desire for better video resolution, we contacted equipment vendors and found that of the three video components (camera, monitor, and VCR), the VCR is the limiting factor. Gaining higher resolution will not be cost effective since it would involve the purchase of new equipment costing 8 to 10 times more than the present equipment.

3. SNOW RATE METER

The Snow Rate Meter was conceived and designed in order to detect, resolve, and record the very short-term variations of snow rate. Snow rate, or the amount of snow deposited on a surface in unit time, is one of the standard parameters used to describe the intensity of falling snow. Snow rates are usually determined from weight or depth readings taken at relatively long intervals (hours or fractions thereof). However, in studies of precipitation-induced attenuation of laser and optical sensors, it is essential to resolve short-term (minutes or less) snow rate variations.

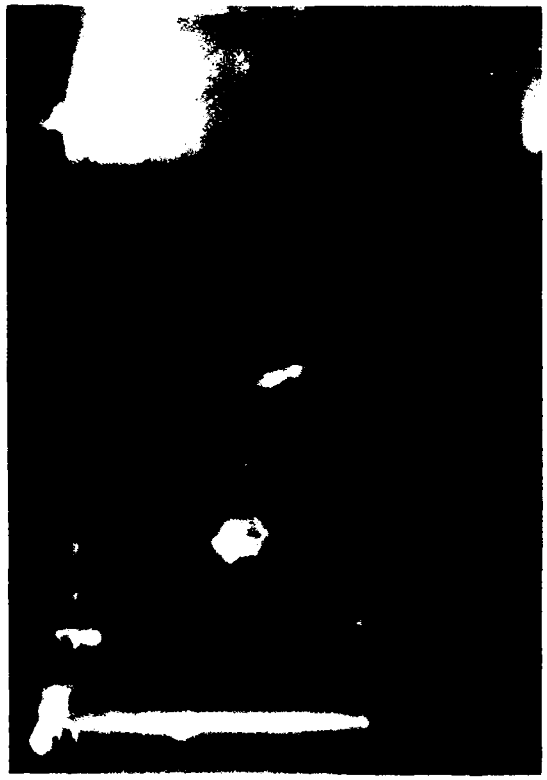


Figure 5. Photograph of 9 December 81 Data From FVI. This recording was taken at 0815:20 EST. The lighter area at the top is the reflection from the angled mirror. The lines at the bottom are guide wires used to focus the optics. The frame number appears on the lower left

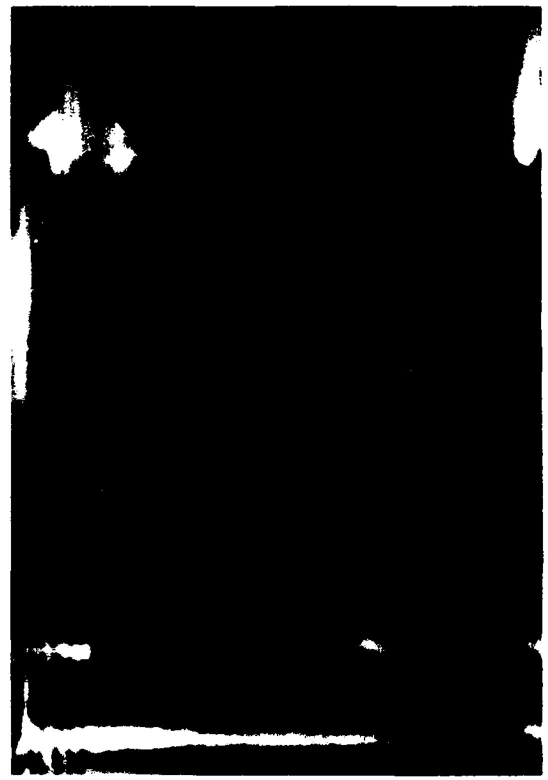


Figure 6. Photograph of 9 December 81 Data From FVI. This recording was taken at 0934:57 EST. Notice the partial image of the falling particle in the reflection from the angled mirror

Table 1. FVI Components

Item	Source
Camera	RCA Model TC 1005/01 Vidicon
Lens	Fuji Optical Model 1:18/16-160 TV Zoom
Environmental Enclosure	Vicon Industries Model V800H
Strobe Lamps	General Radio Model GR1538-A
TV Monitor	Panasonic Model TR-195MB
Counter Timer	Thalner Electronic Lab Model VC405
Video Cassette Recorder	Panasonic Model NV8200

Table 2. Samples of Computed Fall Velocities During Designated Time Periods on 31 January 82

Time Est	Size mm	Fall Vel m/s	Remarks	Time Est	Size mm	Fall Vel m/s	Remarks
1700	3.86	1.12		1800	1.7	0.80	graupel
to	5.23	1.28		to	6.4	1.39	dendrite
1715	1.7	1.13	graupel	1815	1.29	0.67	graupel
	0.86	0.59	graupel		0.86	0.82	graupel
	3.86	1.18	graupel		6.0	0.85	stellar
	2.14	0.95	graupel		2.14	0.59	stellar
	1.28	0.87			7.28	1.08	dendrite
	1.28	0.62	graupel		4.29	0.77	stellar
	1.71	0.95	graupel		3.86	0.62	stellar
	0.86	0.59	graupel		3.0	0.62	dendrite
1900	2.14	0.72	graupel	2000	0.64	0.62	graupel
to	1.93	1.03	graupel	to	0.43	0.59	graupel
1915	2.57	1.23	graupel	2015	1.28	0.59	dendrite
	1.51	0.62	graupel		3.64	1.31	
	2.14	0.87	column		3.0	1.28	dendrite
	2.19	1.23	graupel		5.14	1.16	stellar
	0.51	0.62	graupel		1.37	1.03	graupel
	1.28	0.67			2.57	1.18	graupel
	3.43	1.08	dendrite		0.86	1.41	graupel
	2.57	1.28	dendrite		1.71	1.08	graupel

3.1 Description

The heart of the Snow Rate Meter (see Figures 7 through 9) is an electronic balance that has remote operating capabilities and gives weight determinations of 0.01 g resolutions at time intervals approaching 3 sec. A compatible microprocessor takes the balance output signal and formats it for recording on magnetic tape.

The balance is enclosed in a sheet-metal, styrofoam-insulated box that is electrically heated and thermostatically controlled to maintain the proper operating temperature for the balance. The original shaft purchased with the balance, which connects the sensing head to the weighing pan, was extended to protrude above the heated box so that the snow sample container would be isolated from the possible effects of escaping heat. The sample container itself is cylindrical in shape with a bottom contoured so that it can be centered on the weighing pan. It is made of clear plastic, is 15.1 cm in diameter with a 3 liter capacity, and is inscribed with 200 ml calibration marks to allow volumetric measurements of the snow. Using the volumetric and weight measurements one can compute snow density. Due to the precision of the balance, it was found to be inherently sensitive to wind effects and the problem was addressed by a series of three baffling devices. The first, a 1.3 m high snow fence, was (see Figures 1 and 8) mounted 1 m off the ground in a 5 m (diameter) circle to disrupt the more severe horizontal wind components. Second, a vertically adjustable sheet-metal shield, 30.5 cm in diameter (Figures 7 and 8), is attached to the top of the heater box. Its height is adjusted to limit collection of only those snow crystals having trajectories within 45° of the vertical. The shield is constructed in halves that are hinged to allow access to the sample container. Third, the sample container, weighing pan, and balance connecting shaft are enclosed by a 17.8 cm clear plastic tube (Figures 7 and 8) to further reduce wind effects, as well as to keep snow from accumulating on the moving parts of the balance. A thin copper updraft baffle and a tapered sampling lip (Figure 7) are attached at the top of the tube to ensure that snow entering the sample area would be directed into the container and not allowed to accumulate between the container and tube.

Figures 10 and 11 show plots of snow weight vs time and snow rate vs time for 31 January 82. Table 3 describes some of the Snow Rate Meter's components.

3.2 Future Development

Although the Snow Rate Meter surpassed our expectations in providing accurate data, it initially suffered from data oscillations or "noise" due to wind effects. The present array of baffles has reduced these effects to an acceptable level, but we still are experimenting with new ideas in an attempt to further reduce the noise level. One such plan is to shorten the shaft connecting the balance's sensing head

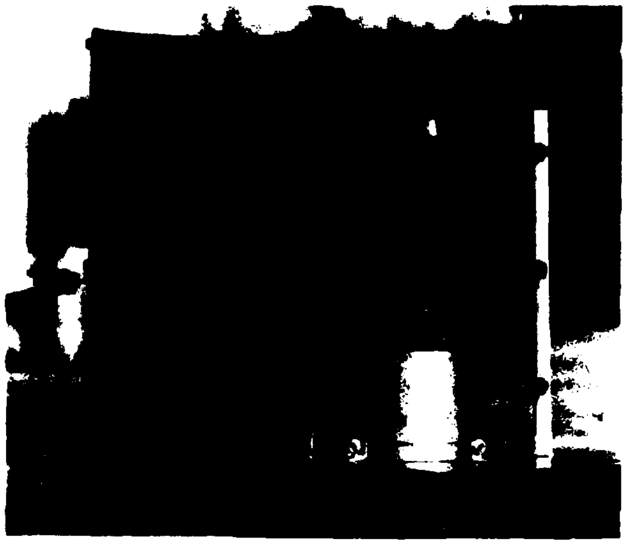


Figure 7. Photograph of Snow Rate Meter. The outer hinged metal wind shield is shown in the open position to expose the inner plastic shield and collection bucket

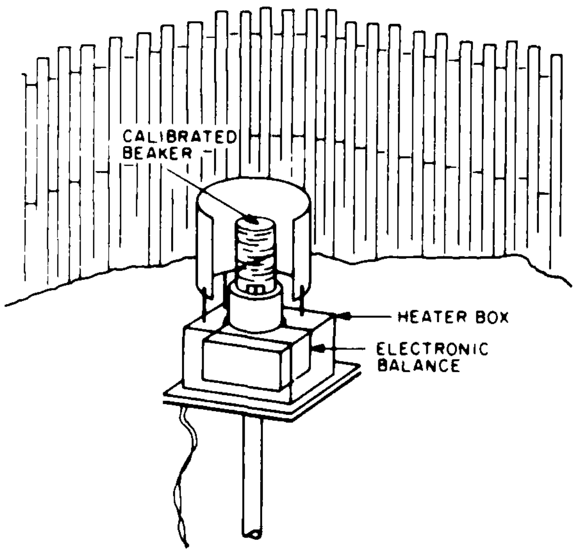
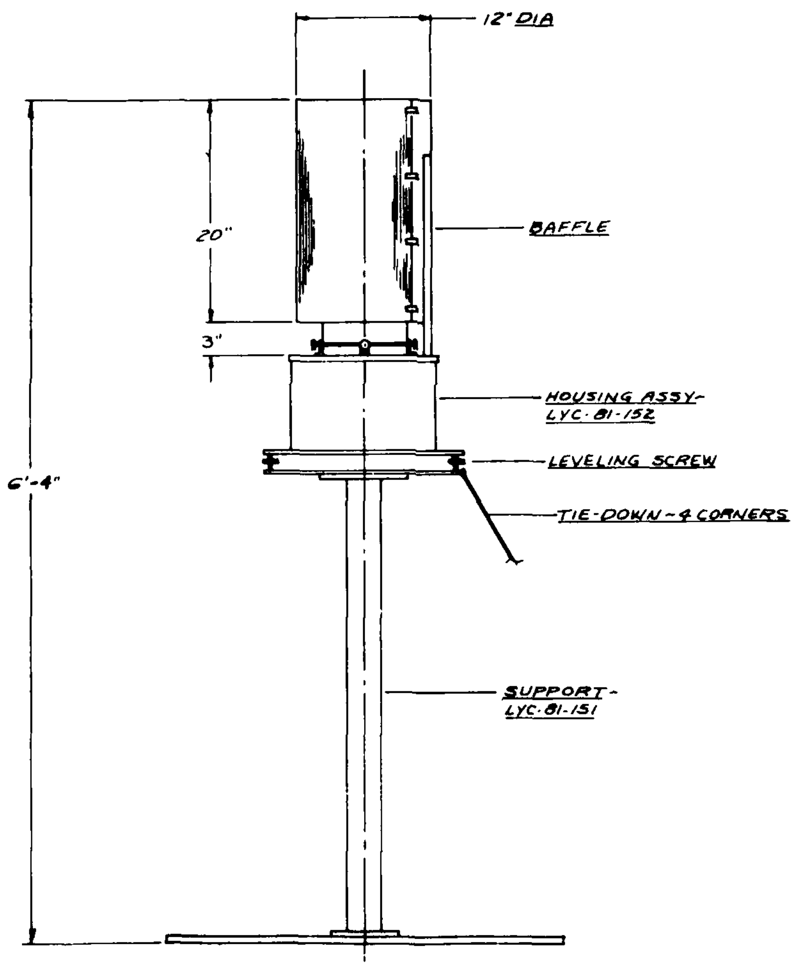


Figure 8. Diagram of Snow Rate Meter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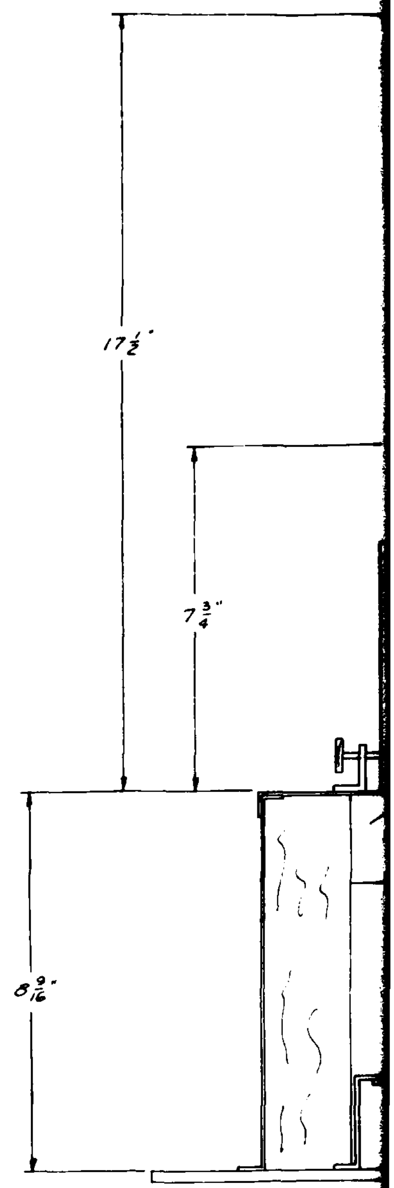
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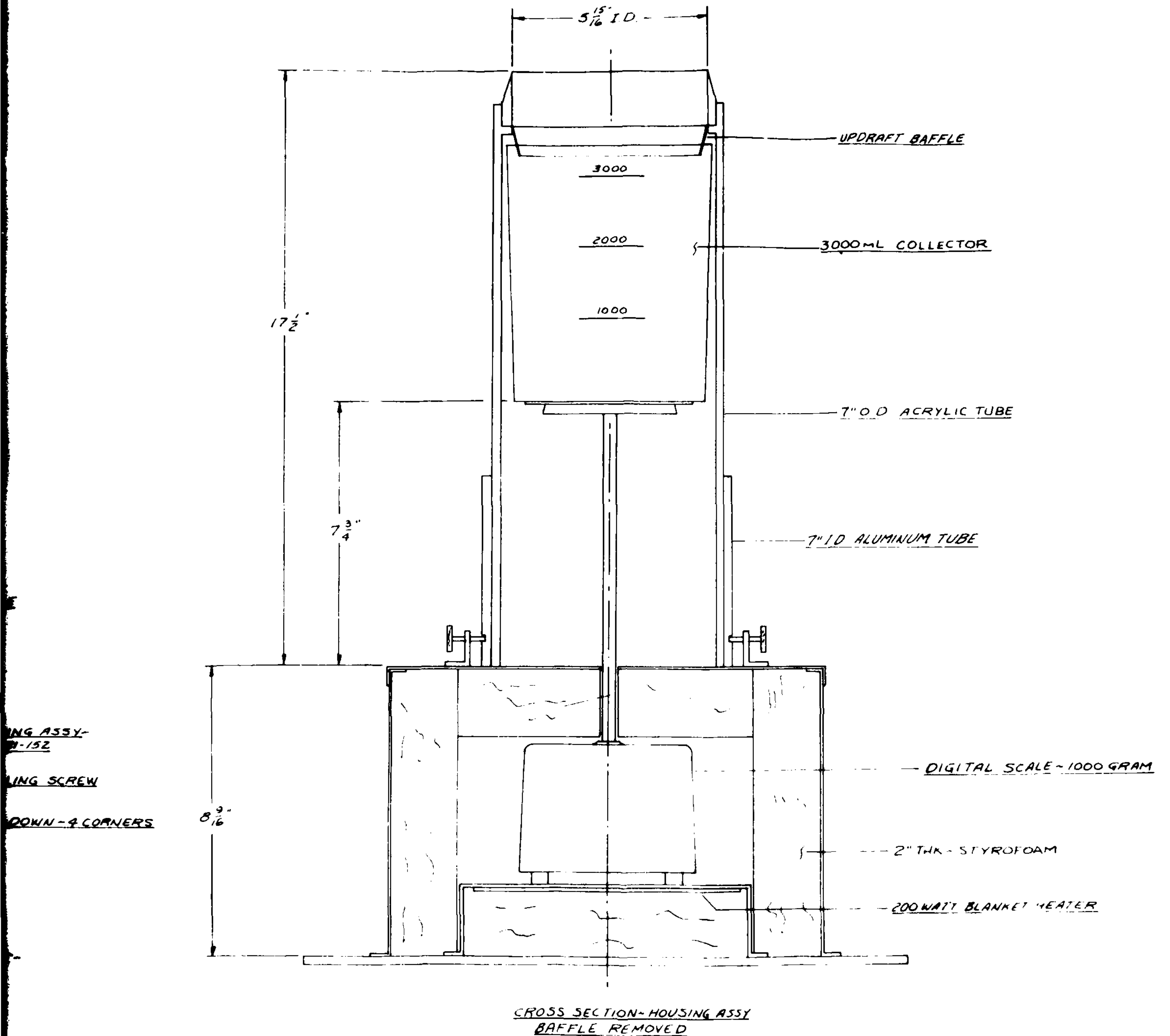


Figure 9. Schematic of Snow Rate Meter

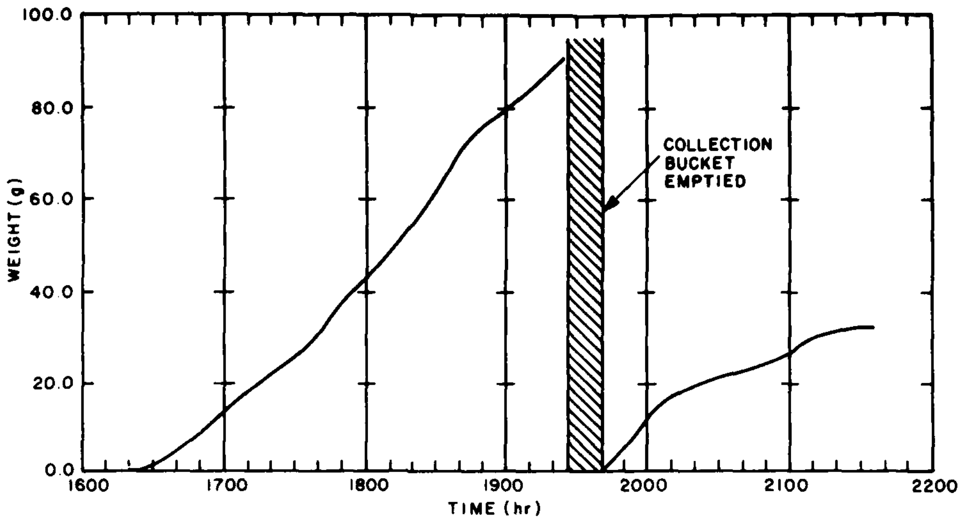


Figure 10. Snow Weight vs Time Plot for 31 January 82

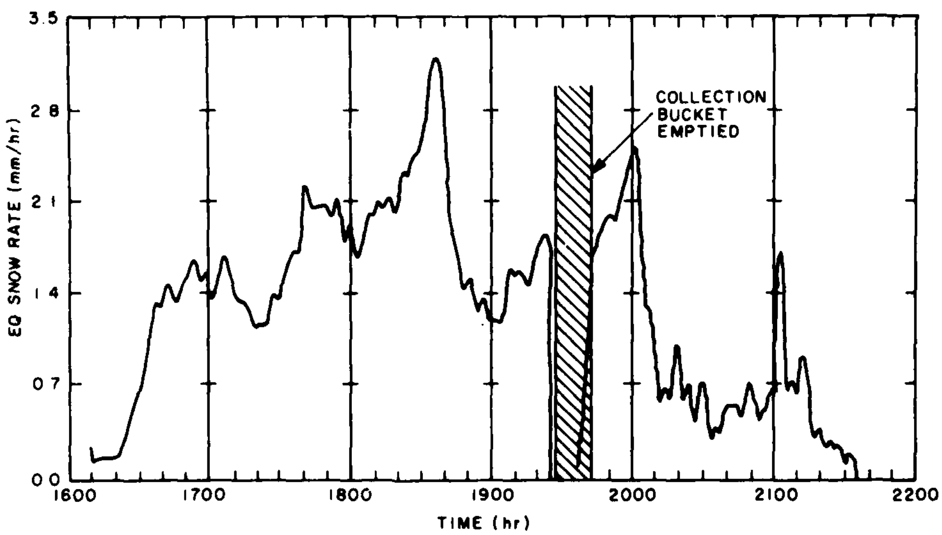


Figure 11. Snow Rate vs Time Plot for 31 January 82

Table 3. Snow Rate Meter Components

Item	Source
Electrical Balance	Scientech Model 3340 with remote scale
Calibrated Beaker	3 liter with 200 ml graduations
Heater Box	Constructed in-house
Inner and Outer Wind Shielding	Constructed in-house
Data Collection	Tektronix Model 4923 Digital Recorder

to the weighing pan by ~ 12.5 cm (5 in.). Since a long shaft is inherently more susceptible to vibration as a result of wind effects, this alteration will tend to minimize this possible noise source. This change will significantly reduce the distance between the sample bucket and the heated chamber, thus vent holes will be cut into the clear plastic tube to dissipate any heat escaping from the chamber.

4. BELT READER

The Belt Reader was specifically designed to record the character of snow crystal type on a continuous basis in order to relate changes in crystalline form to changes in electromagnetic attenuation, snow density, fall velocities, etc. The FVI, as previously mentioned in Section 2, has a limited ability to detect particle type although orientation of the free-falling snowflakes can, in some cases, make identification difficult. This device, on the other hand, views all captured particles in the same horizontal position, thus its primary function is the determination of the prevailing crystal habit or type of snowflakes. Also, the magnification provided by the optics in the Belt Reader has the ability to resolve the individual ice crystals from which the snowflakes are composed.

Construction, parts procurement, and metal fabrication delayed completion of this device until a week after the start of the SNOW ONE-A deployment. Therefore, field testing and subsequent modifications had to proceed concurrently with data gathering and the operation of other deployed equipment.

4.1 Description

As its name might imply, the Belt Reader consists of a belt that transports captured snowflakes into the view of a closed circuit television (CCTV) camera (see Figures 12 through 14). Physically, it is composed of a belt and transport assembly, the camera and enclosure, and the auxiliary VCR and monitor. In the transport section, a 60-Hz motor and suitable gear reduction are used to move a rubber, reenforced-fiber-filament belt along a defined path at a predetermined speed of 2.5 cm/sec. The belt traverses three rollers, thus forming a triangular configuration whose top and longest side is parallel to the ground. The largest roller is the belt driver and it is knurled to increase friction. All of the rollers have flanged ends to keep the belt in position. A fourth roller, shown in Figure 14, may be used to supply additional belt tension. A sheet-metal housing painted flat black on all its interior surfaces encloses all components except for the camera. Cut into the top of this housing is a rectangular sampling port whose opening size is regulated manually by a sliding shutter. The size is dependent upon snow rate and is adjusted to prevent the overlapping of particles from appearing on the TV recording. Snow crystals entering the port are deposited onto the moving belt and transported to the viewing area. The CCTV camera mounted parallel to the ground and orthogonal to the belt's major axis actually looks across the belt. Therefore, a mirror angled at 45° and mounted across the belt from the camera is used to allow viewing of the snow crystals as they pass by. The camera is housed in an environmental chamber that is electrically heated to maintain the camera's proper operating temperature range. The sample viewing area is illuminated by a high-intensity strobe light positioned at the end of the belt's horizontal leg. The flash rate is timed by the vertical sync pulse of the camera. As the belt continues over the viewing end roller, a plastic composite scraper removes any snow crystals remaining. Figures 15 and 16 show samples of video data recorded on 31 January 82. Table 4 describes some of the Belt Reader's purchased components.

4.2 Future Development

Most of the problems experienced with the Belt Reader during field testing and initial operation were associated with the moving parts of the belt transport assembly. Their solutions were basically mechanical in nature and were accomplished before the end of winter. However, even after these difficulties were resolved, we were not completely satisfied with the Belt Reader's video output. We have determined during subsequent data analysis that the camera's small field-of-view combined with the continually moving targets and intense strobe light caused unacceptable blurring. In order to improve the image quality, we intend to make the following modifications. First, a special geneva gear has been obtained that will step drive the belt. This stepping feature will stop and delay each succeeding belt segment in the field-of-view of the camera thus, several frames of video tape

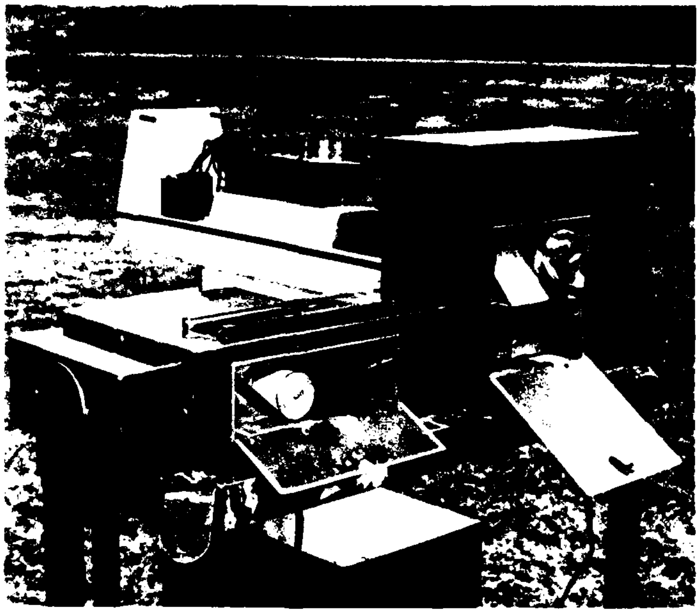


Figure 12. Photograph of Belt Reader. The cover of the heated chamber has been removed to show the vidicon camera and the electronic package that controls the strobe light. The open access door on the right shows the strobe, angled mirror, and the roller used to adjust belt tension. The open access on the left shows the drive roller. The adjustable sampling port can be seen on the housing above the drive roller

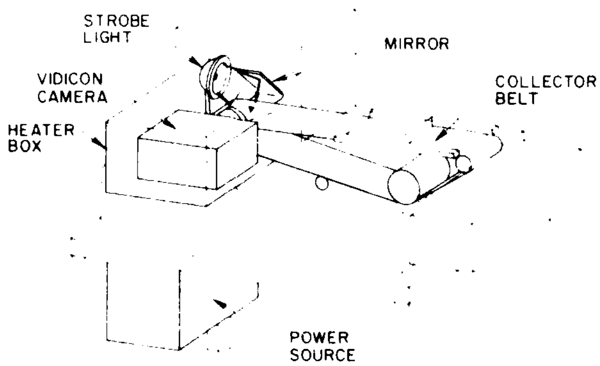
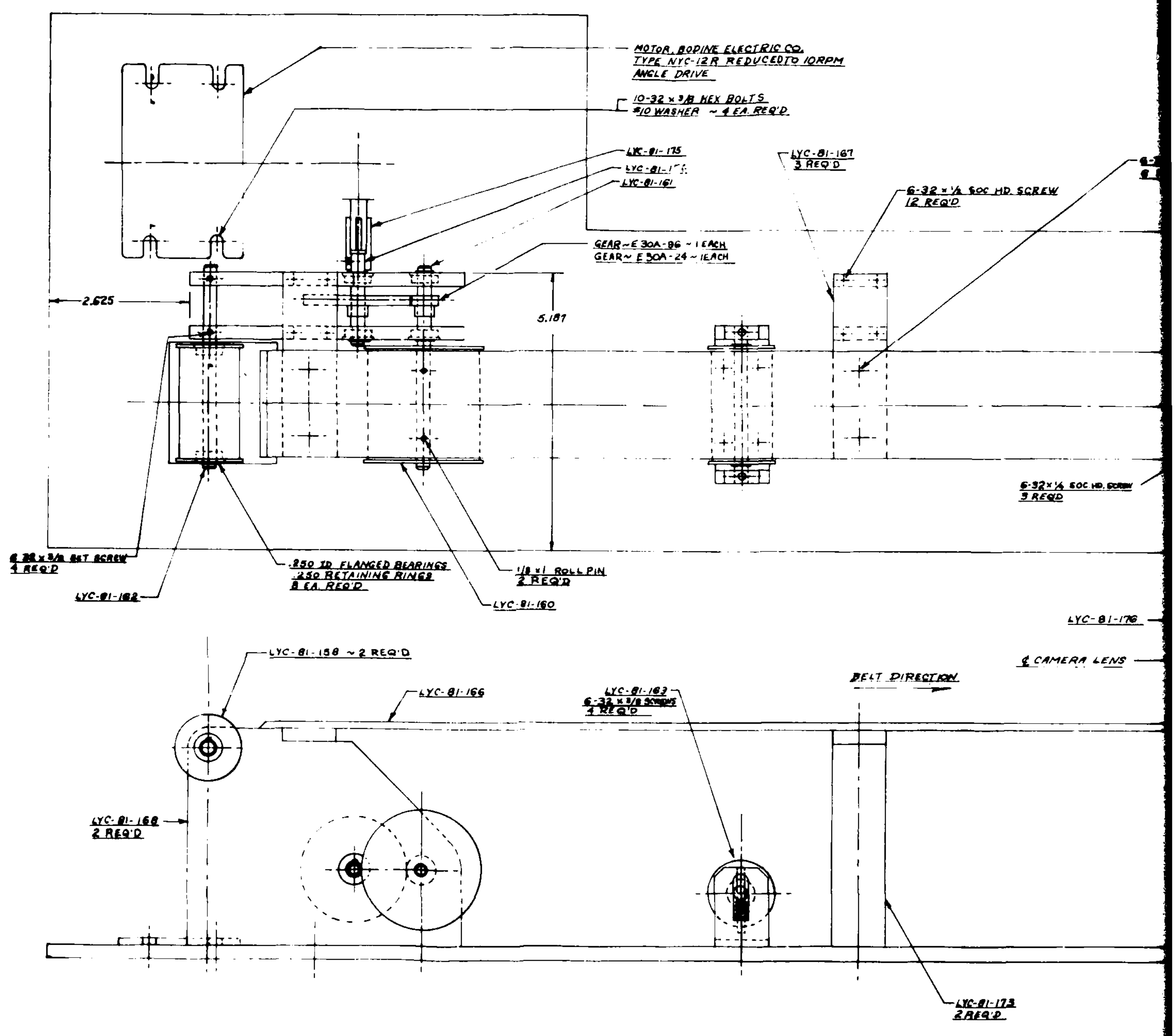


Figure 13. Diagram of Belt Reader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10-32 x 3/8 HEX BOLTS
#10 WASHER ~ 4 EA. REQ'D
LYC-81-175
LYC-81-161
LYC-81-167
3 REQ'D
6-32 x 1/2 SOC HD. SCREW
12 REQ'D
GEAR ~ E 30A-96 ~ 1 EACH
GEAR ~ E 30A-24 ~ 1 EACH
2.625
5.187
6-32 x 1/4 SOC HD. SCREW
3 REQ'D
6-32 x 3/8 SET SCREW
4 REQ'D
.250 ID FLANGED BEARINGS
.250 RETAINING RINGS
8 EA. REQ'D
1/8 x 1 ROLL PIN
2 REQ'D
LYC-81-162
LYC-81-160
LYC-81-176
℄ CAMERA LENS
LYC-81-158 ~ 2 REQ'D
LYC-81-166
LYC-81-163
6-32 x 3/8 SCREWS
4 REQ'D
BELT DIRECTION
LYC-81-168
2 REQ'D
LYC-81-173
2 REQ'D

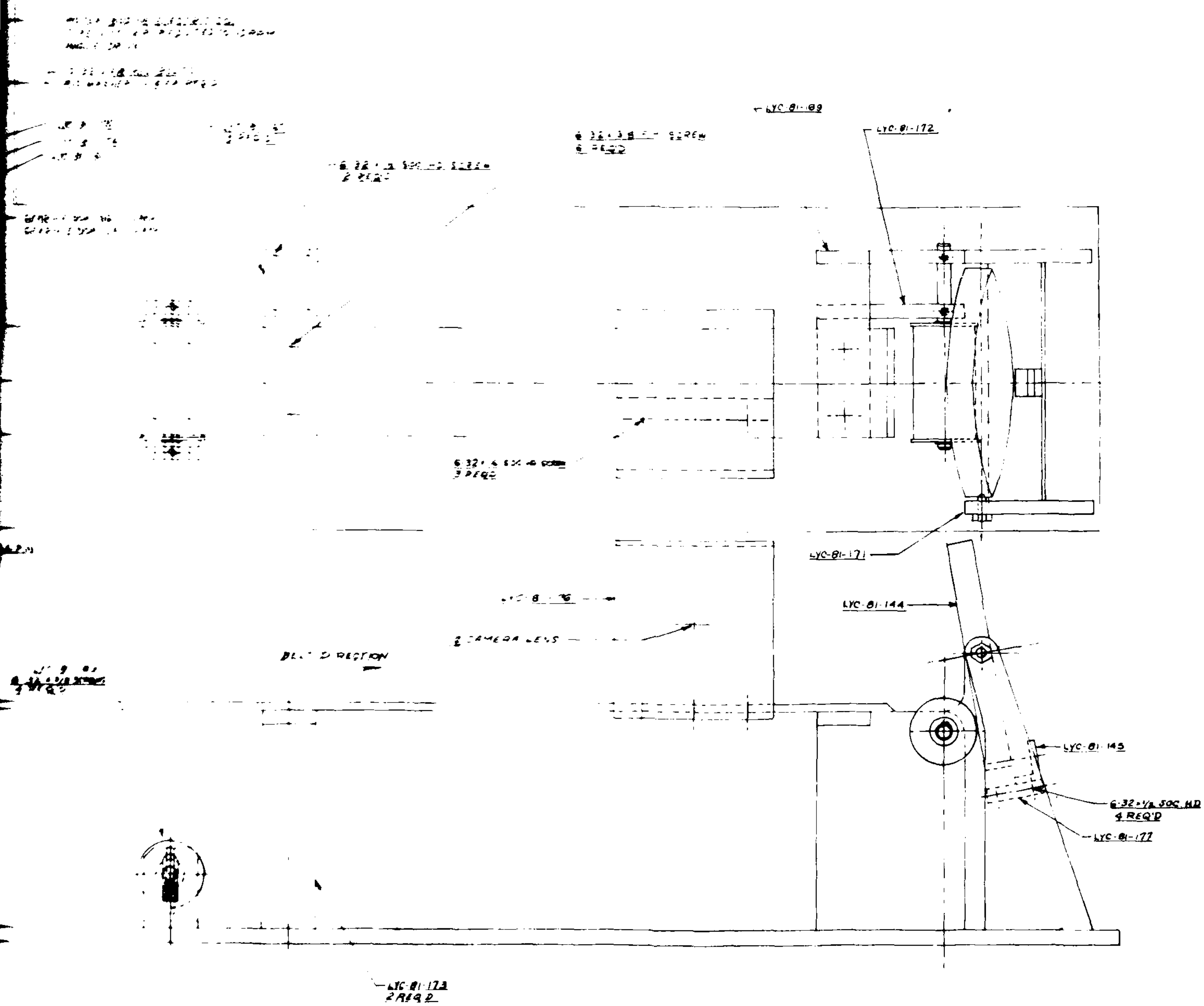

Figure 14. Schematic of Belt Reader

Figure 15. Photograph of 31 January 82 Data From Belt Reader at 1905:38 EST. The belt speed and flash rate combination is such that four images of a particle appear in one frame. Movement is from right to left. The frame number appears in the upper left

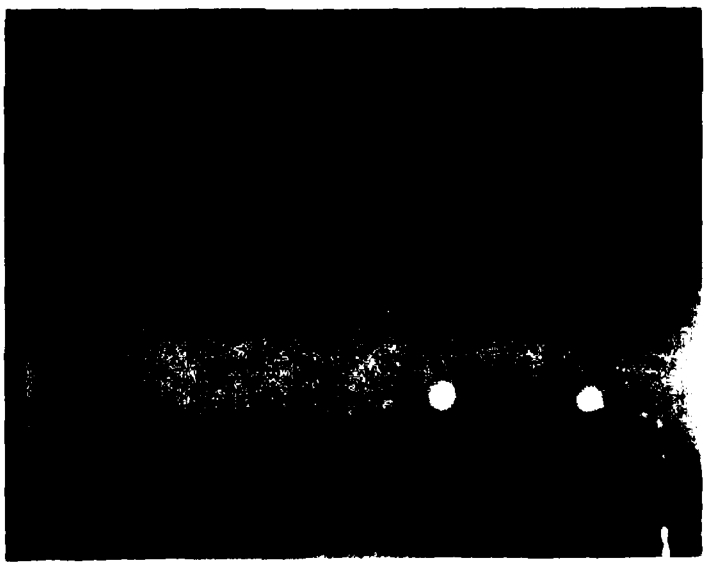

Figure 16. Photograph of 31 January 82 Data From Belt Reader at 1910:00 EST

Table 4. Belt Reader Components

Item	Source
Camera	RCA Model TC1005/01 Vidicon
Lens	Fuji Optical Model 1:18/16-160 TV Zoom Attachments - 1x, 2x and 4x diopters Focus - 100-mm Zoom; 1-ft focus Field - 10 × 13 mm Lens to subject distance - 13 cm
Environmental Enclosure	Vicon Industries Model V800H
TV Monitor	Panasonic Model TR-195MB
Counter Timer	Thalner Electronic Lab Model VC405
Video Cassette Recorder	Panasonic Model NV8200
Strobe Lights	General Radio Model GR1538-A

will be recorded showing each belt segment with its captured crystals. With the crystals stationary, a softer, constant incandescent light will be substituted for the harsher, flashing strobe light. Actual tests performed with these modifications indicate we will achieve significantly improved video resolution of the snow crystals. Lastly, the camera will be repositioned opposite the sampling port end of the belt and the transport assembly will be shortened by more than a third. This will necessitate mounting the mirror over the belt so that it still faces the camera, yet, leaving enough space for the crystal samples to pass beneath. These last changes will result in a considerable size reduction of the overall instrument.

5. SUMMARY

The three new instruments described herein enjoyed varying amounts of success in their first winter's operation. None produced trouble-free operation but all showed indications of becoming important devices for the characterization of naturally falling snow. However, valuable lessons were learned since this operational experience suggested alterations that promise to increase these instruments' effectiveness.

Currently, all devices are undergoing refinements being readied for deployment to Fort Grayling, Mich. for participation in the SNOW ONE-B field experiment during December 1982.

As mentioned previously, patent disclosures have been submitted for all three instruments. Initial patent searches have indicated that these devices are sufficiently unique in nature to provide excellent probabilities of being patentable items. Thus, official patent applications have been filed on behalf of the U.S. Government.

References

1. Barnes, A.A. Jr., Nelson, L.D., and Metcalf, J.I. (1974) Weather documentation at Kwajalein Missile Range, Preprints of the Sixth Conference on Aerospace and Aeronautical Meteorol... American Meteorological Society, November 1974, pp. 66-69; AF... -TR-74-0430, AD A000925.

2. Metcalf, J. I., Kraus, M. J., and Barnes. A. Jr. (1975) Final Report of PVM-6 and PVM-7 Weather Documen... n, AFCRL/Minuteman Report No. 6, AFCRL-TR-0481, AD B011353L.

3. Plank, V.G. (1974) Liquid-Water-Content and Hydrometeor Size-Distribution Information for the SAMS Missile Flights of the 1971-72 Season at Wallops Island, Virginia, AFCRL/SAMS Report No. 3, AFCRL-TR-74-0296, AD A002370.

4. Plank, V.G. (1977) Hydrometeor Data and Analytical-Theoretical Investigations Pertaining to the SAMS Missile Flights of the 1972-73 Seasons at Wallops Island, Virginia, AFGL/SAMS Report No. 5, AFGL-TR-77-0149, AD A051192.

5. Plank, V.G., Berthel, R.O., and Barnes, A.A. Jr. (1980) An improved method for obtaining the water content values of ice hydrometeors from aircraft and radar data, J. Appl. Meteorol. 19(No. 11):1293-1299; AFGL-TR-81-0011, AD A094328.

6. Barnes, A.A. Jr., Cohen, I.C., and McLeod, D.W. (1982) Investigations of Large Scale Storm Systems, AFGL-TR-82-0169, AD A119862.

7. Berthel, R.O. (1982) Snow characterization measurements at SNOW-ONE-A, CRREL SNOW-ONE-A Data Report, pp. 421-437, AFGL-TR-82-0003, AD A118140.

8. Dyer, R.M., and Glass, M. (1982) Observed changes in ice crystal type in thick stratiform clouds, Conference on Cloud Physics, 15-18 November 1982, Chicago, Ill.

9. Hunter, H.E., Dyer, R.M., and Glass, M. (1982a) Comparison of human and machine classification of poorly defined patterns, IEEE Trans. on Pattern Analysis and Machine Intelligence (to be published).

10. Hunter, H.E., Dyer, R.M., and Glass, M. (1982b) A 2-D hydrometeor machine classifier derived from observed data, submitted for publication to J. Appl. Meteorol., also in ADAPT Report 82.3.

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