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Ancient Monuments Laboratory
Report 58/94

ENVIRONMENTAL MONITORING AT ST ALBANS ABBEY: FIRST REPORT ON MEASUREMENT OF VISIBLE AND ULTRA-VIOLET LIGHT FALLING ON WALL PAINTINGS

Barry Knight BA MSc DPhil CChem MRSC

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Summary

Data loggers to record air temperature, relative humidity, visible and ultra-violet light have been set up in St Albans Abbey to monitor light levels falling on two recently-restored wall paintings. This is in response to the discovery that light-sensitive red lake and indigo pigments were used, and to concerns that they might start to fade now that they have been revealed. First results show that light levels are generally low, but that direct sunlight with a high ultra-violet content does fall on the paintings for about two hours per day in summer. The significance of these findings is discussed, as is the question of what are acceptable light levels for wall paintings.

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Environmental monitoring at St Albans Abbey: First report on measurement of visible and ultra-violet light falling on wall paintings

Barry Knight

1. Introduction

Since the restoration of the wall-paintings depicting St William and an Unknown Archbishop in the Feretory of St Albans Abbey in 1992, and the discovery that they contained light-sensitive red lake and indigo pigments (Howard 1993), there has been concern that these pigments might start to fade, as they are now more exposed to light following the removal of dirt and wax from the surface of the paintings. In order to see whether the levels of visible and ultra-violet light falling on the paintings were high enough to cause concern, it was decided to monitor the light falling on two paintings, one containing organic pigments and the other containing inorganic pigments which have darkened. This is thought to be caused by the conversion of white lead into black lead sulphide, and the conversion of red cinnabar into black metacinnabarite (Daniels 1987).

To do this, two Hanwell data-loggers were set up on 20th April 1994, one on the stump of the first Romanesque pier (fourth from the west on the north side of the nave), just above the painting of the Crucifixion and about 5m from the floor, and the other on a corbel just above and to the left of the painting of St William in the Feretory, about 2m from the floor (see plan). These miniature loggers (approx 13 x 4.5 x 3.5 cm) record values of temperature, relative humidity and visible and ultra-violet light. A light meter had previously been set up in front of the St William painting, but this only recorded total visible light exposure (lux-hours), not peak levels, and did not record ultra-violet light.

The loggers were downloaded for the first time on 16th August, and data for the whole period was retrieved from the logger adjacent to St William. Unfortunately, the logger on the nave pier was found to have failed after three weeks, but even during this period some useful results were obtained.

2. Nave pier

Graphs 1 to 3 show the complete data for the period 20th April - 9th May. As expected, there is considerable variation in the light levels, with the visible peaking at over 1000 lux and the ultra-violet at 392 uW/lumen. However, the total exposure over the 19 days the logger was operational was 35,400 lux-hours, giving an average illuminance of 78 lux and an extrapolated annual exposure of 680,000 lux-hours. The total UV exposure was 2.736 joules cm^{-2}, giving an average irradiance of 1.67 uW cm^{-2} and an extrapolated annual exposure of 52.56 joules cm^{-2} per year.

Further useful information can be obtained by examining the data more closely. Graph 4 shows that the visible light peaks at over 1000 lux between 2pm and 3pm and between 5pm and 6pm. The corresponding UV content is approx 100 μW/lumen, giving a UV irradiance of approx 10 μW cm^{-2}. The first peak is caused by direct sunlight falling on the logger through one of the south clerestory windows, and the second by sunlight coming through the west window. These peaks are of short duration because of the angle between the windows and the logger, and because the clerestory windows are quite deeply recessed.

Graph 5 shows the effect of the artificial lighting. The nave is lit by coronae consisting of 12 compact fluorescent lamps hanging in each bay of the arcades. The nearest lamp is about 1.5m from the logger and the top of the wall-painting. It can be seen that these lamps give an illuminance of about 200 lux at this level (less lower down), with a UV content of about 320 μW/lumen, giving a UV irradiance of about 6.4 μW cm^{-2}.

It is noteworthy that the temperature and relative humidity are very steady. The temperature ranges between 17.0° and 23.0°, with a mean of 18.8°, while the RH ranges between 38% and 57%, with a mean of 45.8%. (Note that because the logger is resting on the pier it will to a certain extent be recording the temperature of the stone rather than the air temperature.) There is certainly no reason to suspect dampness or condensation.

3. St William

Graphs 6 to 10 contain the complete data from the logger adjacent to the St William painting in the north-east corner of the Feretory. The total exposure was 98,400 lux-hours in 118 days, giving an average illuminance of 35 lux and an extrapolated annual exposure of 304,000 lux-hours. The total UV exposure was 5.0 joules cm^{-2}, giving an average irradiance of 0.49 μW cm^{-2} and an extrapolated annual exposure of 15.48 joules cm^{-2}.

Graph 11 shows the data for one day only. It can be seen that the maximum illuminance exceeds 1000 lux between 2pm and 4pm, with a UV content of about 100 μW/lumen. This is due to direct sunlight from the presbytery south windows. The peak lasts longer than the one seen by the logger on the nave pier because the presbytery windows are larger and the angle of incidence is not so acute.

Surprisingly, the temperature and relative humidity show more variation than on the nave pier. The temperature ranged between 14.5° and 23.5°, with a mean of 18.9°, while the RH ranged between 33% and 68%, with a mean of 56.6%. The mean temperature is similar to that on the pier, but the mean RH is significantly higher.

4. What is an acceptable level of illuminance?

On sunny days, the illuminance on both paintings can exceed 1000 lux, although only for a couple of hours. Because this is unfiltered daylight, the UV content can also exceed 300 μW/lumen. For the rest of the time the visible and UV levels are low. How damaging is this likely to be?

For the museum display of light-sensitive artefacts, such as water colours and textiles, the recommended maximum continuous illuminance is 50 lux visible with an ultra-violet content of 75 μW/lumen (Thomson 1978). 50 lux at 75 μW/lumen corresponds to 0.375 μW cm^{-2} ultra-violet. A museum which is open and lit for 7 hours per day, 6 days per week, 52 weeks per year, the rest of the time assumed to be in darkness, is illuminated for 2184 hours annually. This gives a total visible exposure of 50 x 2184 = 109,200 lux-hours per year, and an ultraviolet exposure of 0.375 x 10^{-6} x 3600 x 2184 = 2.95 joules cm^{-2} per year.

Extrapolation from the present data suggests that the Crucifixion on the nave pier might be exposed to about 680,000 lux-hours per year, and the St William painting to about 300,000 lux-hours per year. These are probably gross over-estimates, since there will be less direct sunlight during the winter months, although the effect of the artificial light will be greater. The extrapolated UV exposures are about 52 joules cm^{-2} and 15 joules cm^{-2} respectively. From this, it seems that both the recommended annual visible and ultra-violet exposures are likely to be exceeded.

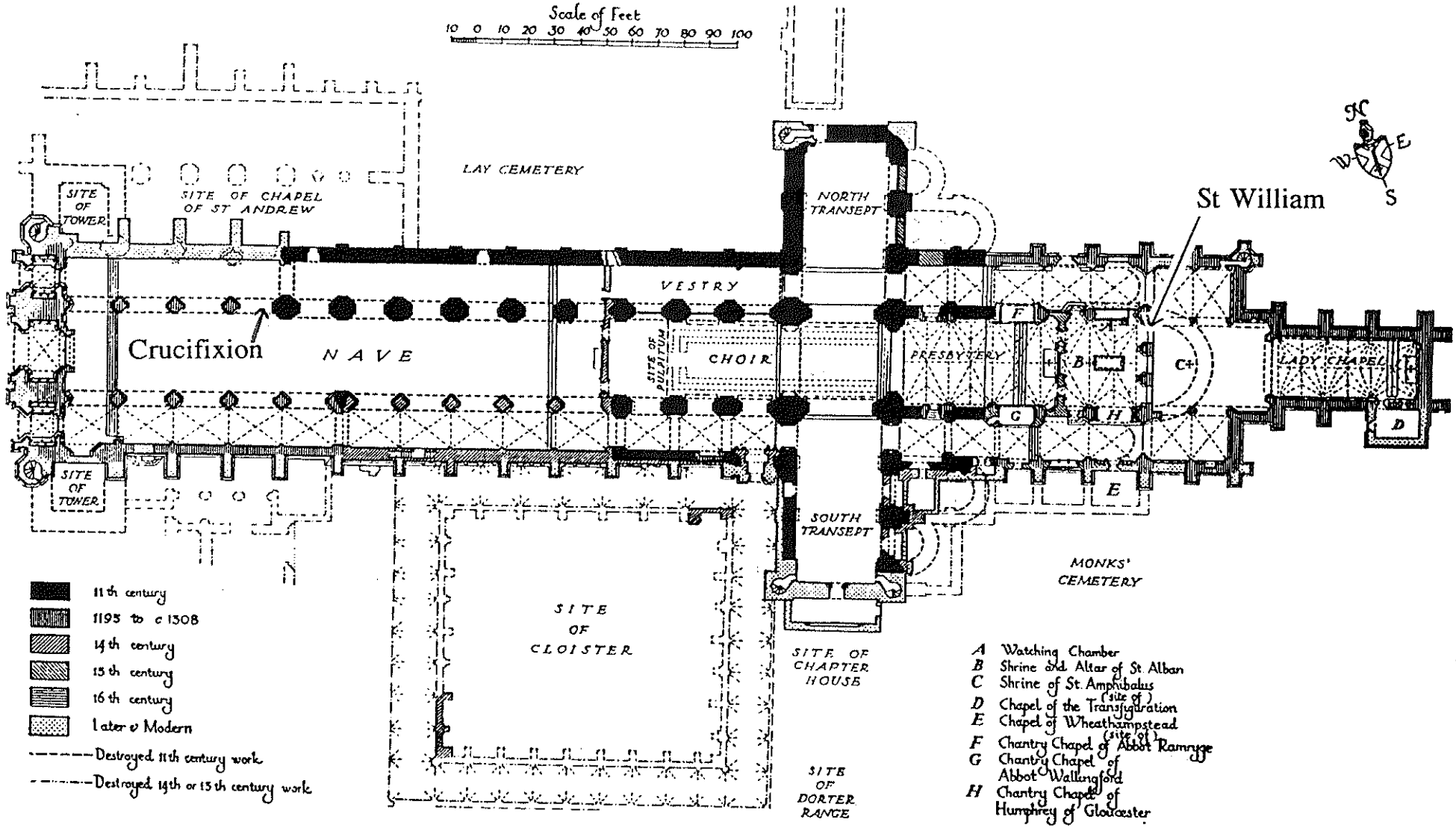
Clearly the monitoring needs to continue for the rest of the year so that a better idea of the annual exposures can be obtained. Also, given that St Albans Abbey is an active church and not a museum, light control would be difficult and expensive to install. It is therefore important that direct colour measurements are taken over a period of time, which will indicate whether fading is actually occurring. This work is due to be undertaken by the Building Research Establishment.

References

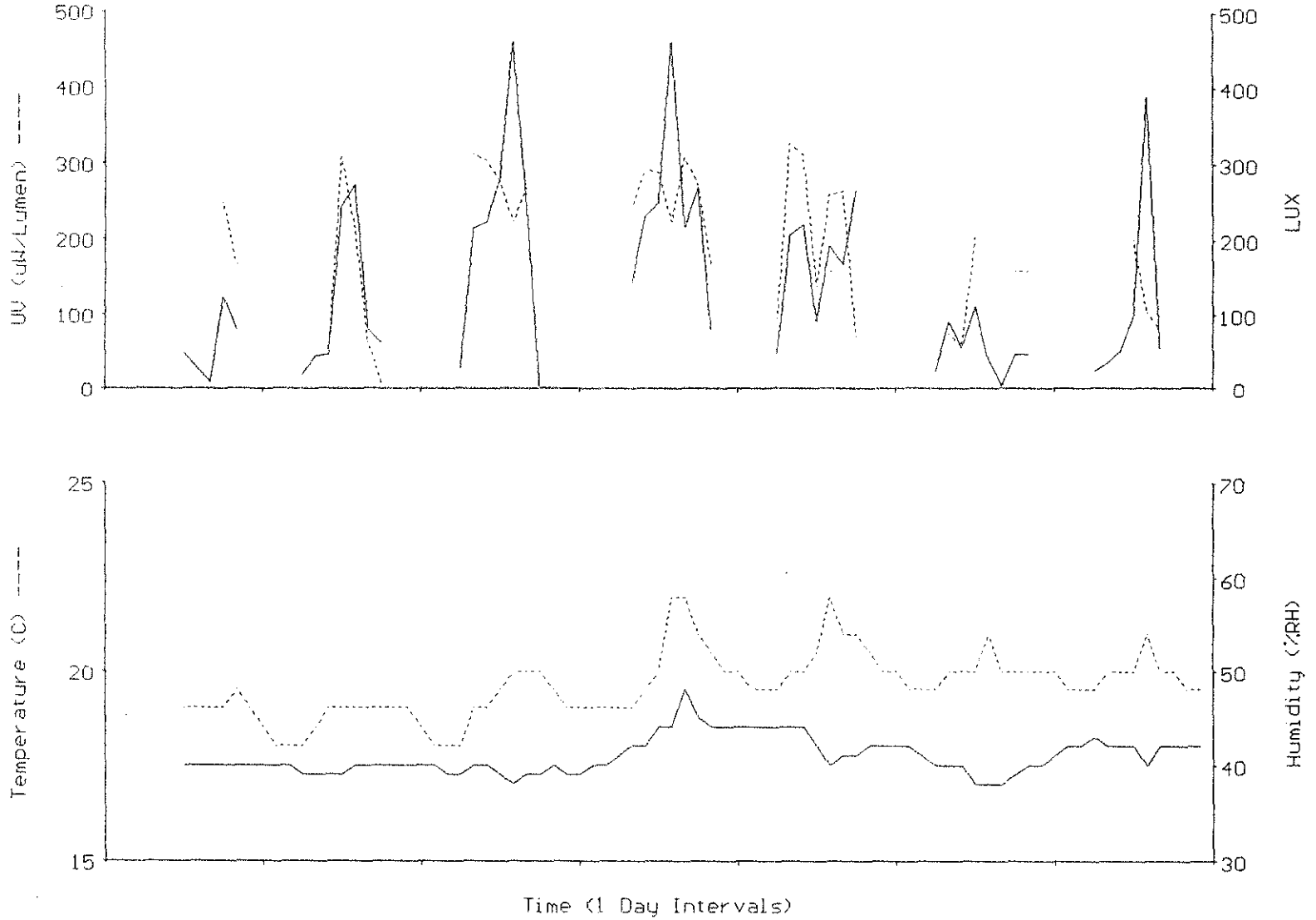
Daniels, Vincent, 1987. The blackening of vermilion by light, in *Recent Advances in the Conservation and Analysis of Artefacts* (Summer Schools Press, London), 280-282

Howard, Helen 1993. Workshop practices and the identification of hands: Gothic wall paintings at St Albans, The Conservator **17**, 34-45

Thomson, Garry 1978. *The Museum Environment* (Butterworths, London), 23


Scale of Feet
10 0 10 20 30 40 50 60 70 80 90 100
LAY CEMETERY
SITE OF TOWER
SITE OF CHAPEL OF ST ANDREW
NORTH TRANSEPT
St William
Crucifixion
NAVE
VESTRY
SITE OF PULPITUM
CHOIR
PRESBYTERY
LADY CHAPEL
SITE OF TOWER
SOUTH TRANSEPT
MONKS' CEMETERY
SITE OF CLOISTER
SITE OF CHAPTER HOUSE
SITE OF DORTER RANGE
11th century
1195 to c 1308
14th century
15th century
16th century
later & Modern
Destroyed 11th century work
Destroyed 14th or 15th century work
A Watching Chamber
B Shrine & Alt. Altar of St. Alban
C Shrine of St. Amphibalus
D Chapel of the Transfiguration (site of)
E Chapel of Wheathampstead
F Chantry Chapel of Abbot Ramryge (site of)
G Chantry Chapel of Abbot Wallingford
H Chantry Chapel of Humphrey of Gloucester

NAVE PILLAR



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HANWELL MONITORS

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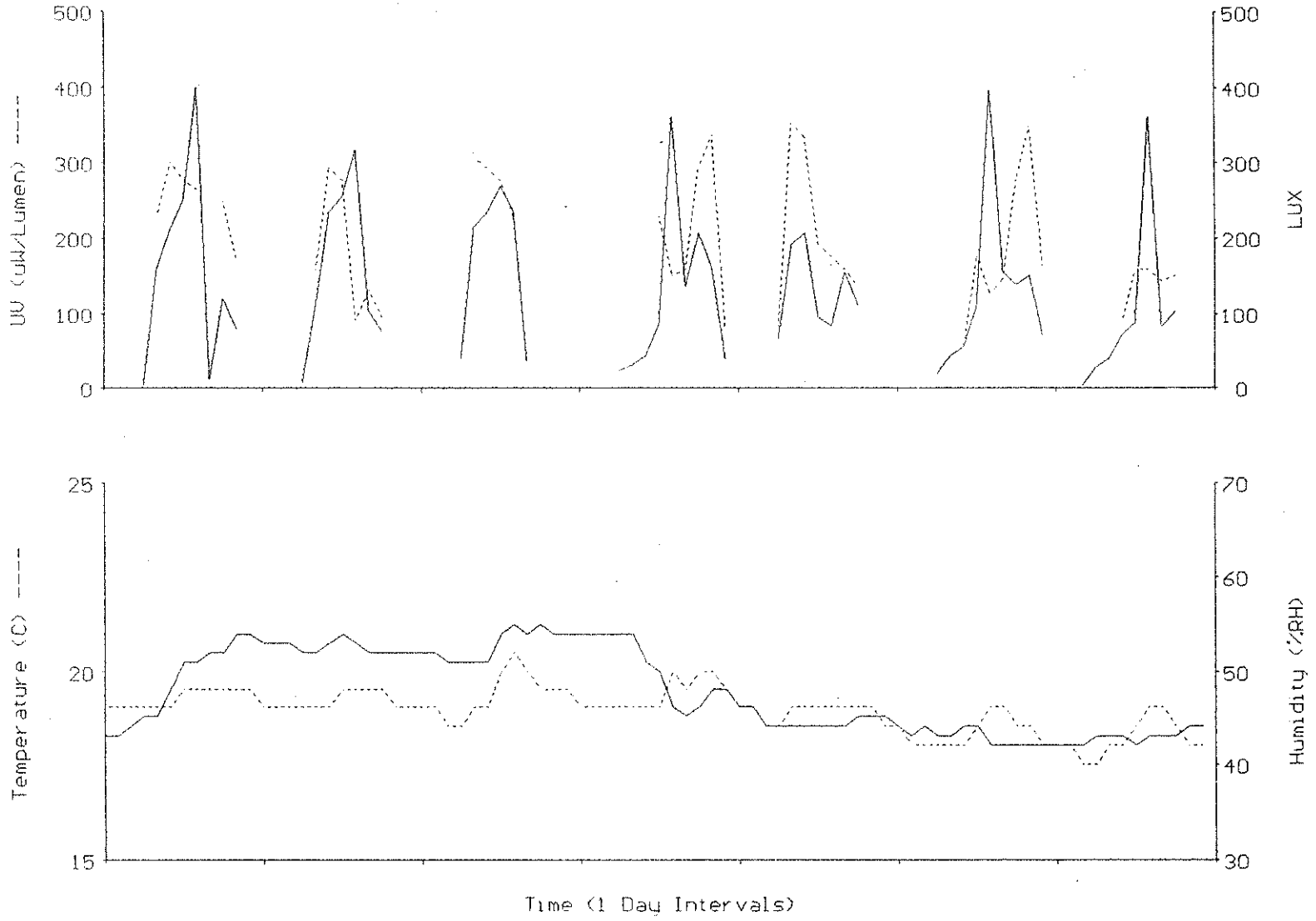

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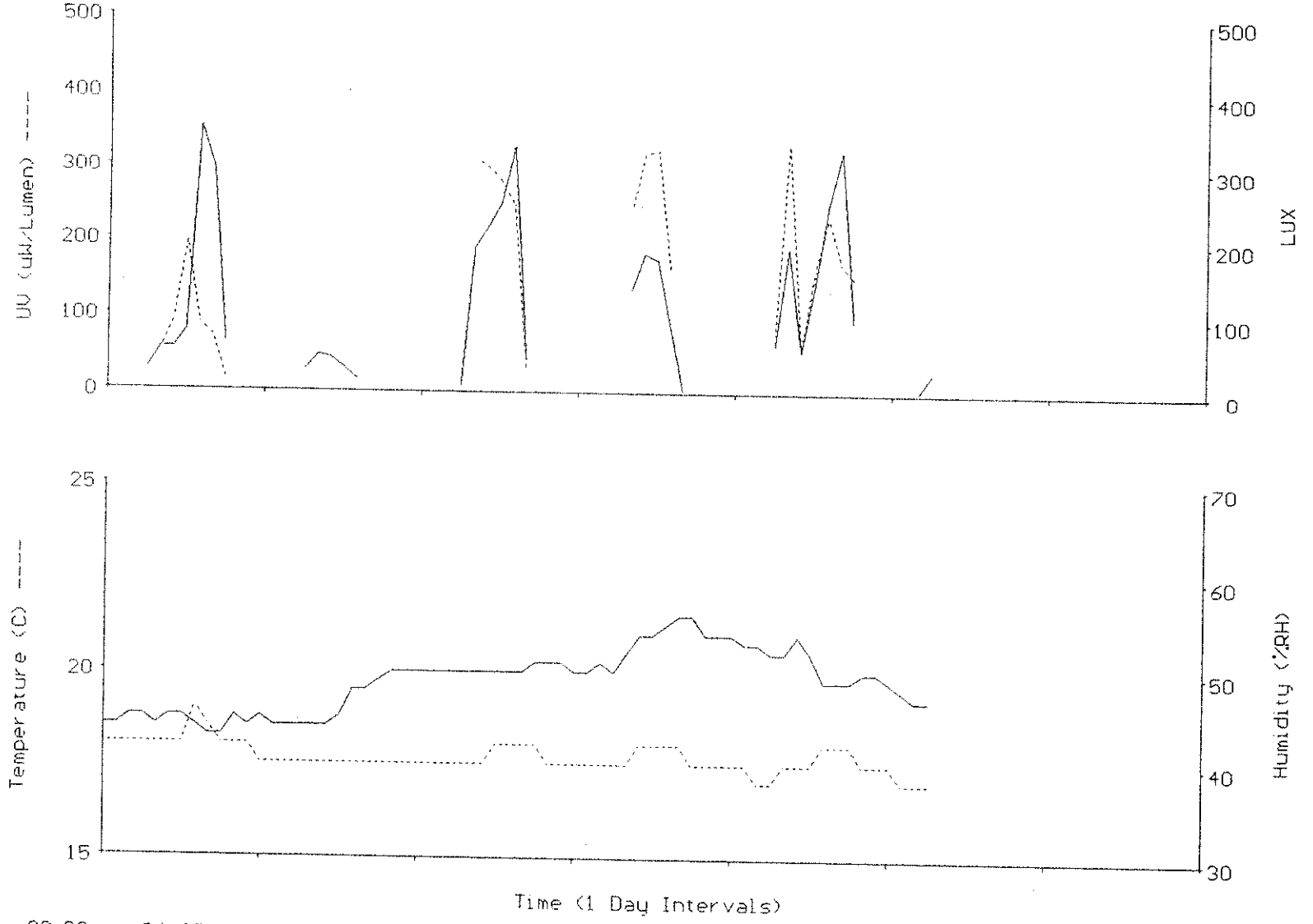

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Graph 3 of 3

HANWELL MONITORS

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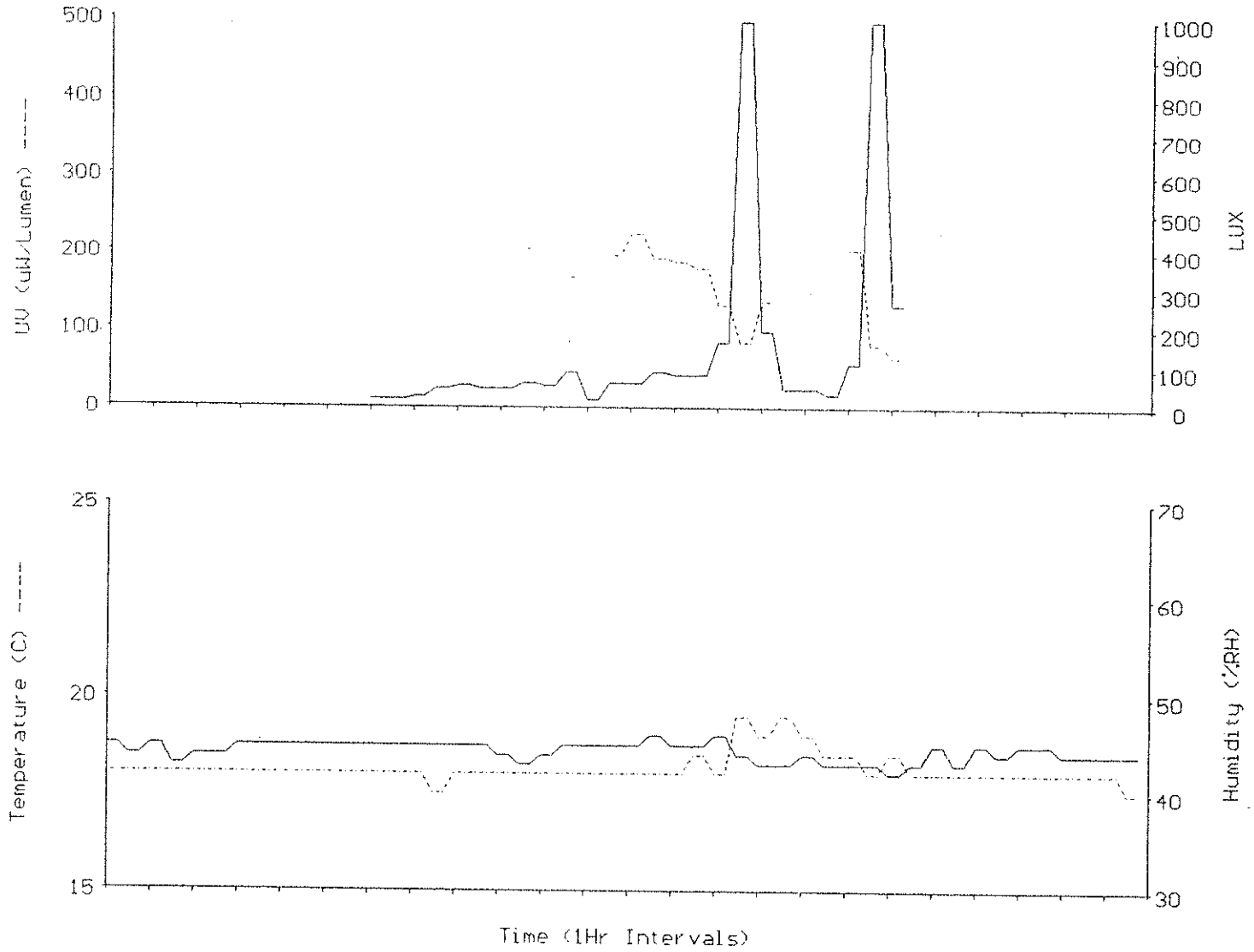

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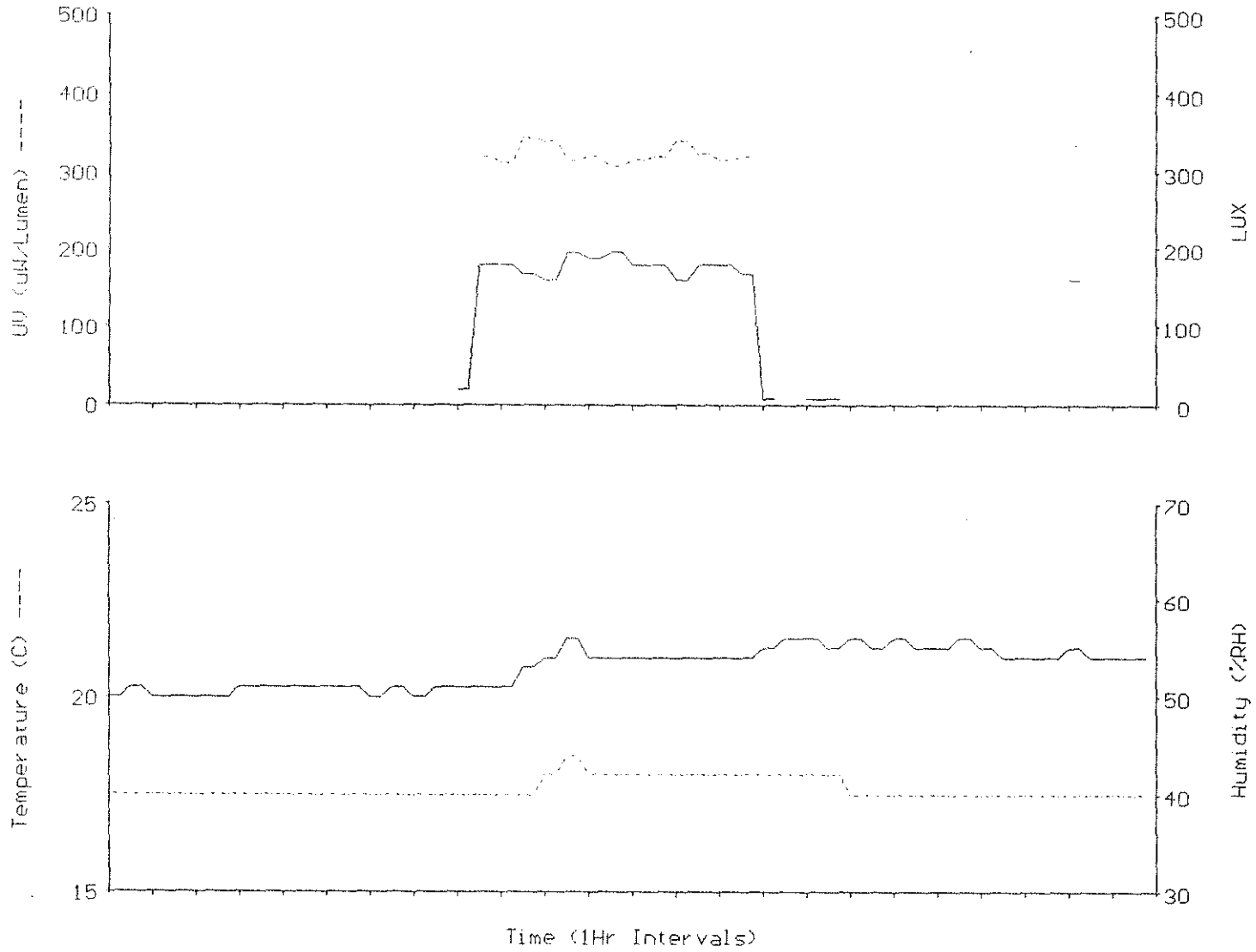

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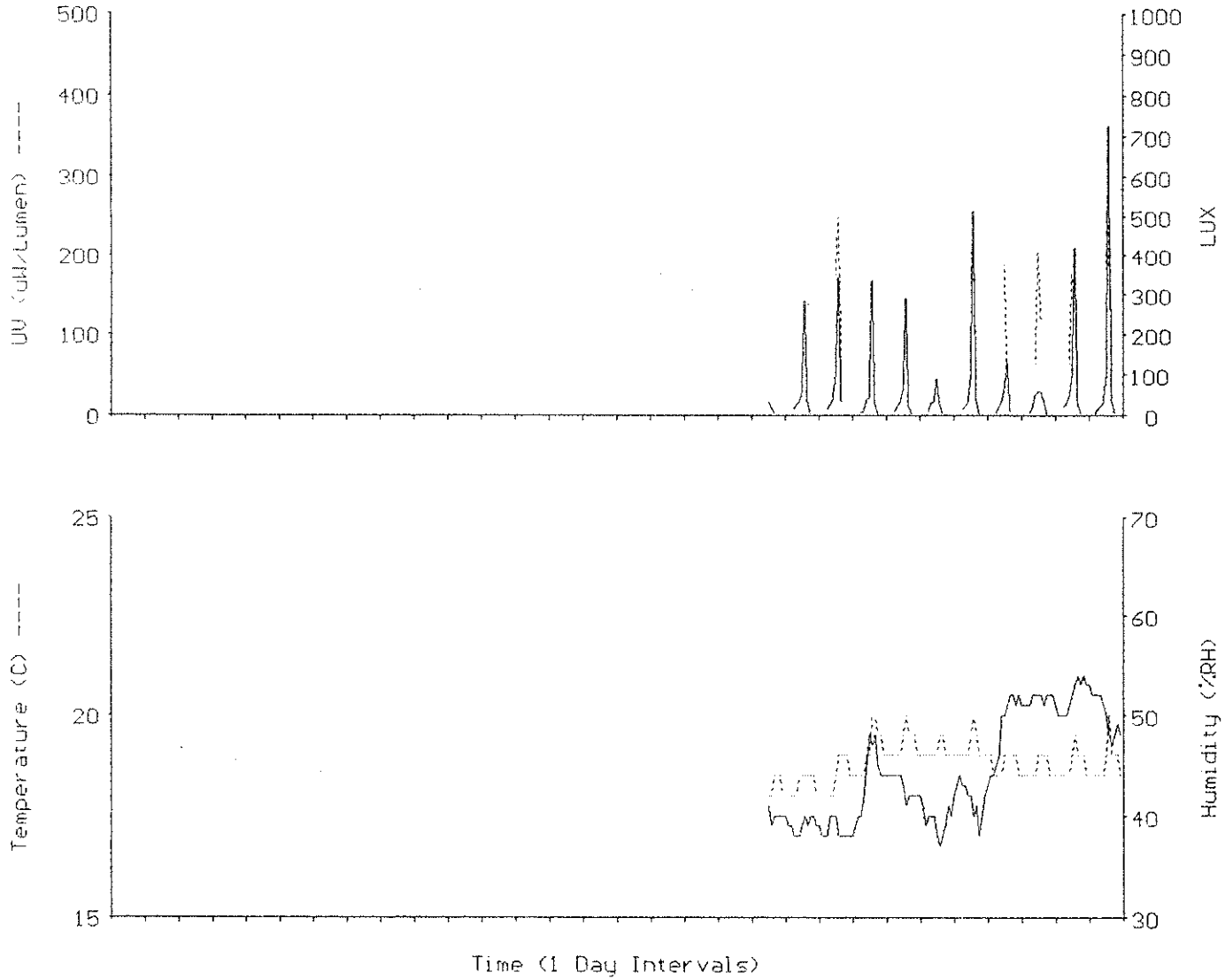
ST WILLIAM



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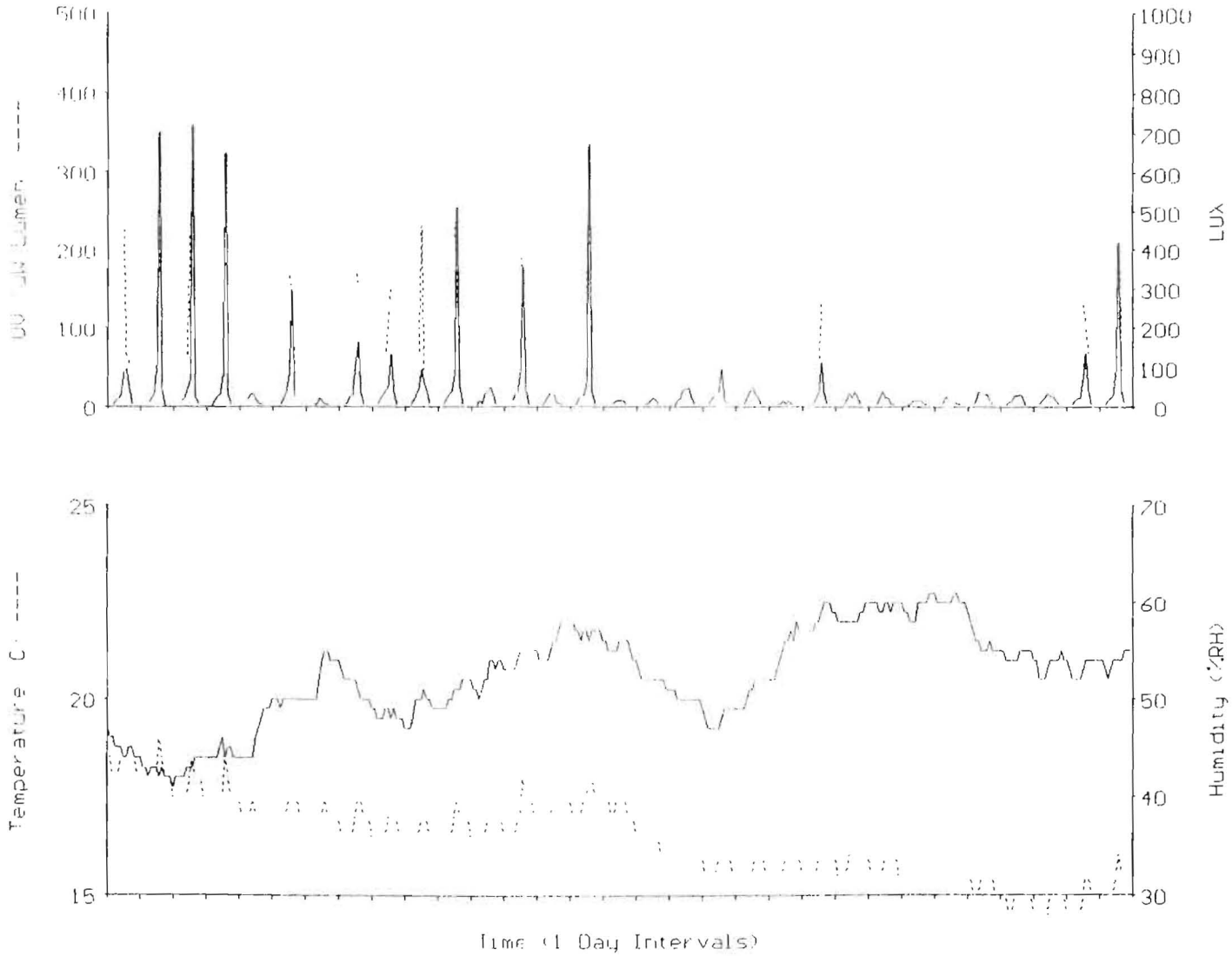

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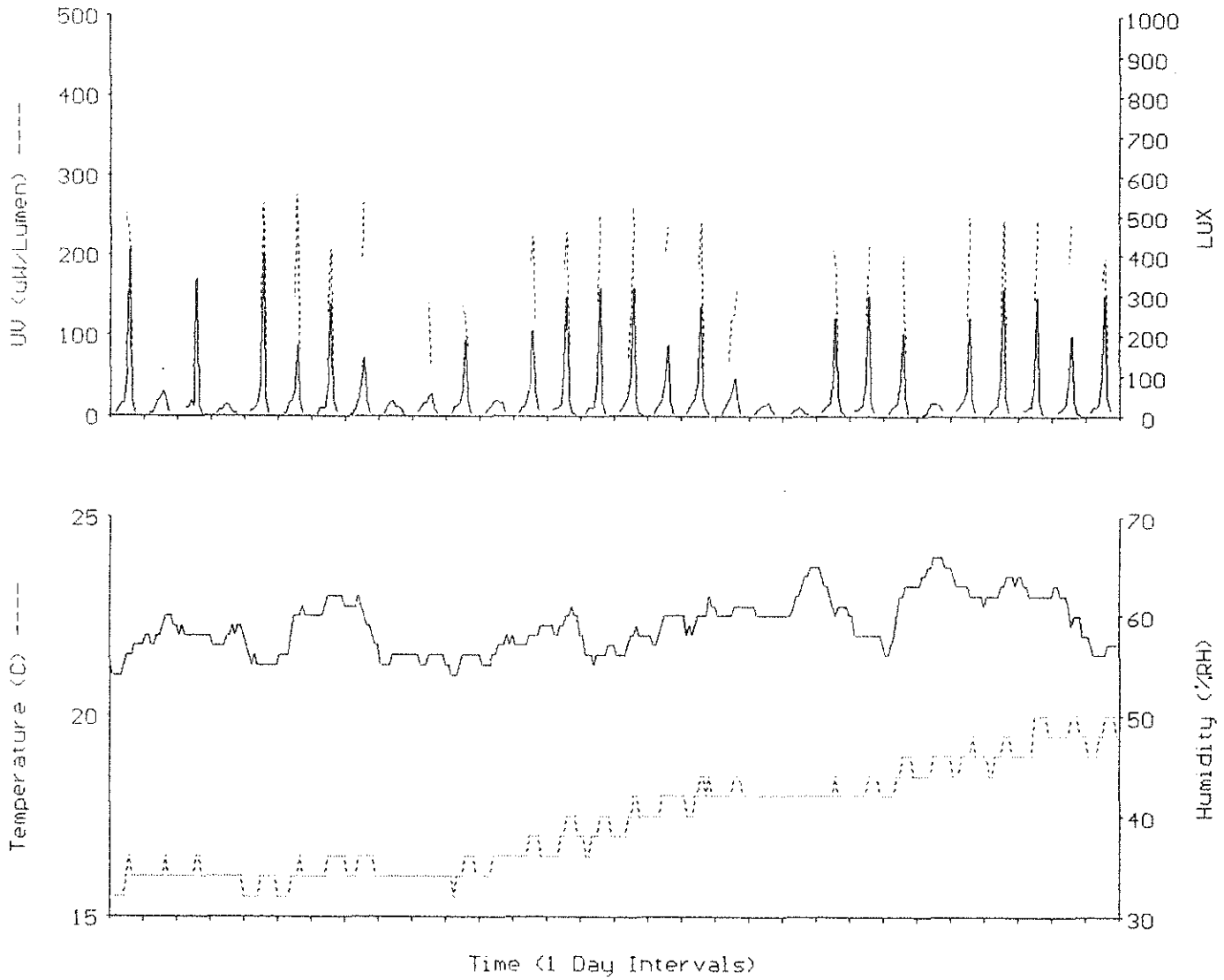

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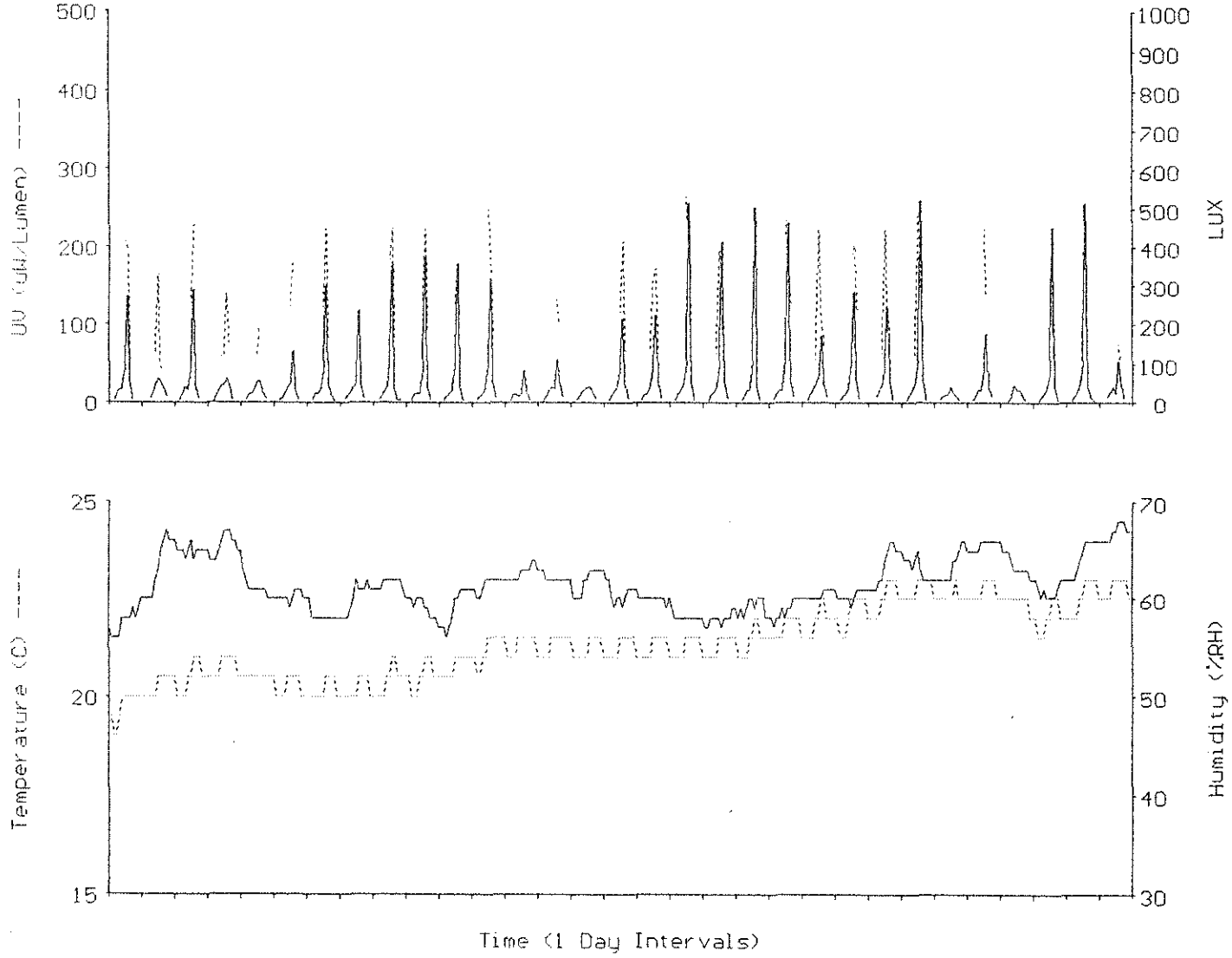

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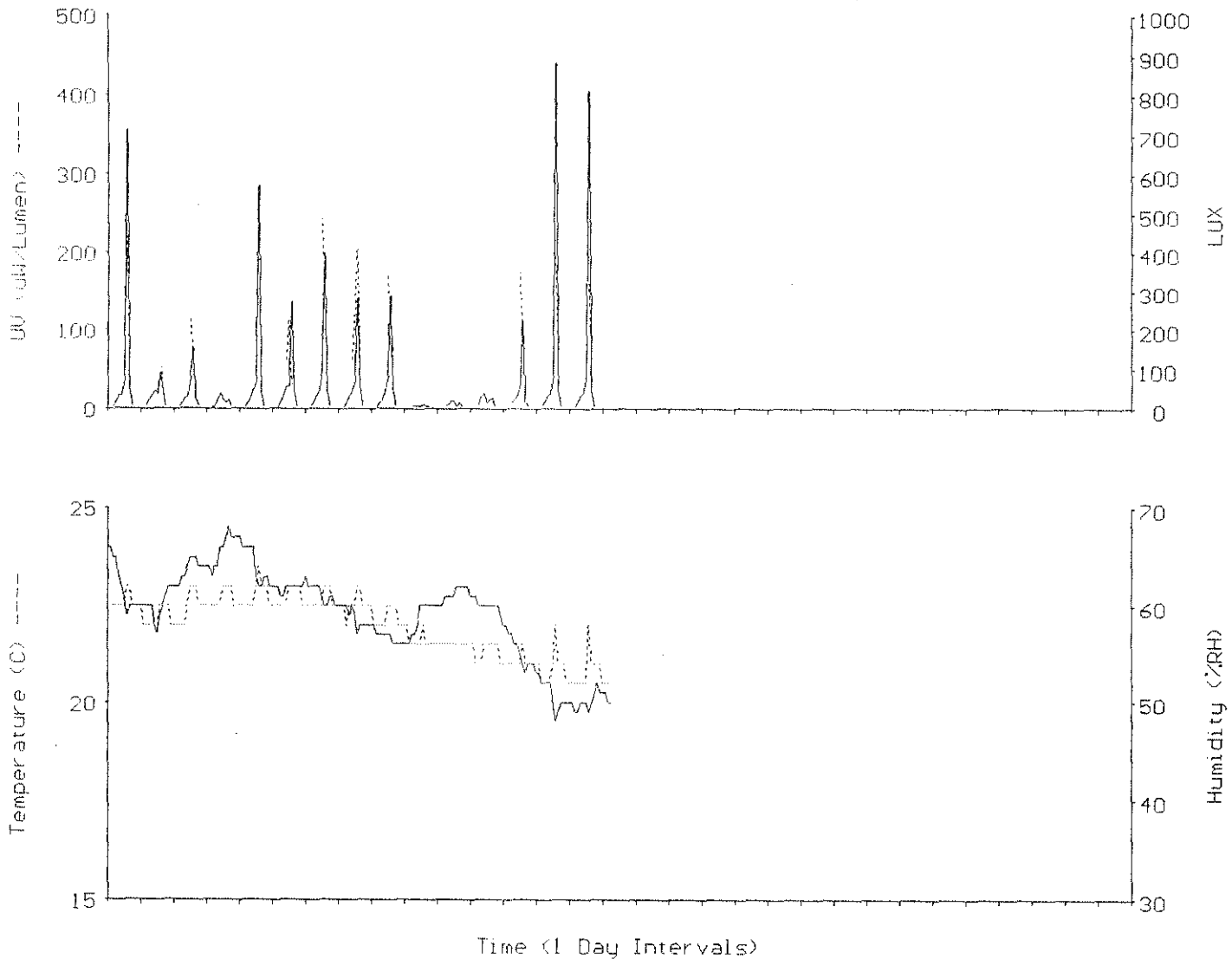

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HANWELL MONITORS

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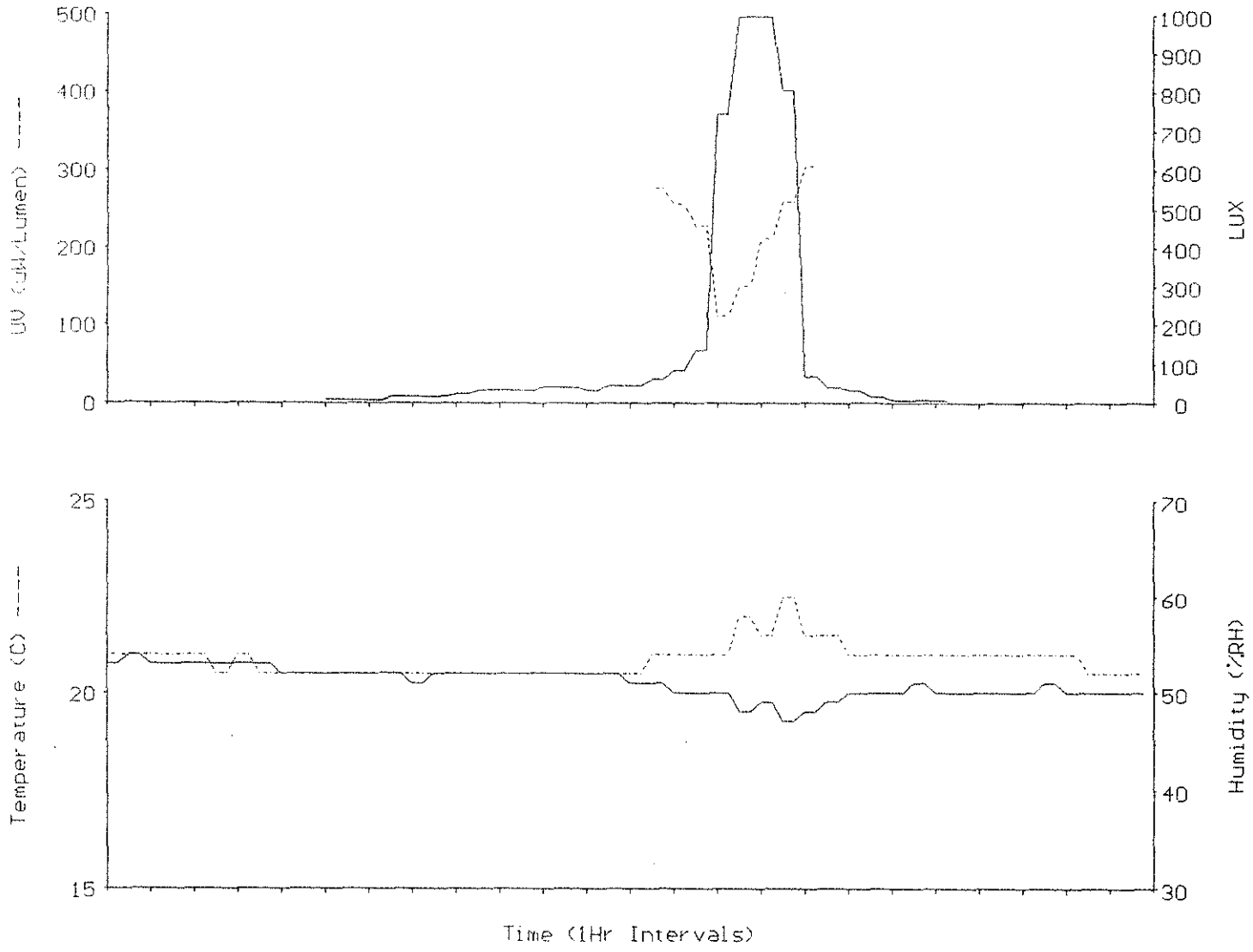

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HANWELL MONITORS