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THE TIME HISTORY OF SOLAR RADIATION AND HEAT FLUX, KOOTENAY LAKE 1976 - 1978

by

P. F. Hamblin

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August 1979

LIST OF FIGURES

1. INTRODUCTION

In this report the radiation data collected during the study of Kootenay Lake, 1976 to 1978 is summarized. The solar radiation data represent direct readings of field instrumentation while the total heat flux is derived from surface meteorological data in conjunction with the downward radiation and in some cases solar radiation. During the collection of the radiation data frequent and large gaps in the continuity of the radiation data were experienced. This report details the methods of data interpolation employed to reconstruct the missing data.

Results of the measurement program in Kootenay Lake are summarized in a graphical form which is considered to be most convenient for users.

2. INSTRUMENTATION AND DATA RECORDING

Two standard floating meteorological stations were established during the study period in open lake positions (Figure 1), at which wind speed and direction, air and water temperatures, and relative humidity were recorded at 10 minute intervals. The solar radiation was measured by means of a pyranometer which measured global radiation (downward direct and diffuse solar radiation as received on a horizontal surface from a solid angle of 2π) at a shore location in the west arm of the lake. Beside the pyranometer a pyrradiometer (Latimer, 1974) measured downward radiation (the sum of downward solar and downward atmospheric radiation).

Outputs from the two radiation instruments were recorded on strip charts and then were digitized manually at hourly intervals. The

meteorological data were recorded by a Plessey meteorological recorder (Hymet) in a digital format on one quarter inch magnetic tape. The sensor resistances were encoded in a ten-bit serial binary number.

3. DATA REDUCTION AND CORRECTION

a) Solar Radiation

Hourly scaled values were converted to solar radiation in Langleys (cal/cm^2/hr.) by the standard methods. In several instances gaps in solar radiation were as long as 30 days, however, more generally, gaps lasted for several days. In such cases of low data return, ten minute integrations from a recording quantum photometer placed in the close proximity to the solarimeter were used to calculate an hourly average value which in turn was converted to solar radiation by means of the empirically determined scale factor of 0.04337. This factor which converts radiation in units of Einsteins to Langleys was determined by a best linear fit of approximately one month's simulataneous solarimeter and quantum photometer data. In this way a reasonably accurate estimate of solar radiation could be determined for the missing periods.

b) Downward Radiation

The correction of hourly downward radiation data was based upon the concurrently measured solar radiation data and proceeded once the complete time history of solar radiation was prepared. For the purposes of explanation we may distinguish two types of procedures, one, for the estimation of missing downward radiation, and second, for the correction of measured hourly data for instrumental error.

In the case of error correction, the average downward radiation for the six hour period comprising the three hours before local midnight to the three hours after midnight was computed. If values were missing during this period the average was computed from the remaining values. Next, the residual downward radiation was computed by subtracting the average nighttime radiation from the individual values. The resultant residual was compared with the solar radiation and in instances where the residual fell outside plus or minus ten percent of the solar radiation the value of downward radiation was deleted. In its place an estimate was inserted constructed from the sum of the measured solar radiation plus the average nighttime downward radiation.

In the case of missing data we may distinguish two problems, data missing over the entire daily period, and data missing only during the middle part of the day. In the latter case, daily values were estimated according to the above procedure from the measured residual downward and the hourly solar radiation.

Finally, when the instrument failed for an entire day or more, the background downward radiation was estimated by either interpolation from nearby days or in some cases from the appropriate monthly average. It was felt that these methods were superior to more indirect means of establishing the downward radiation and have lead to both a continuous time series and to downward total radiation readings with a reasonable degree of accuracy (±10%, W. Schertzer, per comm.). A similar technique was employed in the analysis of radiation data collected during the International Field Year on the Great Lakes

(Latimer, 1974).

c) Surface Heat Flux

For the purposes of calculation of the surface heat flux when the two meteorological floats were operational a simple average of meteorological quantities was formed on an hourly basis. When either of the stations failed, the remaining station represented the meteorological field. There were only several days during the experimental period when neither station was operational. In this case there was no attempt to interpolate the meteorological data.

The calculation of the rate of heat, ΔQ, exchanged per unit area per hour across the air-water interface is similar to that described by Ng (1976).

$$\Delta Q = Q_s - Q_r - Q_b - Q_e - Q_h$$

where Q_s is the measured downward radiation;

Q_r is the total reflected solar radiation;

Q_b is the outgoing longwave radiation;

Q_e is the latent heat; and

Q_h is the sensible heat.

Q_s has been discussed in part (b)

Because of the small contribution to the surface heat flux of reflected solar radiation Q_r was not taken into account in the calculations.

Q_b the outgoing longwave radiation was calculated from the Stefan Boltzman fourth power radiation law.

$$Q_b = 4.8736\ 10^{-9}(T_w + 273.0)^4$$

where the emissivity, ε, is taken as unity.

The latent heat, Q_e, was calculated according to the relation

$$Q_e = E*L$$

where the latent heat, L

$$L = 596.0 - 0.52 * T_a,$$

where T_a is the air temperature in ^oC, and the evaporation, E (cm/hr).

$$E = V * (e_w - e_a) * 4.66 \times 10^{-4}$$

where V is the hourly average of the 10 minute scalar wind speeds (m/s), e_w is the saturated surface water vapour pressure and e_a is the air vapour pressure (m bar)

$$e_a = F_n\ (T_a * 10., SAT) * RH/100\ (m\ bar)$$

where RH is the relative humidity and the functions, Fn and the saturation, SAT, were supplied from standard tables. The sensible heat flux, Q_h, was given by

$$Q_h = Q_e \times B$$

where B is the Bowen ratio defined from $0.62 \times (T_w - T_a)/(e_w - e_a)$ where T_w is the water surface temperature. Note that the sensible heat is available as well from a mass transfer formula, but was not used in the final computation of surface heat flux.

4. DATA DISPLAY

The heat flux and solar radiation were plotted as hourly and

daily time histories for the convenience of the user. Finally, a monthly average of each radiation field is presented on an hourly basis. In all cases, times are specified in Greenwich mean time.

The effects of heat gain and loss, the absorption of solar radiation on the heat budget and thermal structure of Kootenay Lake are currently being investigated.

ACKNOWLEDGEMENTS

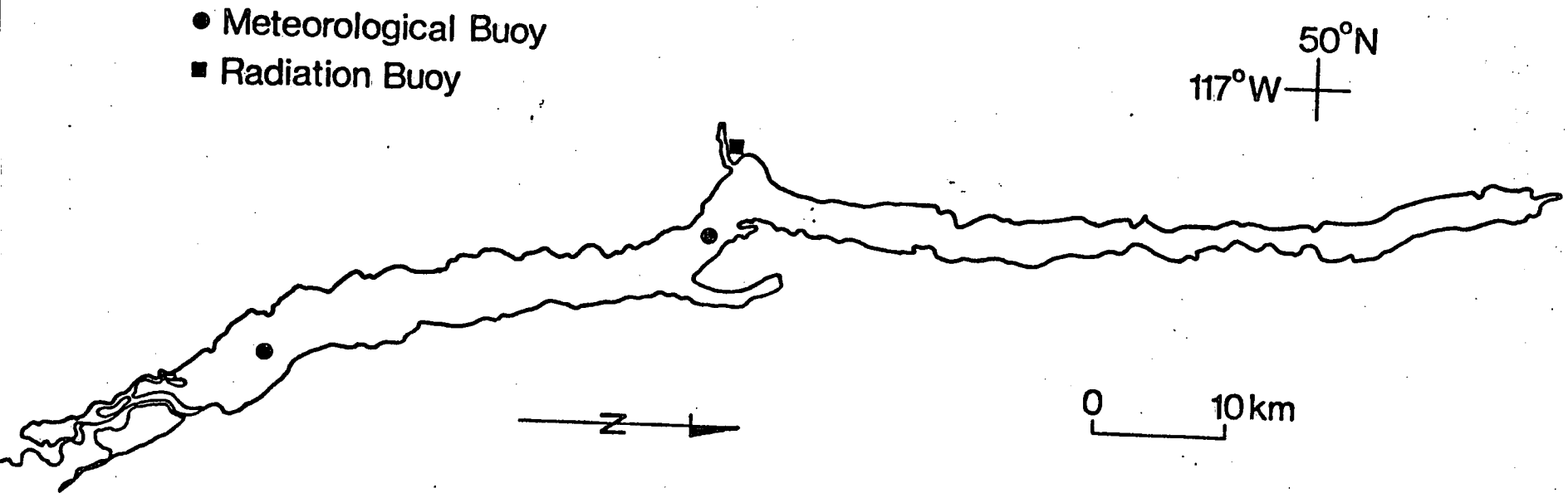
The assistance of W. Nagel, J. Dowell, A. Zingaro, R. Freeman, and J. Hodson in Computer Programming is gratefully acknowledged. W. Schertzer is thanked for his advice on the reduction of the data and S. Jasper for providing the quantum photometer data.

REFERENCES

Latimer, J.R. 1974. Radiation measurement. I.F.Y.G.L. Tech Manual No. 2, NRC Canada.

Ng, H.Y.F. 1976. The winds and the time history of heat flux of Kamloops Lake, British Columbia. Unpublished report, CCIW.

Figure 1



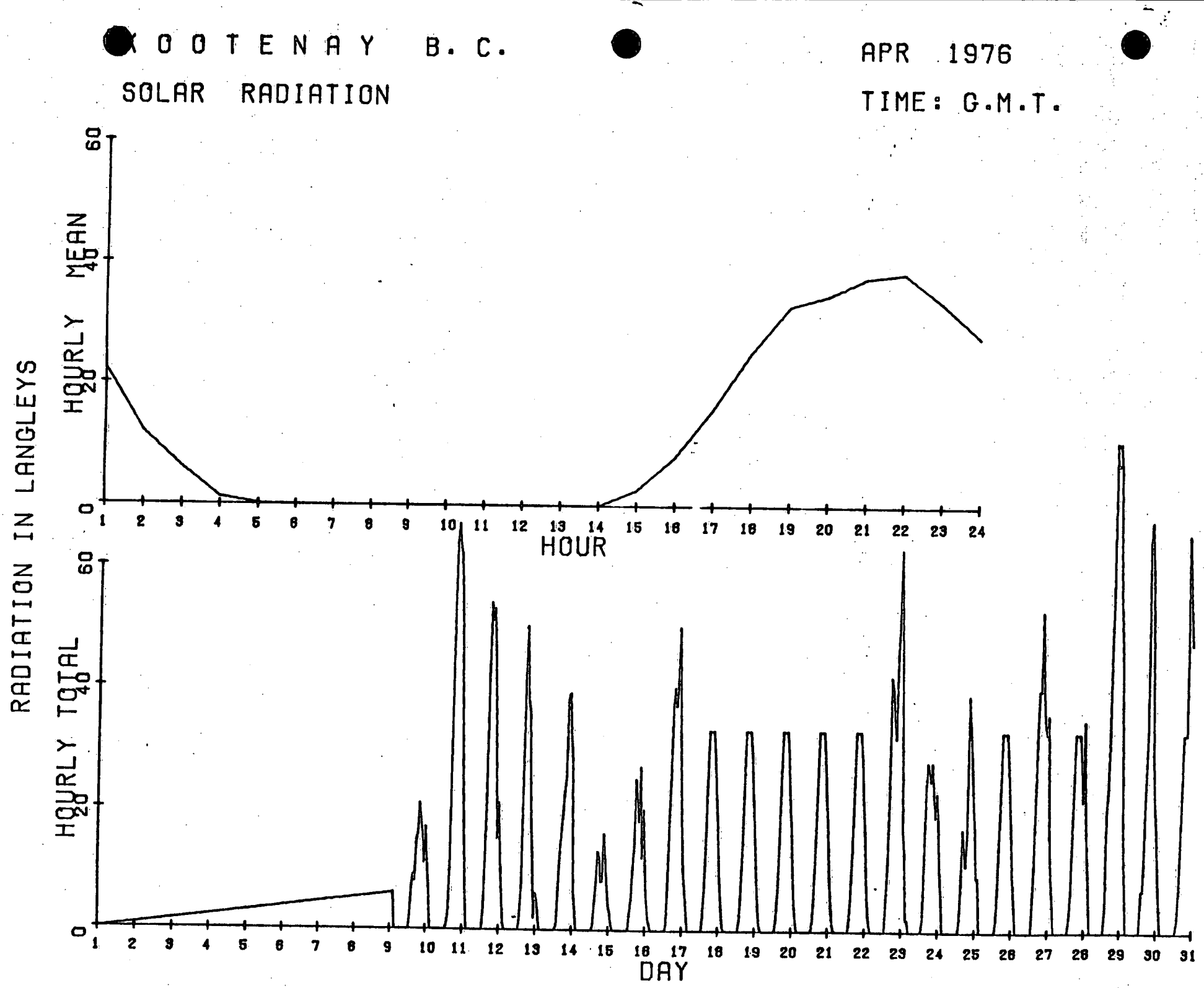

KOOTENAY B. C.
APR 1976
SOLAR RADIATION
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 2

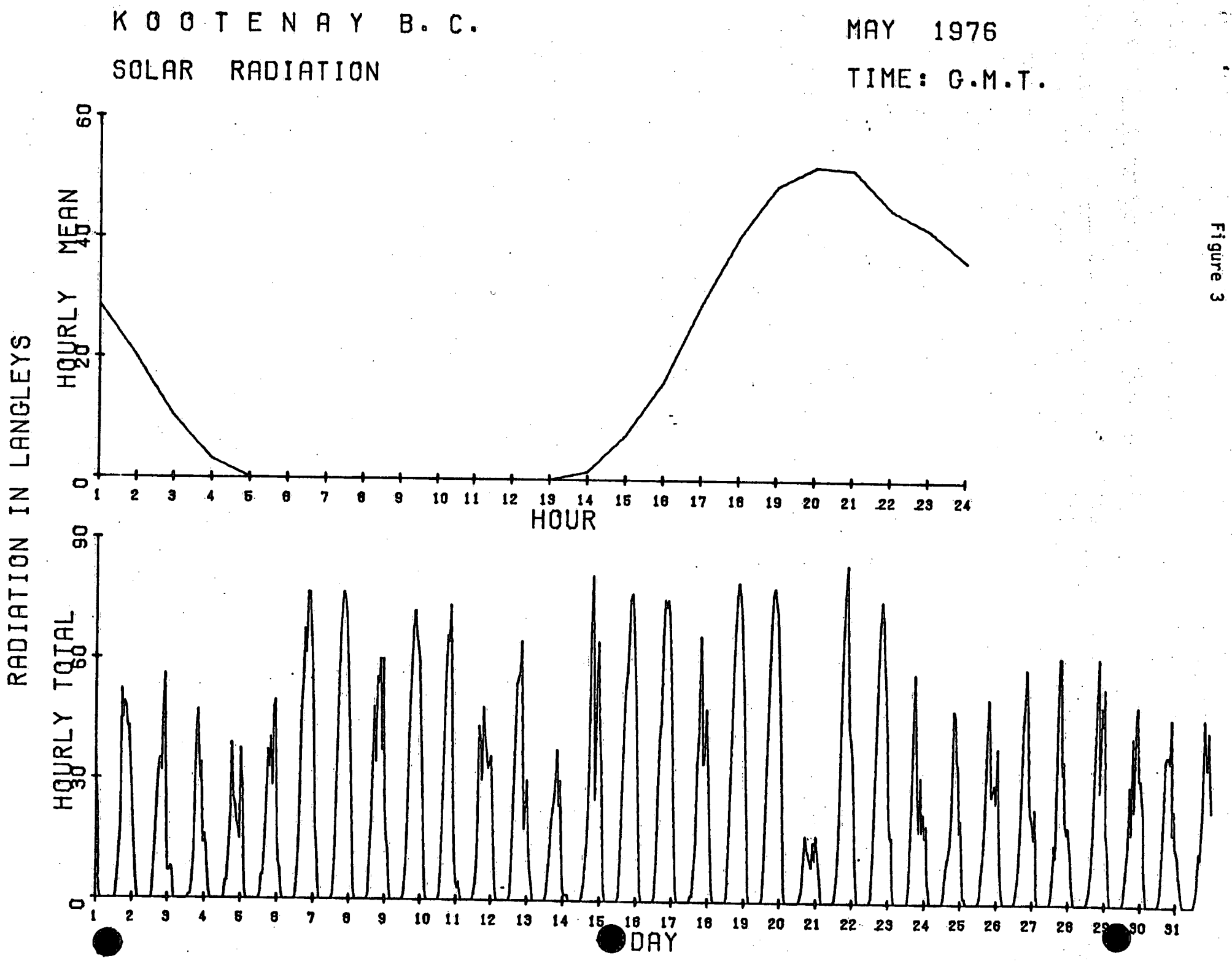

KOOTENAY B.C.
SOLAR RADIATION
MAY 1976
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 3

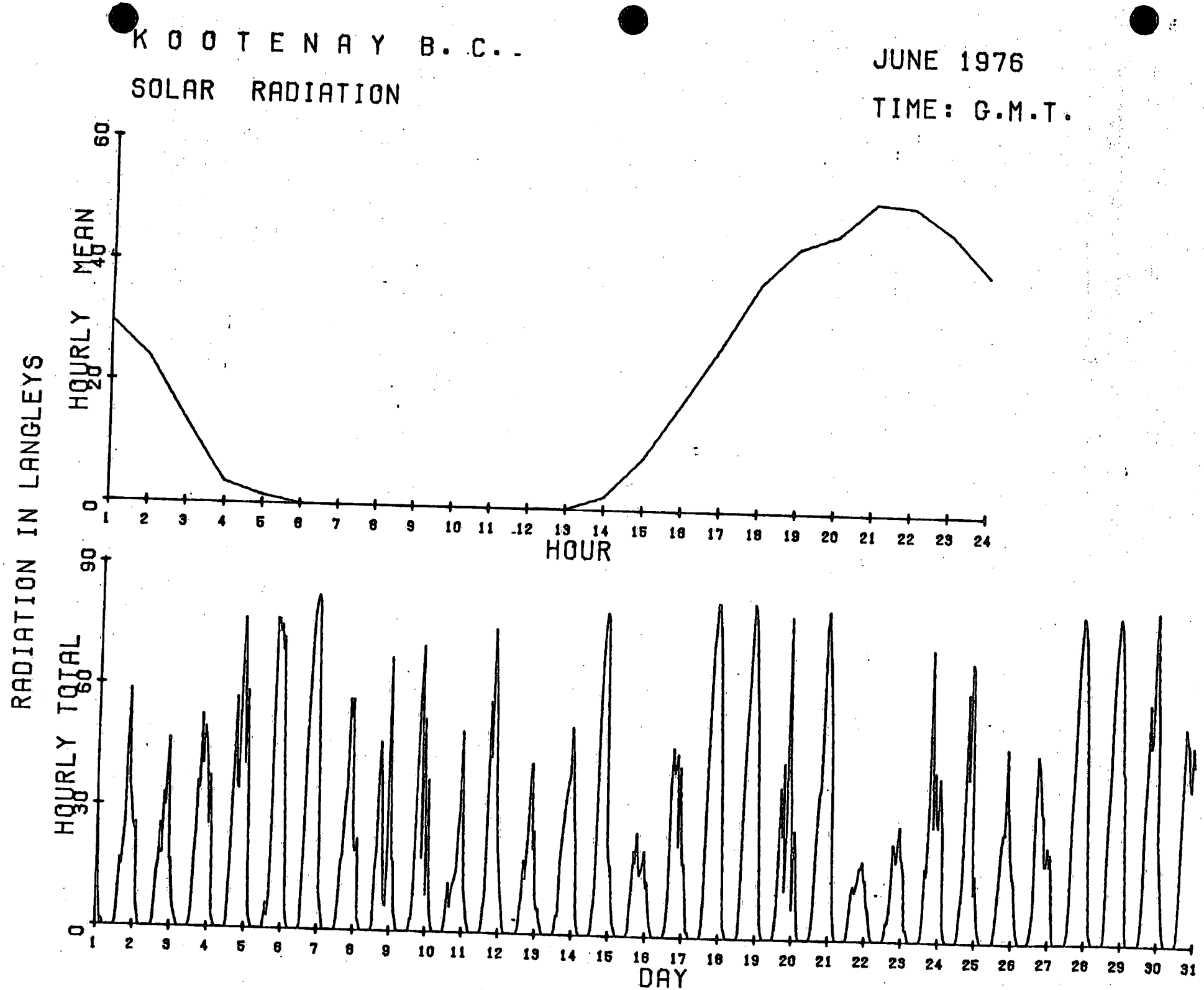
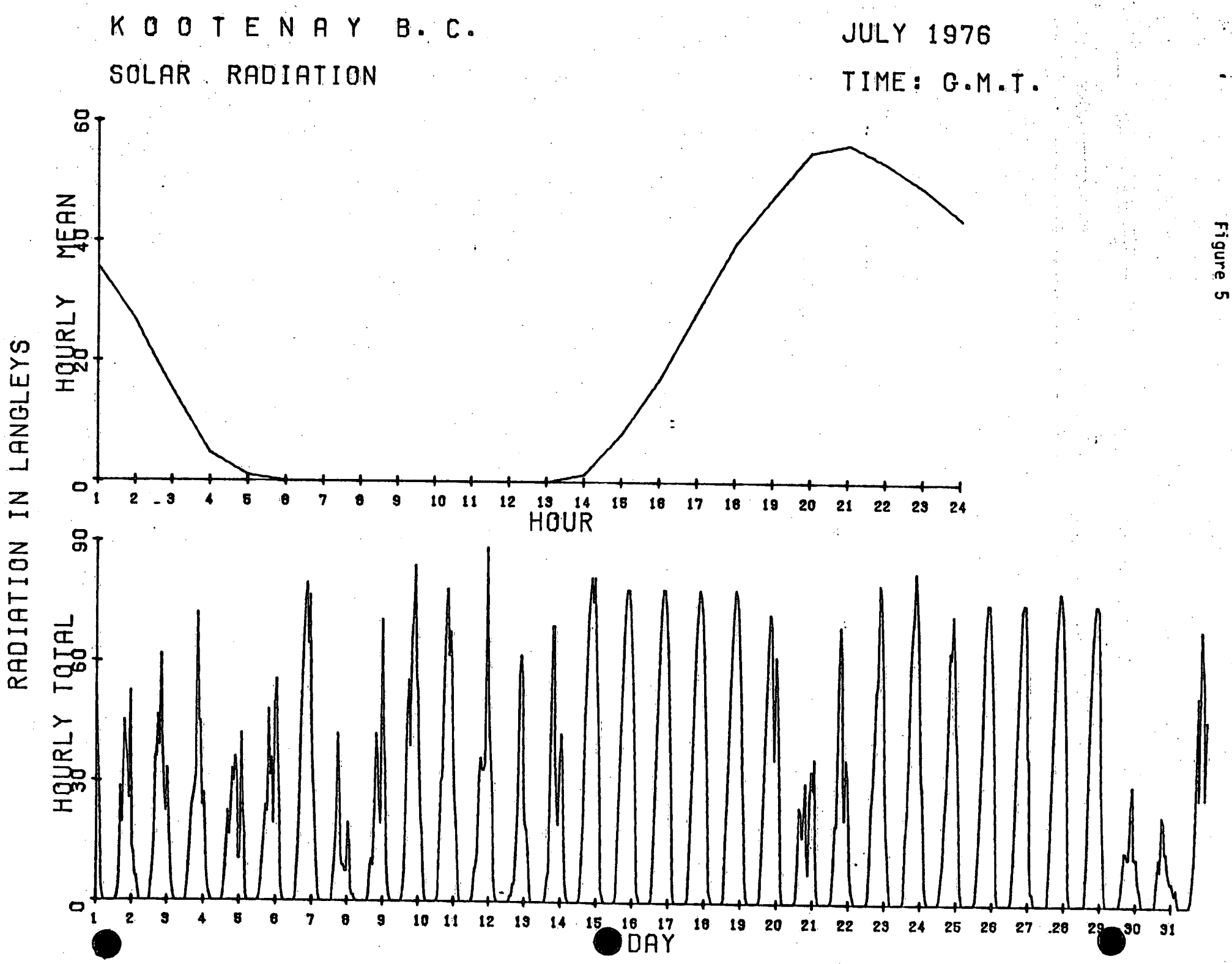

KOOTENAY B.C.
SOLAR RADIATION
JUNE 1976
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 4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SOLAR RADIATION
JULY 1976
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 5

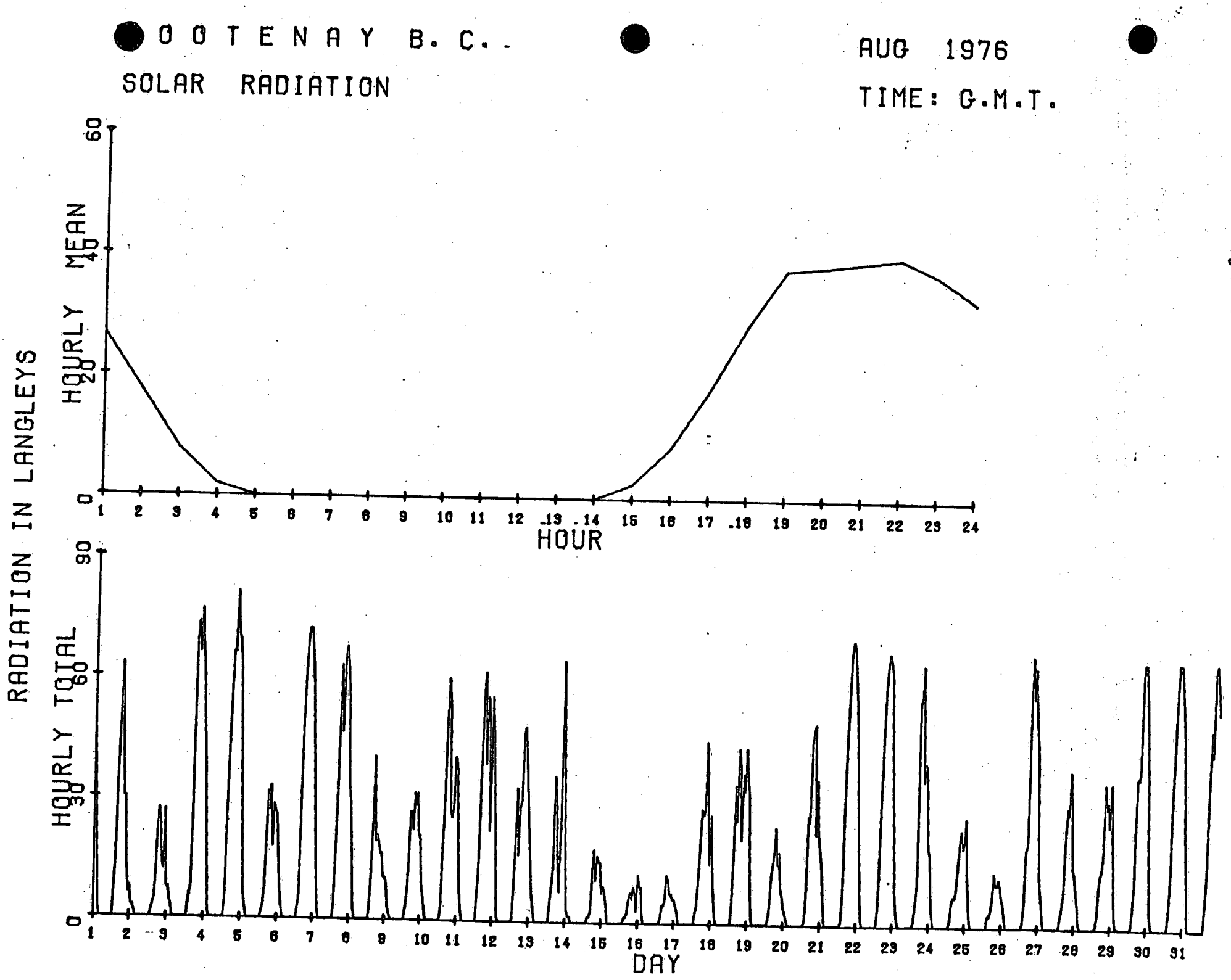
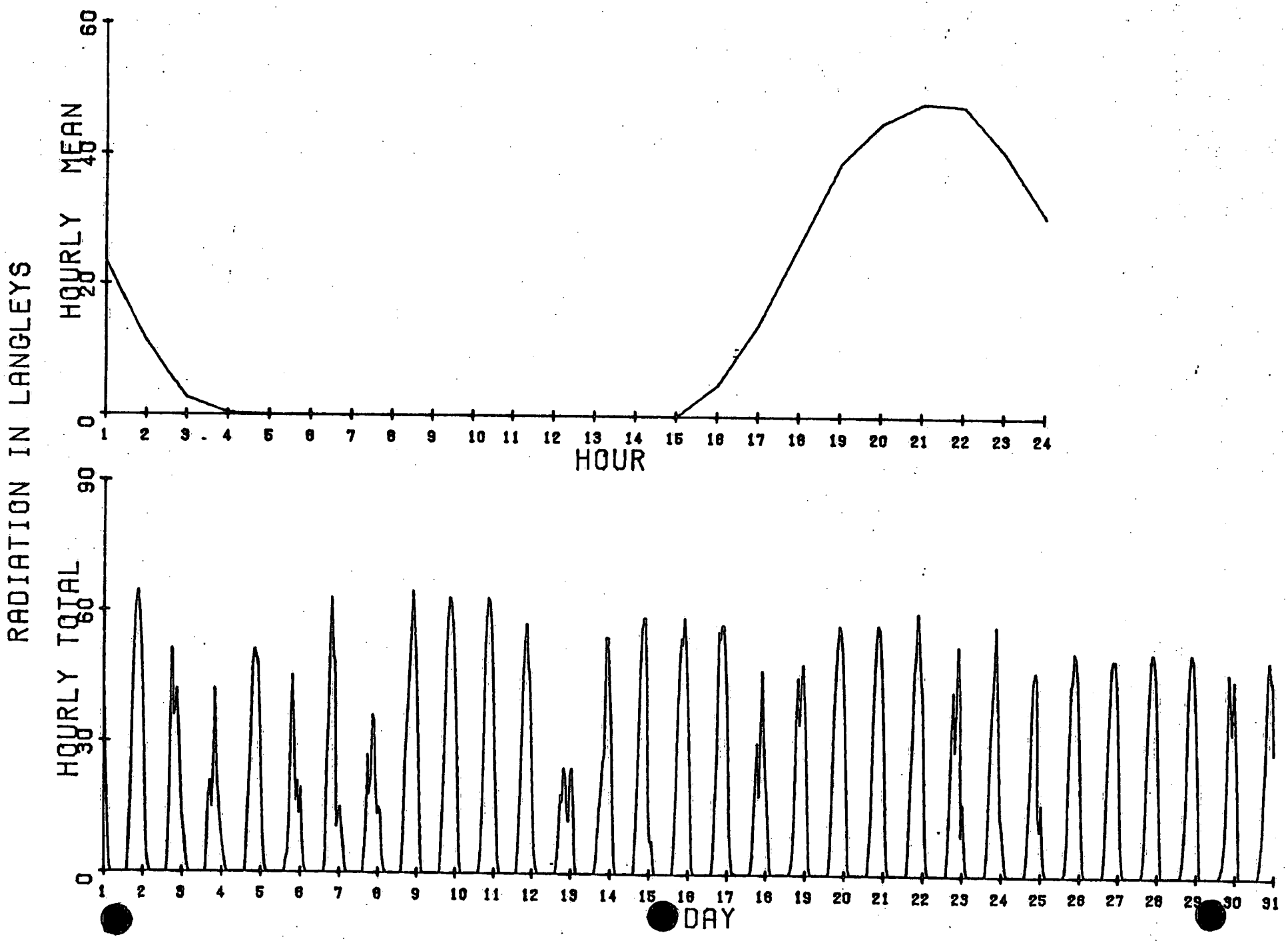

OOTENAY B. C.
AUG 1976
SOLAR RADIATION
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 6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SOLAR RADIATION
SEPT 1976
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 7

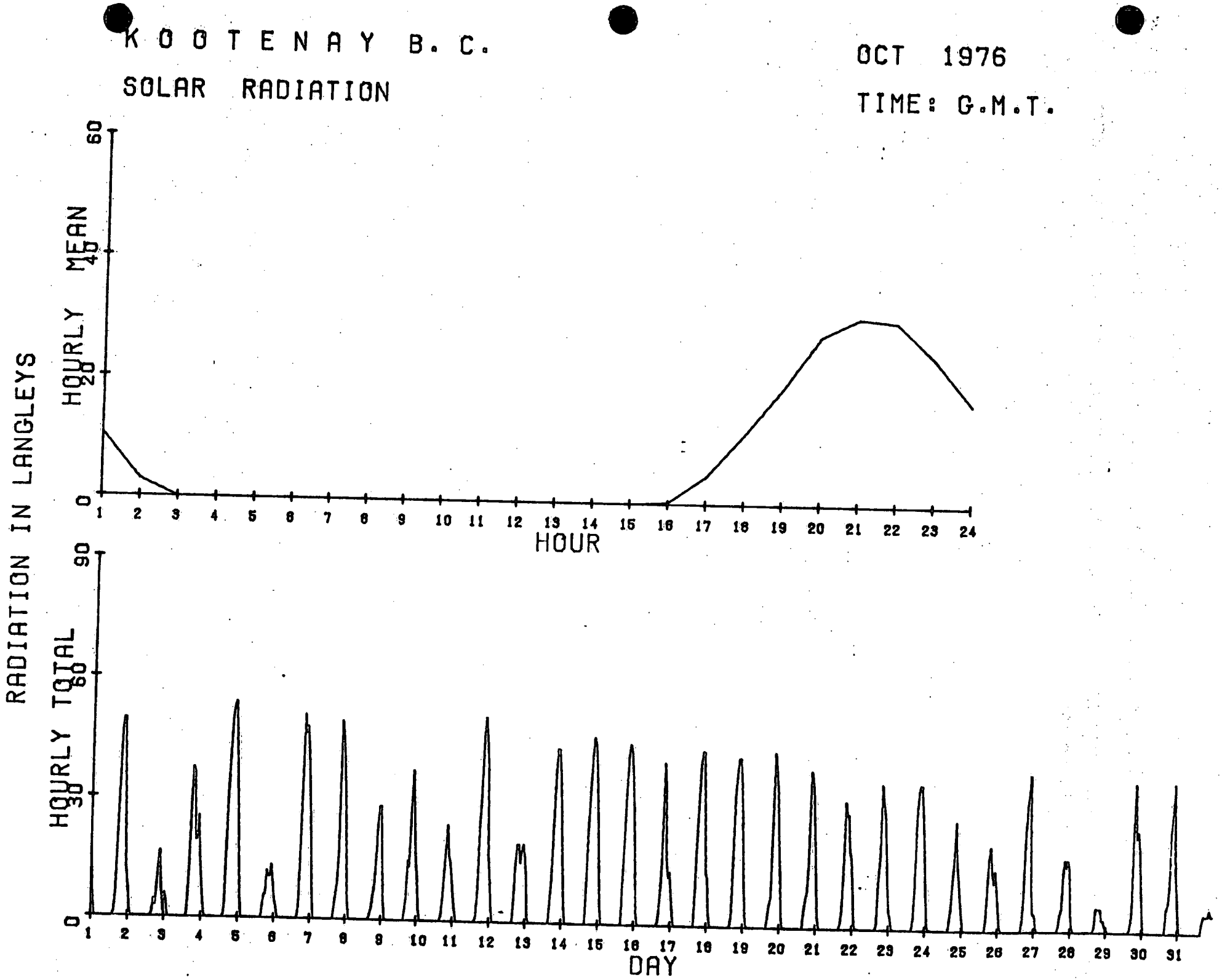

KOOTENAY B. C.
SOLAR RADIATION
OCT 1976
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 8

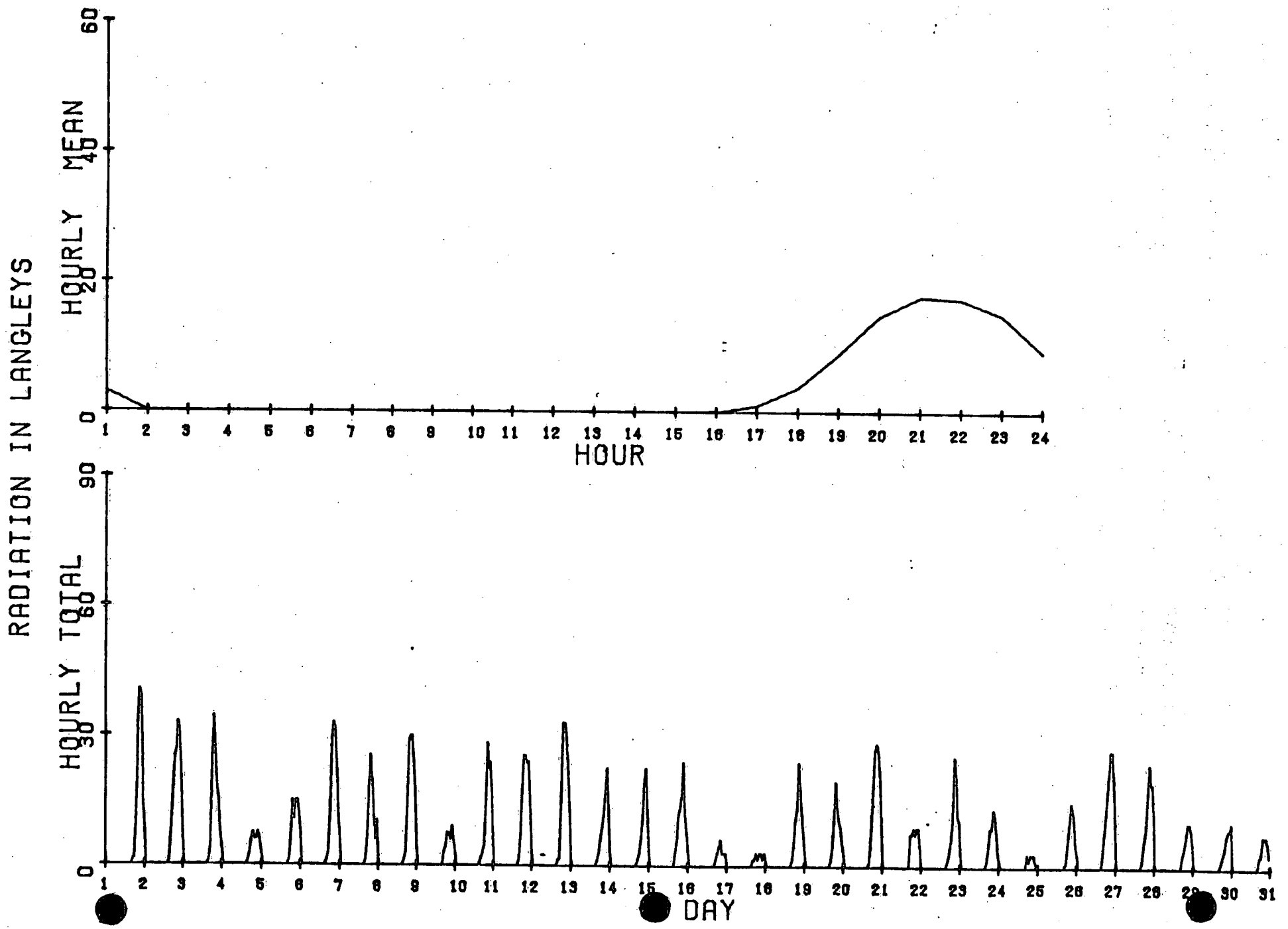

KOOTENAY B. C.
SOLAR RADIATION
NOV 1976
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

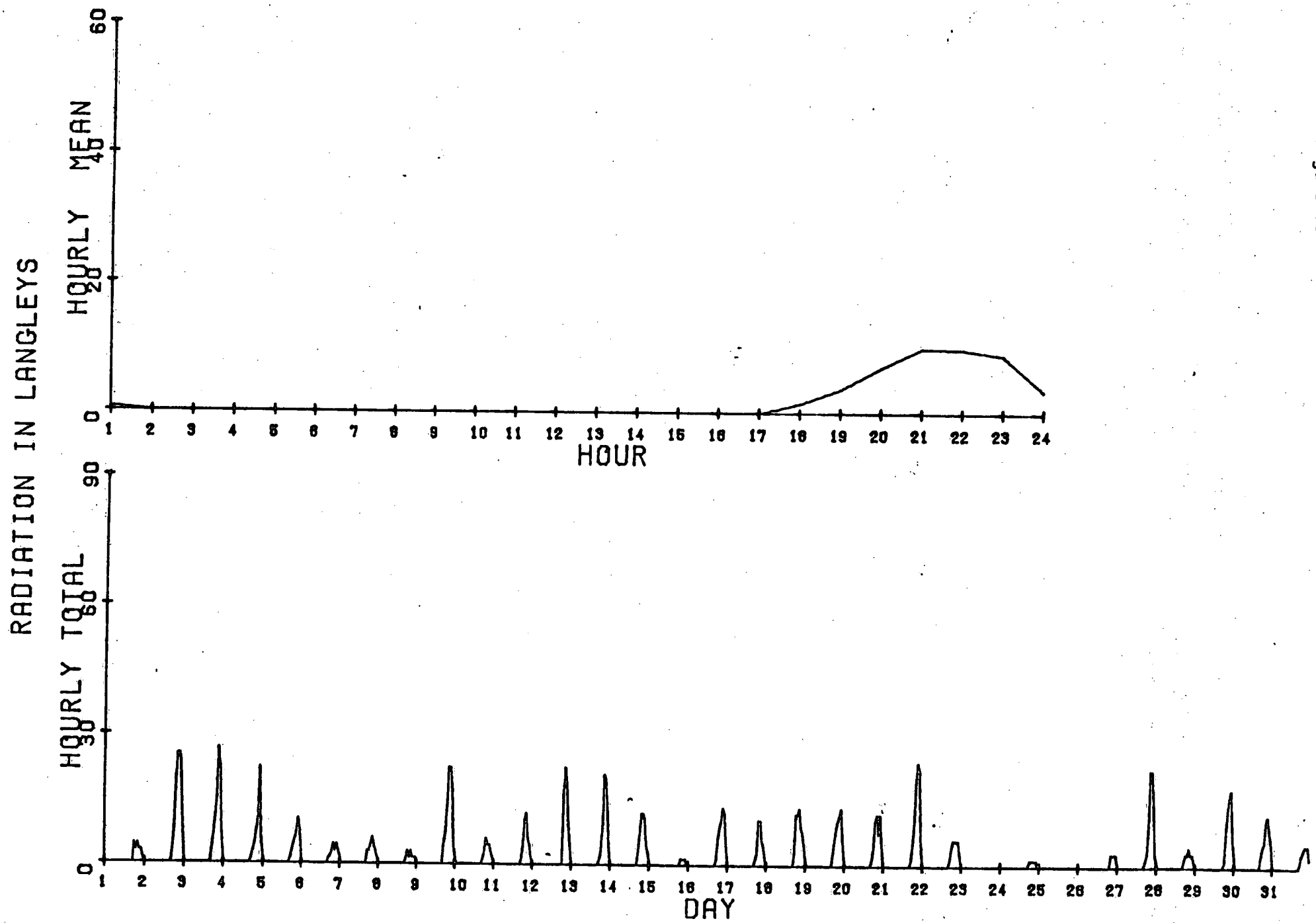
Figure 9

KOOTENAY B. C.

DEC 1976

SOLAR RADIATION

TIME: G.M.T.



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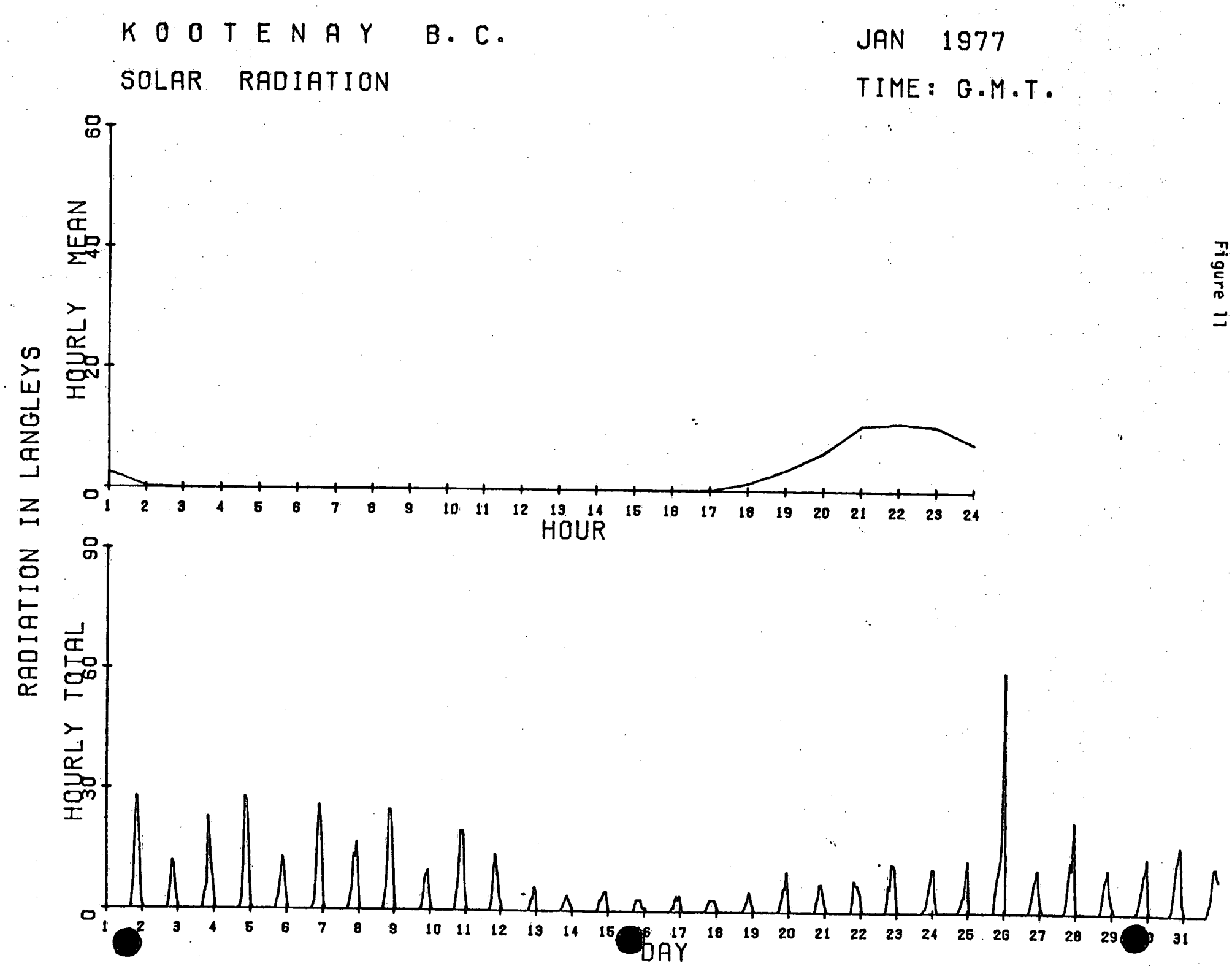

KOOTENAY B.C.
SOLAR RADIATION
JAN 1977
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 11

KOOTENAY B. C.

SOLAR RADIATION

FEB 1977

TIME: G.M.T.

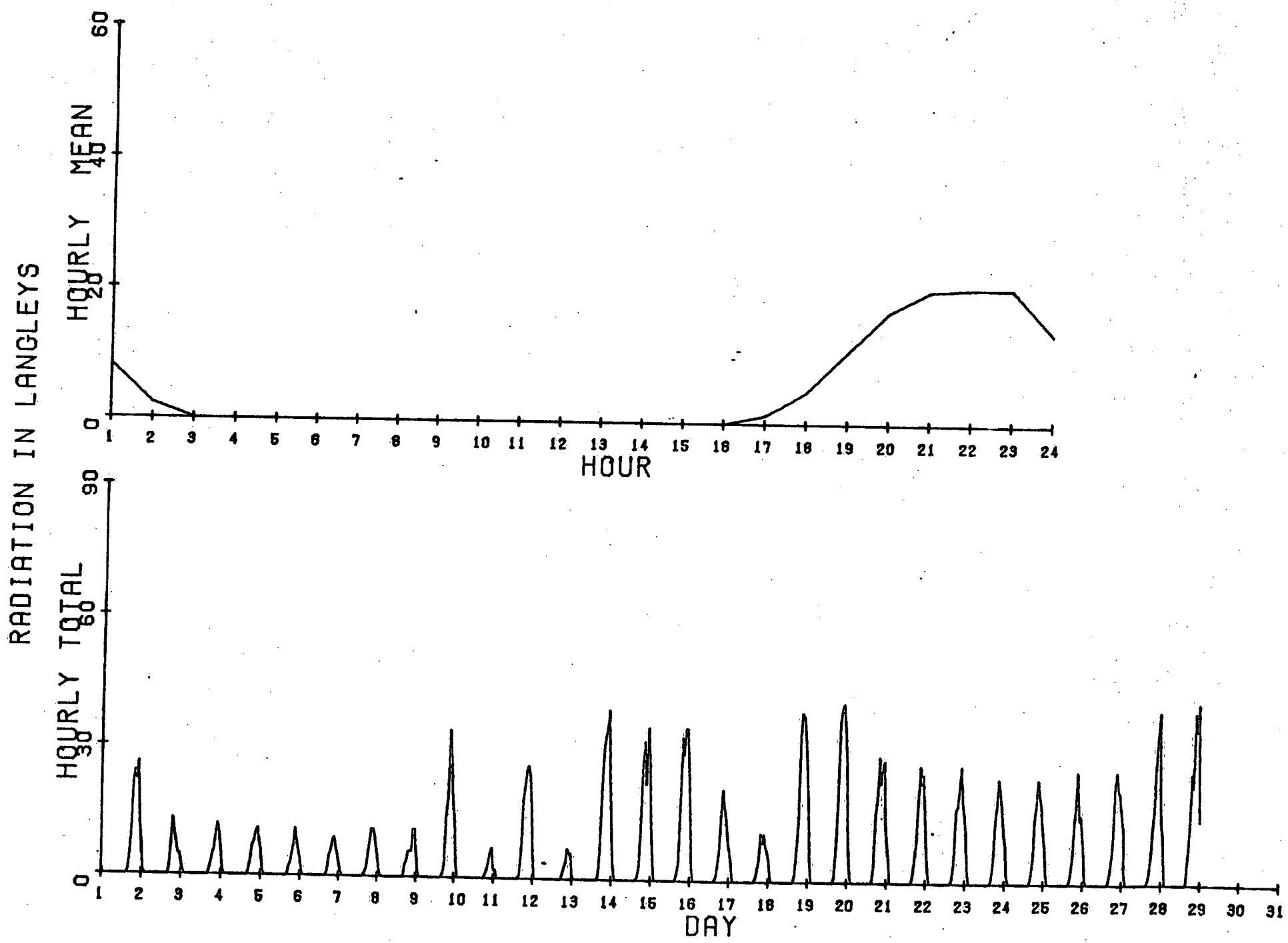
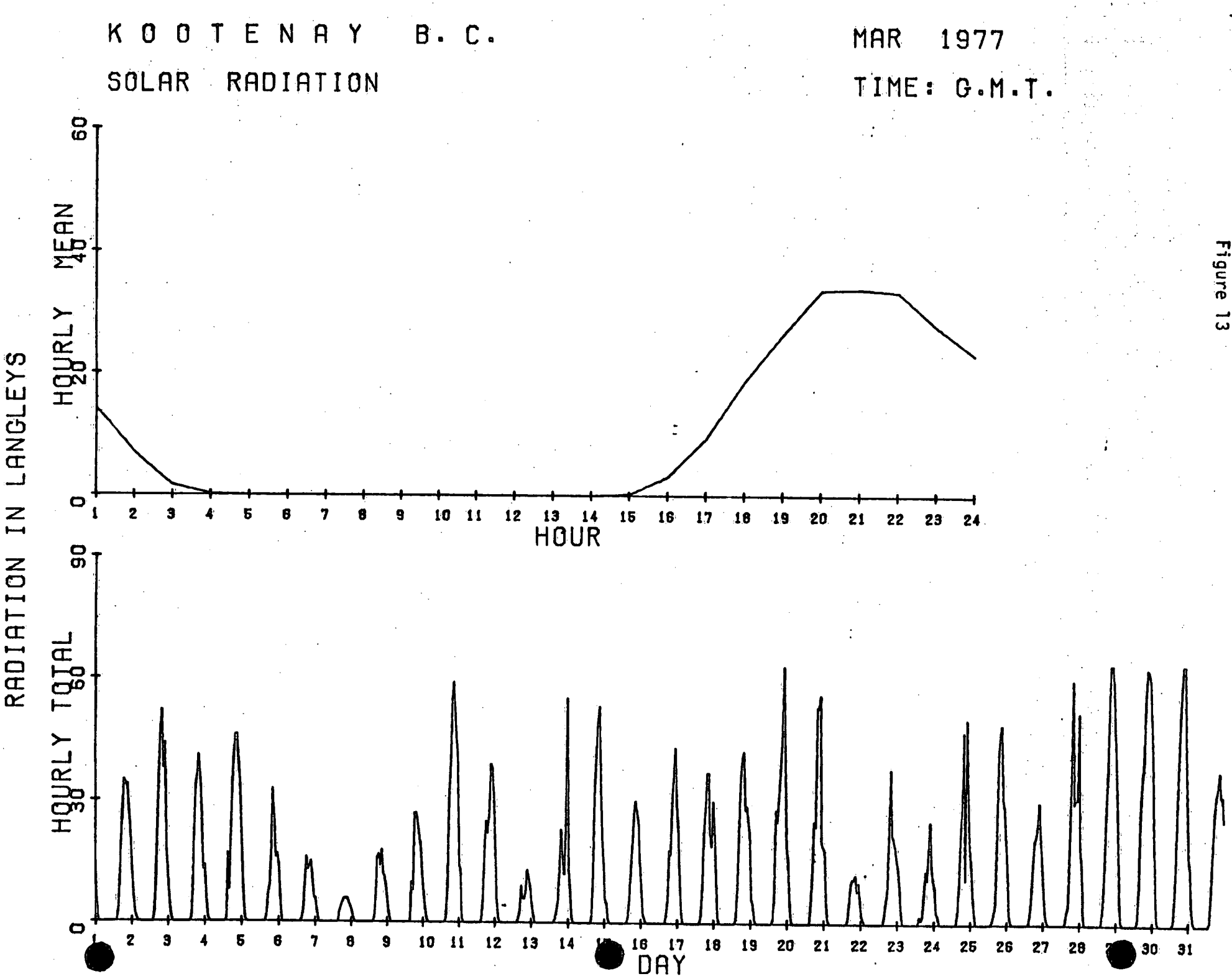


Figure 12

Figure 13


KOOTENAY B.C.
SOLAR RADIATION
MAR 1977
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

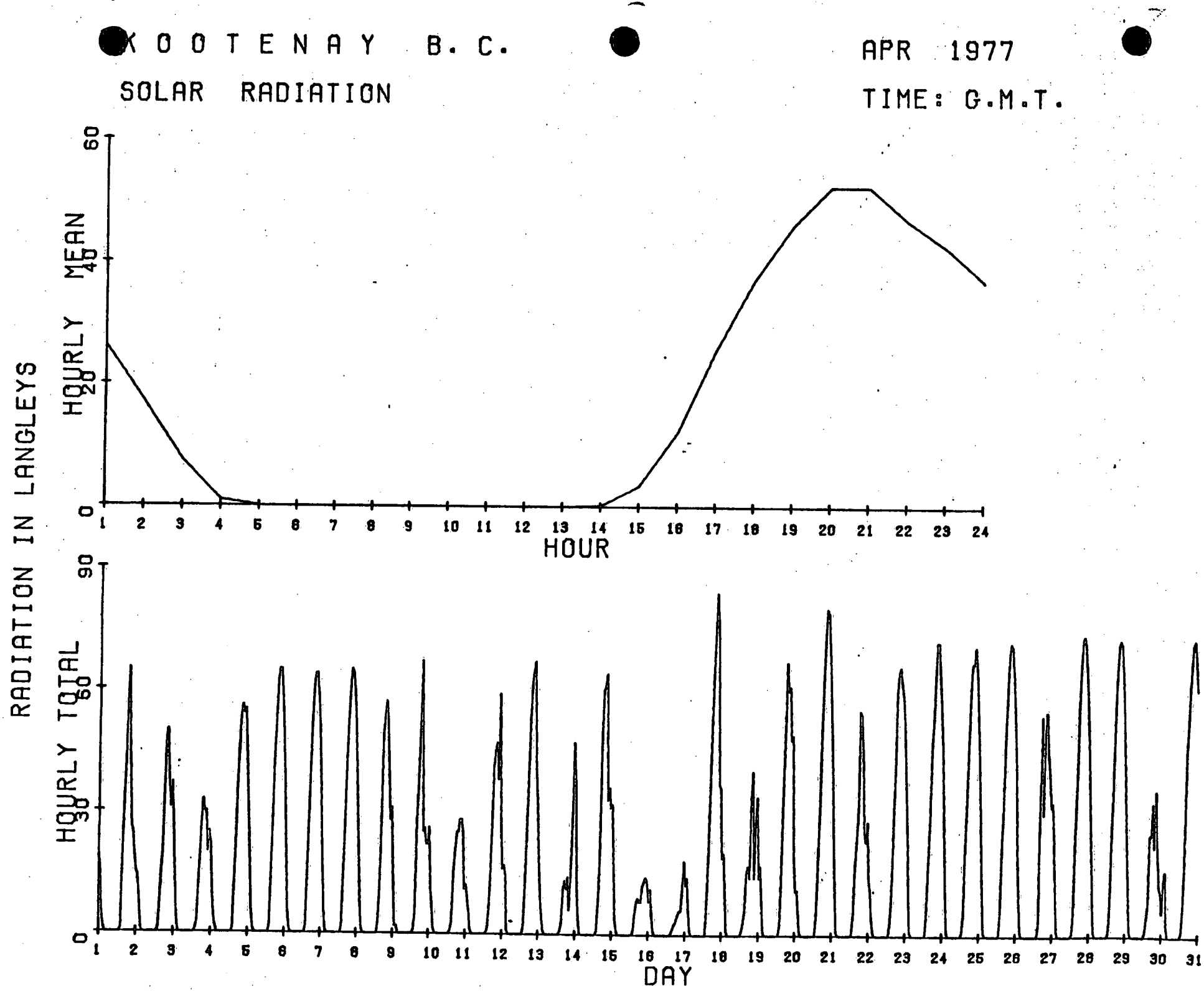

KOOTENAY B. C.
APR 1977
SOLAR RADIATION
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 14

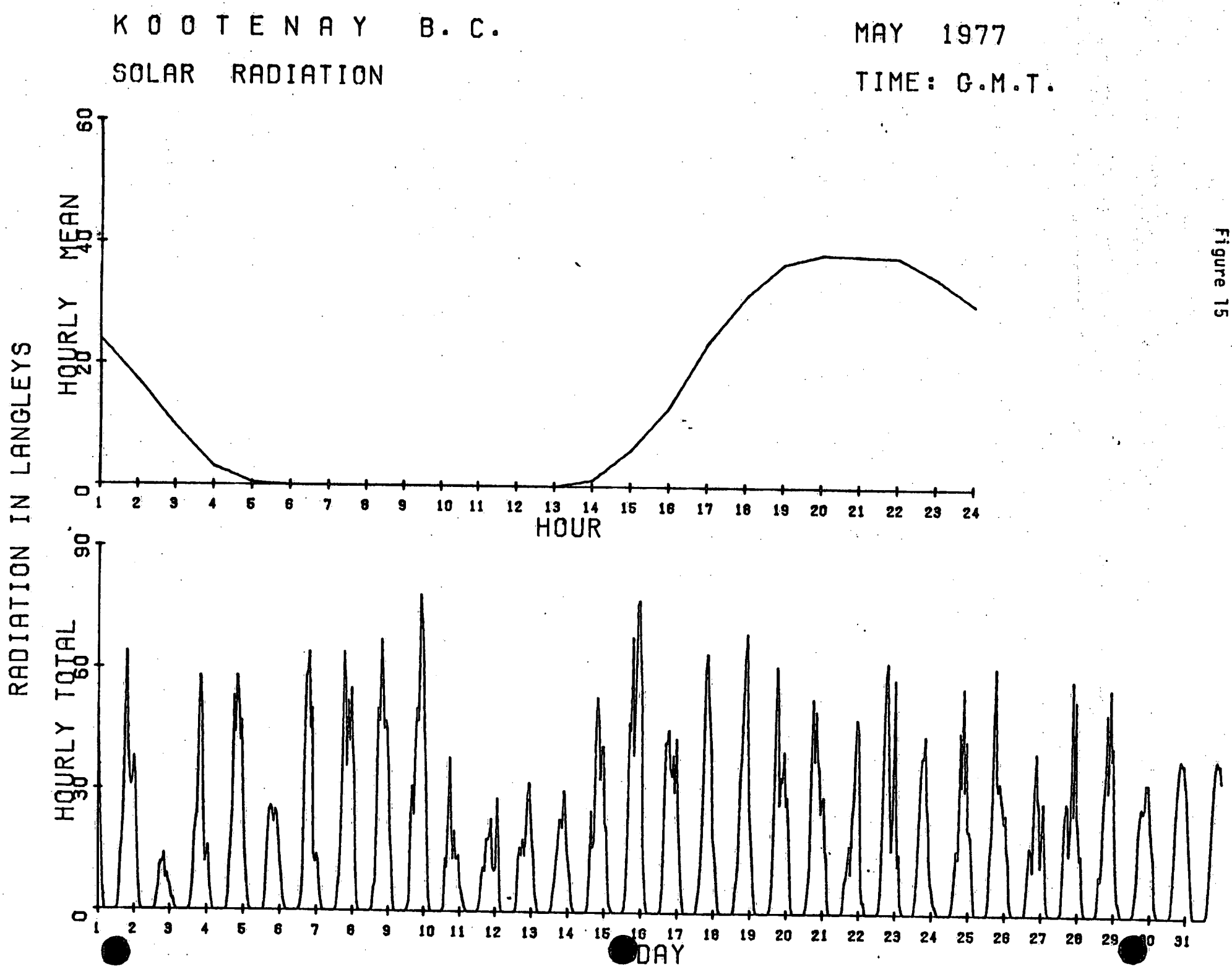

KOOTENAY B.C.
SOLAR RADIATION
MAY 1977
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOURLY TOTAL
HOUR
DAY

Figure 15

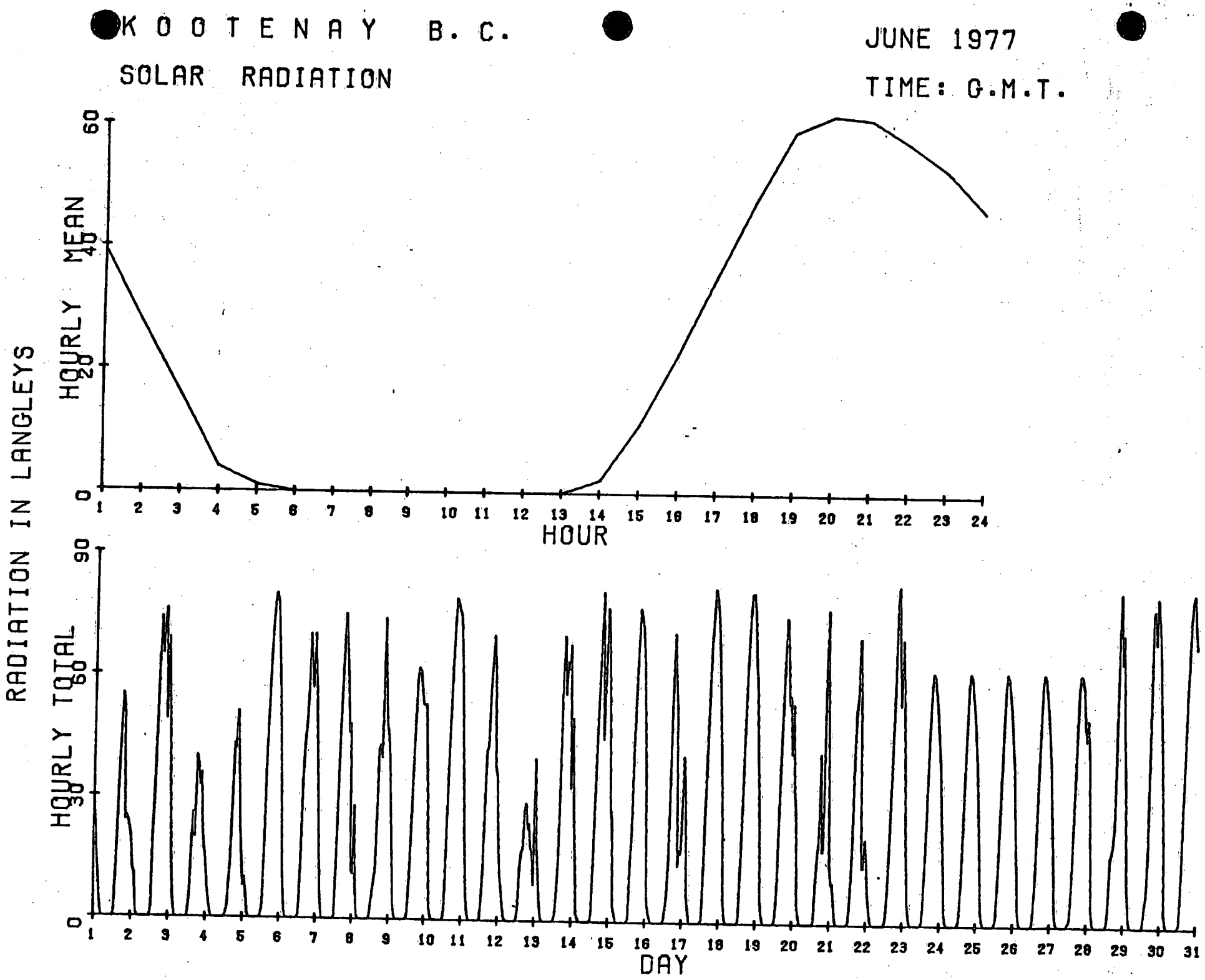

KOOTENAY B. C.
SOLAR RADIATION
JUNE 1977
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 16

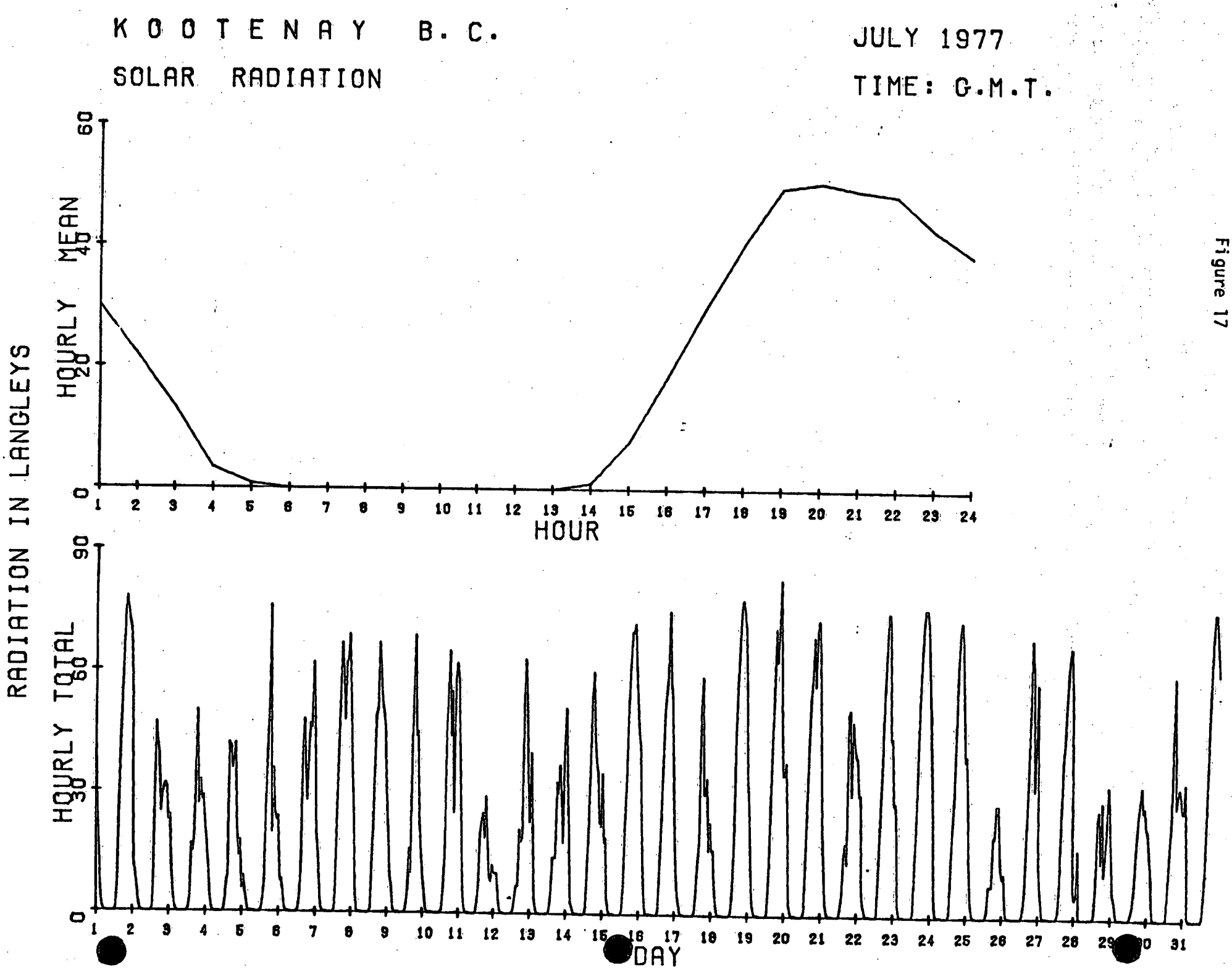

KOOTENAY B.C.
SOLAR RADIATION
JULY 1977
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOURLY TOTAL
HOUR
DAY
0
20
40
60
30
90

Figure 17

KOOTENAY B.C.

AUG 1977

SOLAR RADIATION

TIME: G.M.T.

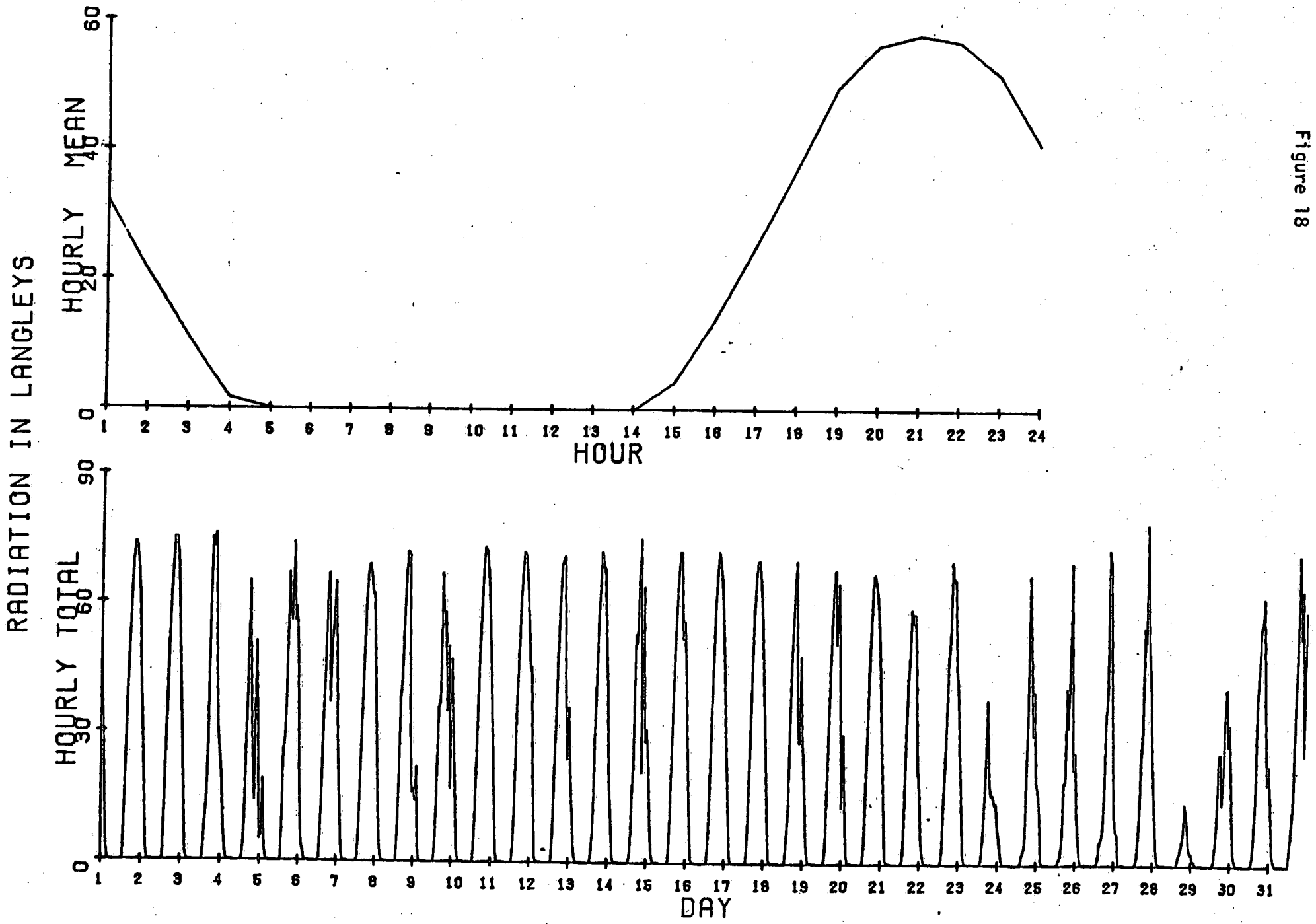


Figure 18

KOOTENAY B.C.

SOLAR RADIATION

SEPT 1977

TIME: G.M.T.

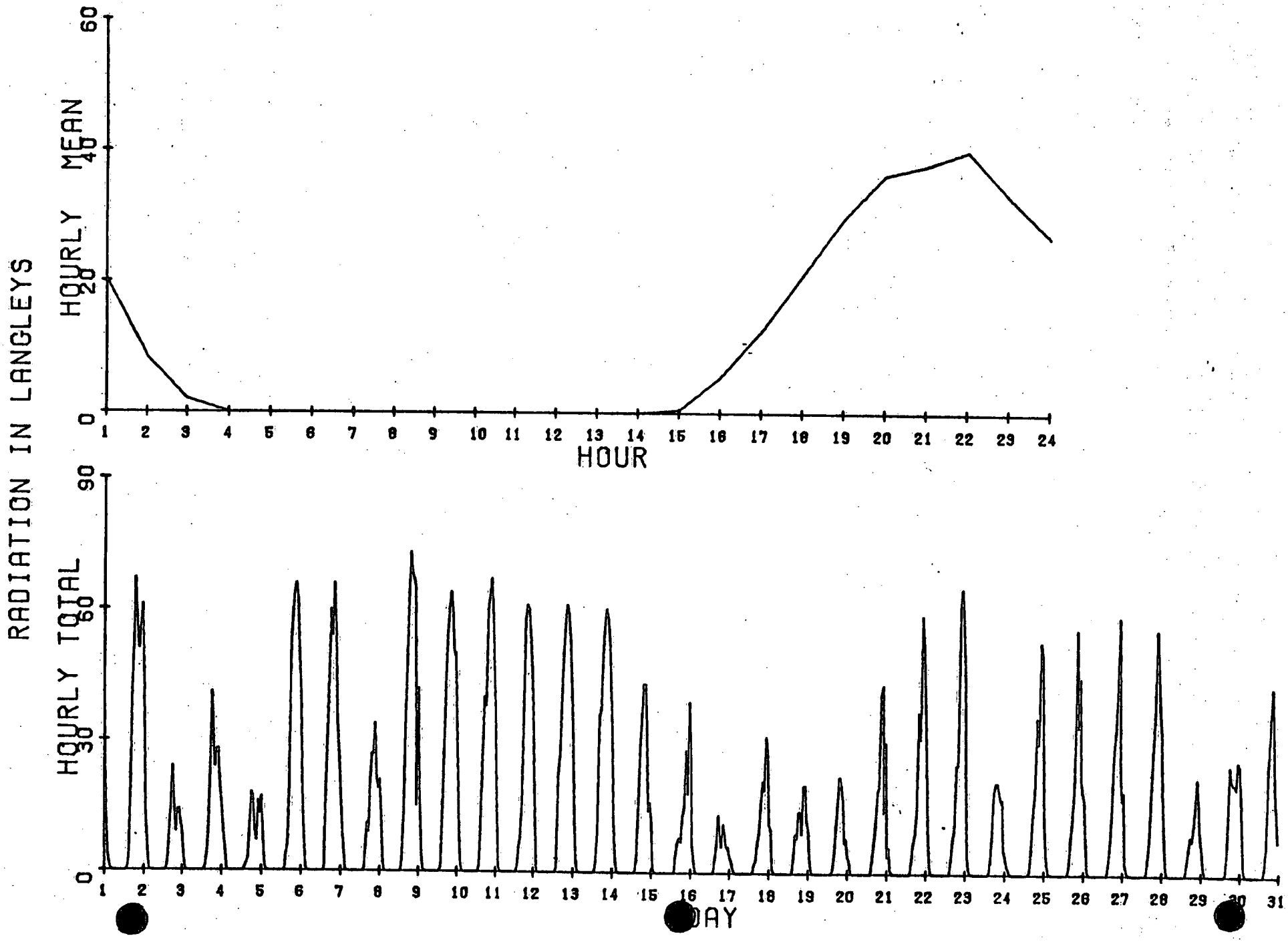


Figure 19

KOOTENAY B. C.

OCT 1977

SOLAR RADIATION

TIME: G.M.T.

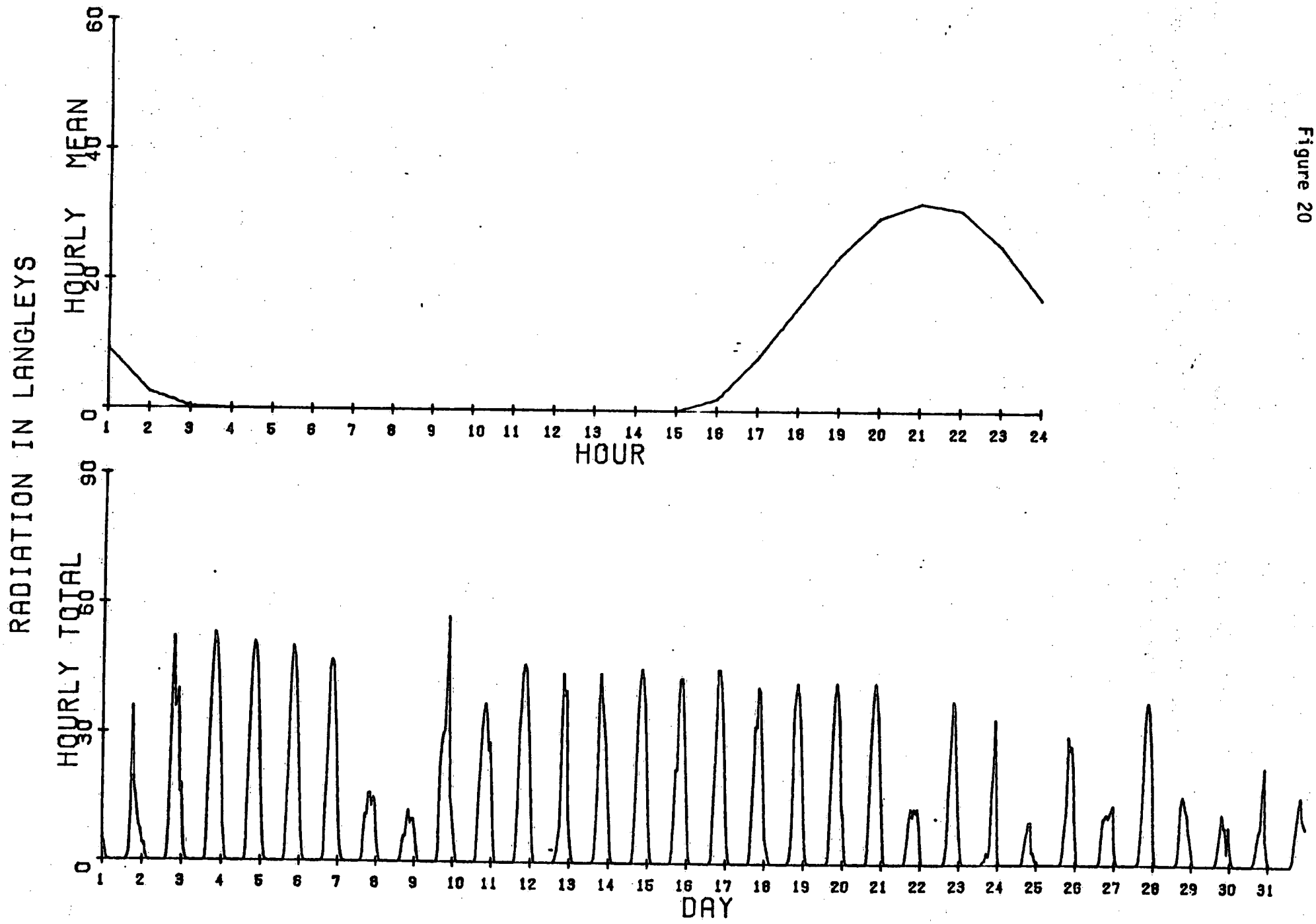
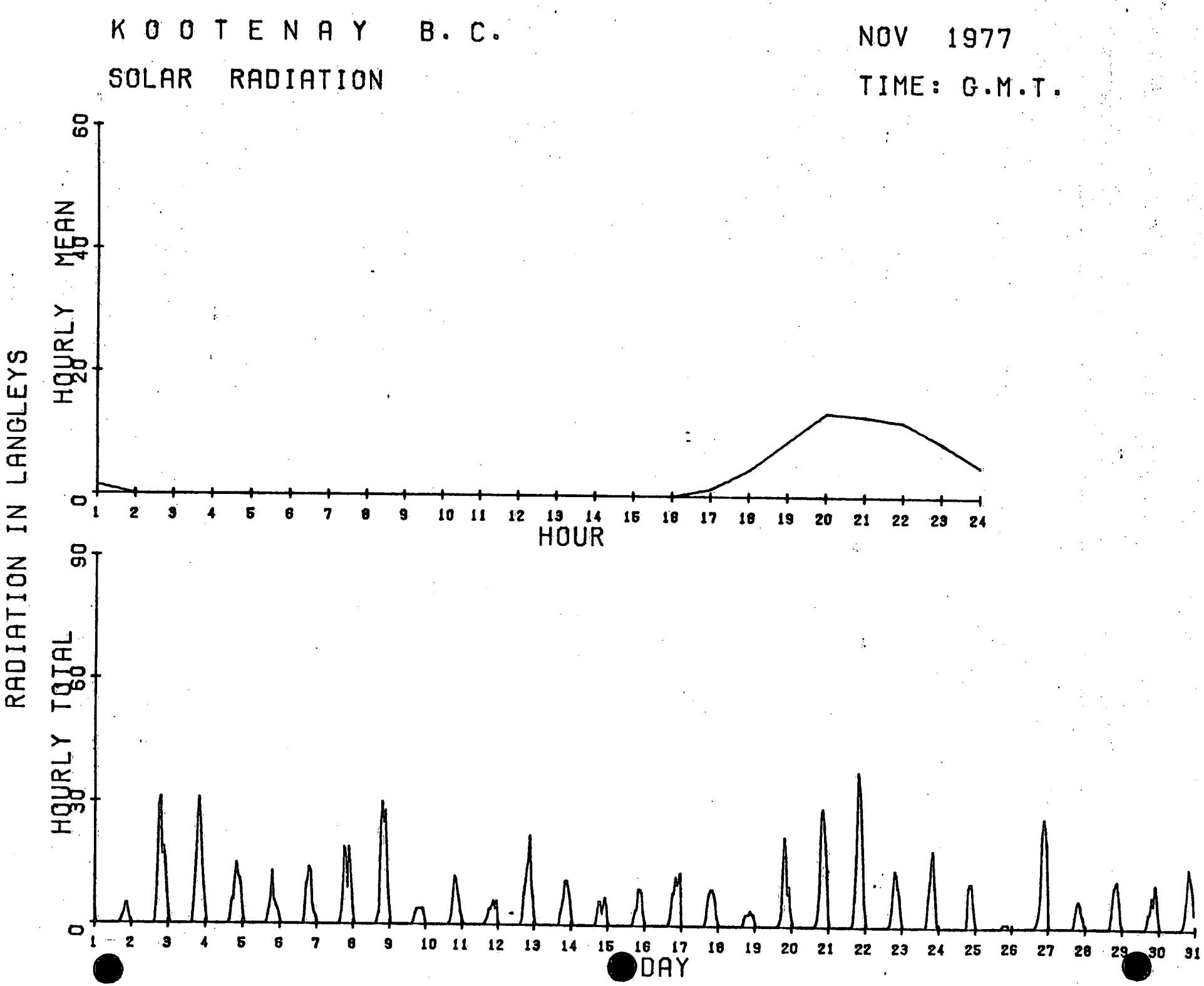


Figure 20

Figure 21


KOOTENAY B.C.
SOLAR RADIATION
NOV 1977
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOURLY TOTAL
HOUR
DAY

KOOTENAY B. C.

DEC 1977

SOLAR RADIATION

TIME: G.M.T.

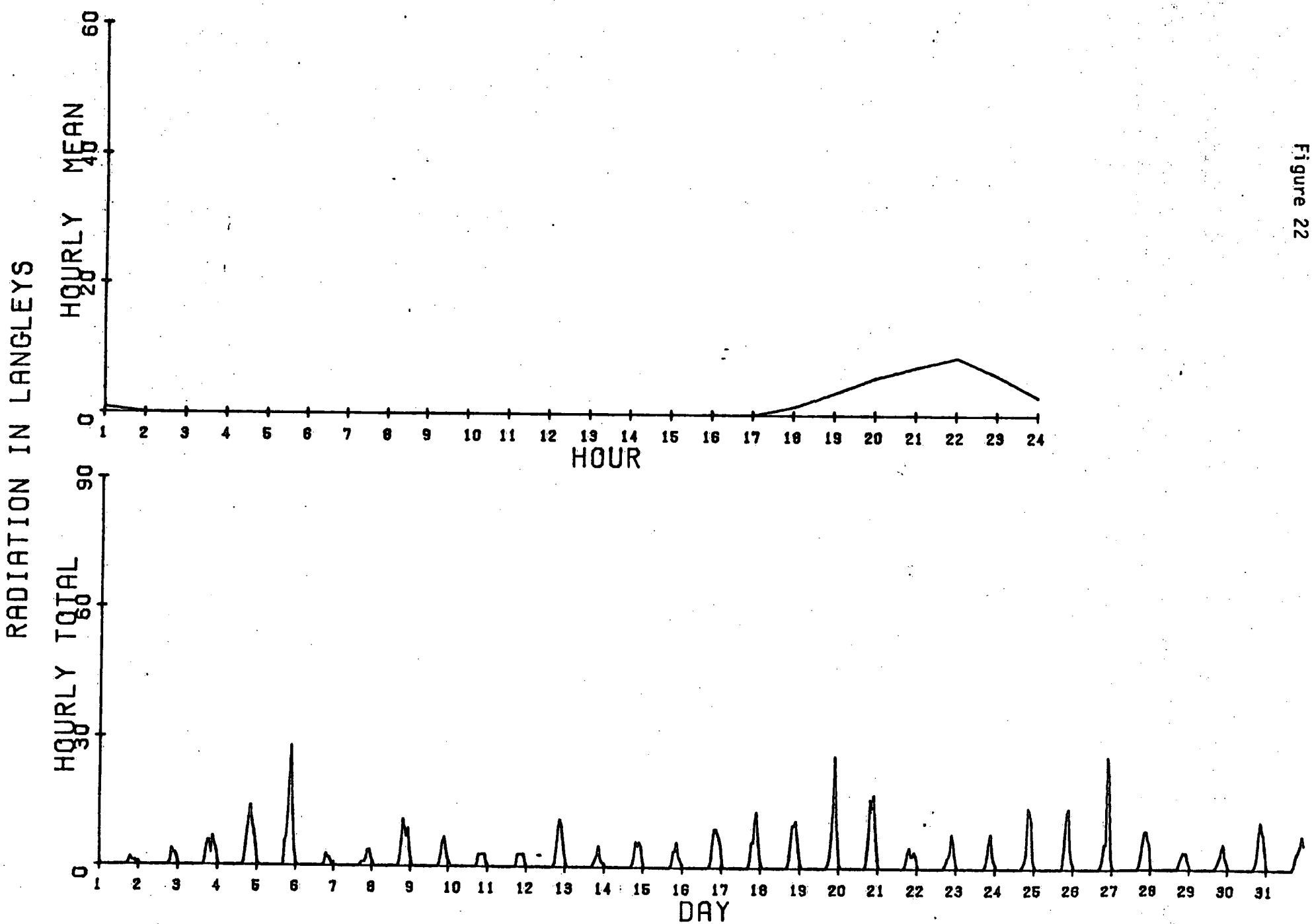


Figure 22

Figure 23

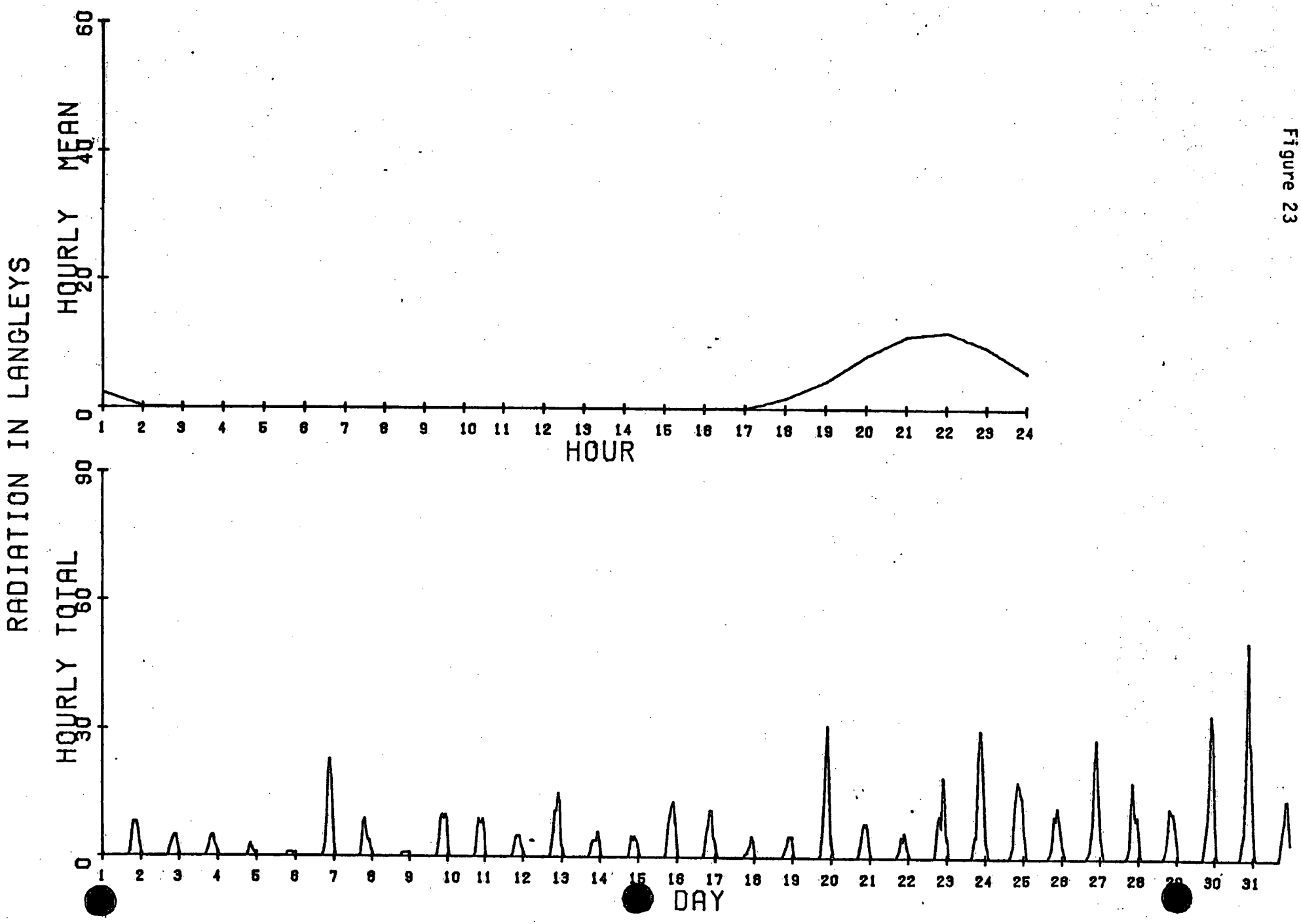
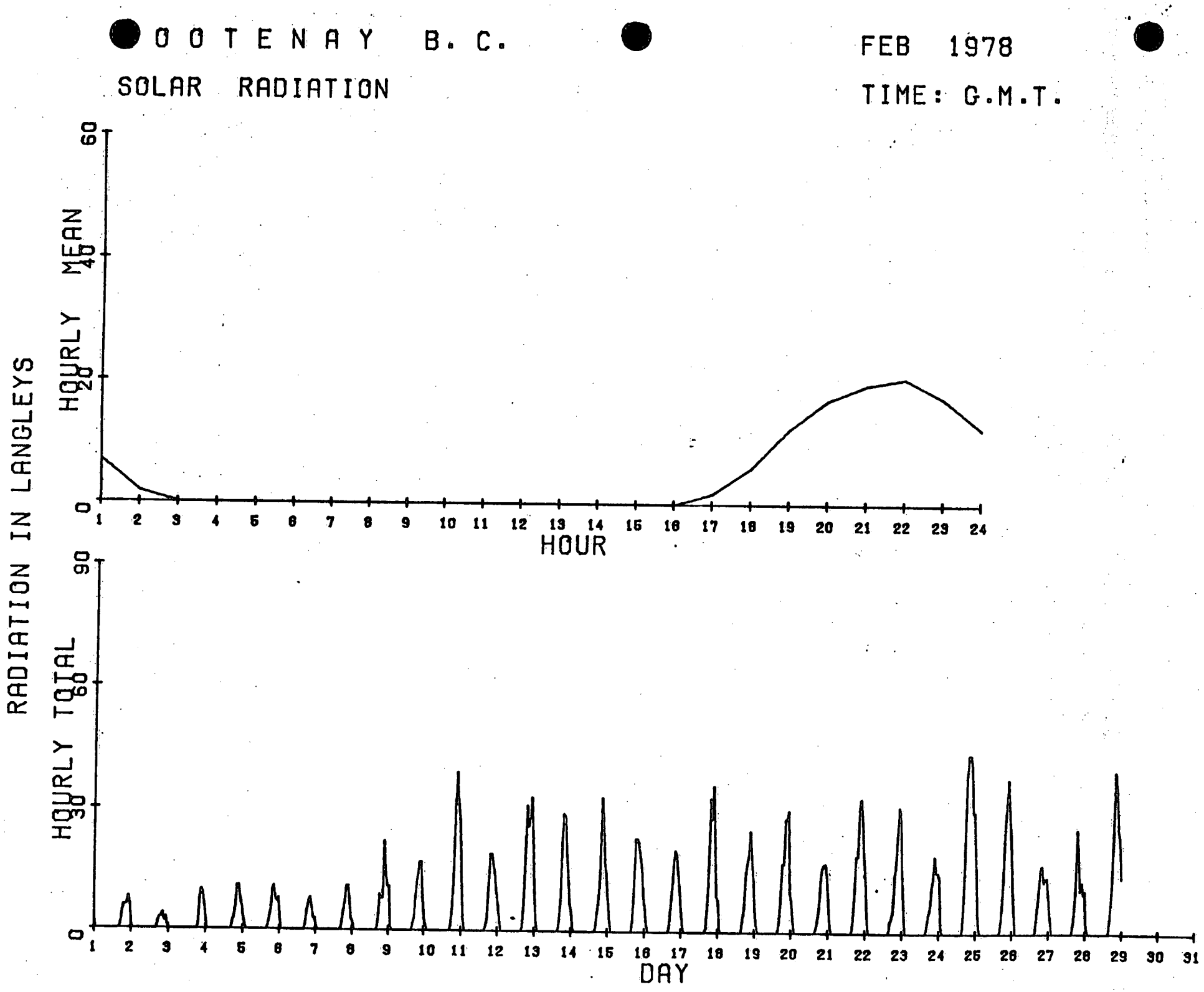

KOOTENAY B.C.
SOLAR RADIATION
JAN 1978
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 24

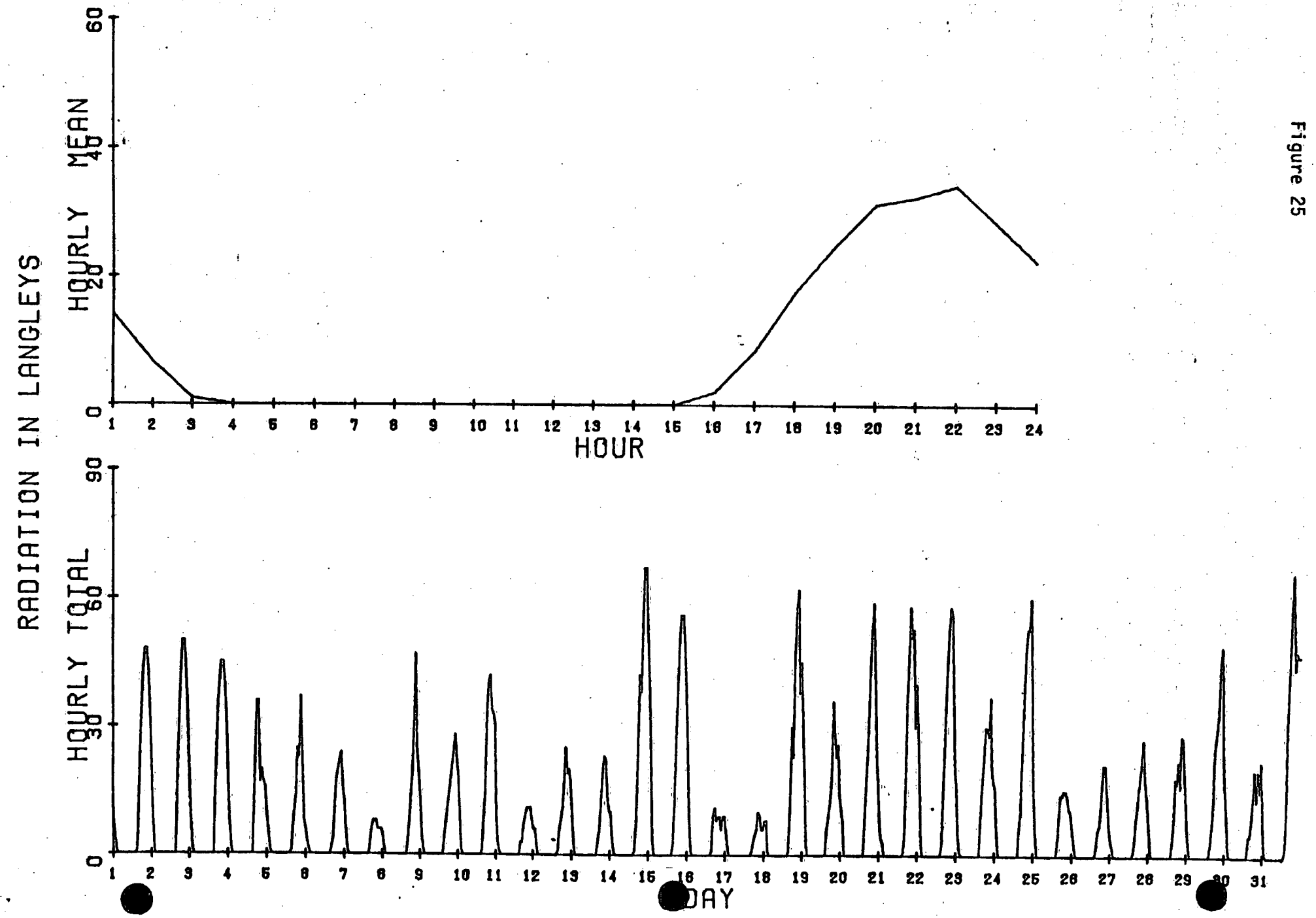

OOTENAY B.C.
FEB 1978
SOLAR RADIATION
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
0
20
40
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
0
30
60
90
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

K O O T E N A Y B. C.

MAR 1978

SOLAR RADIATION

TIME: G.M.T.



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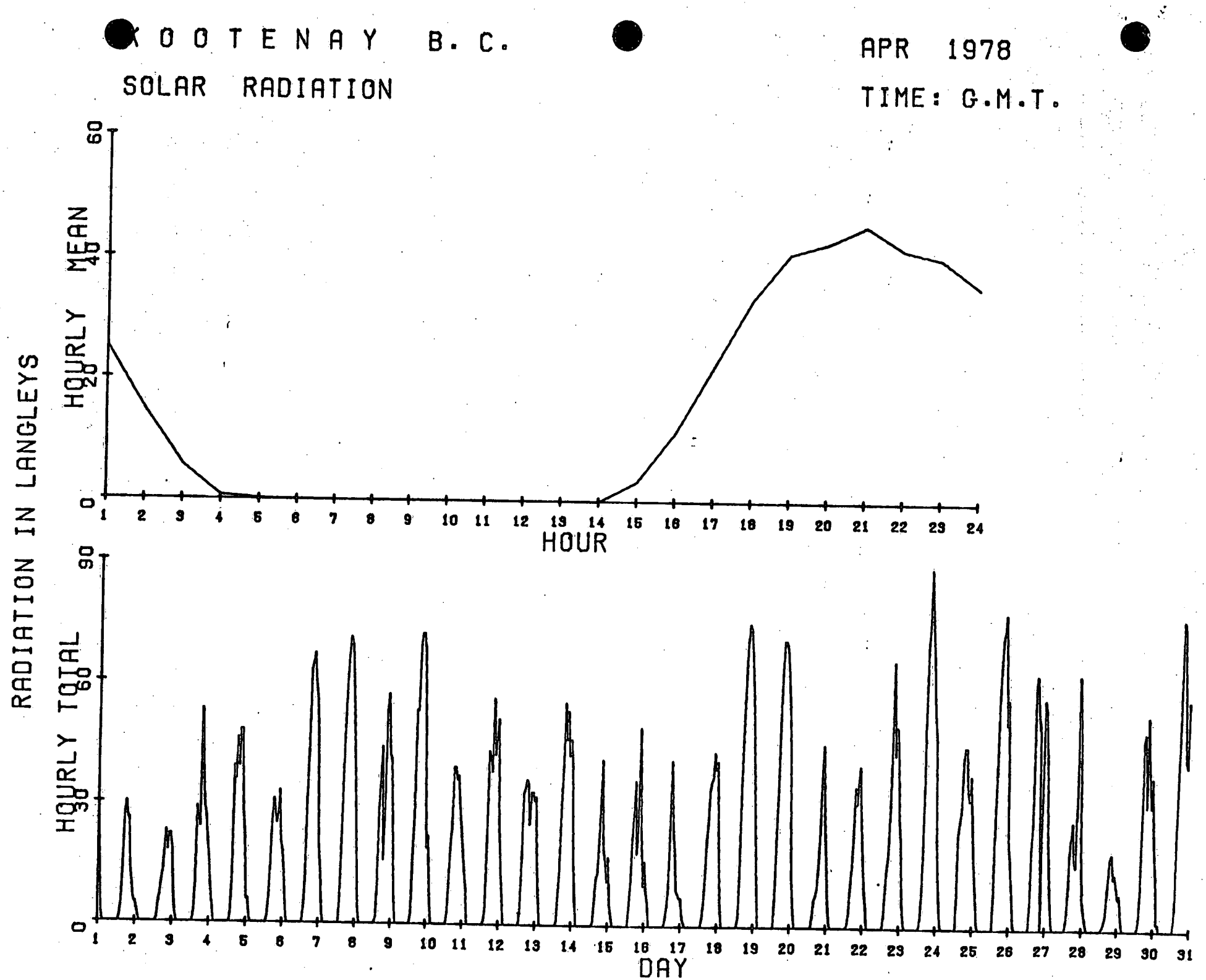

KOOTENAY B. C.
APR 1978
SOLAR RADIATION
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 26

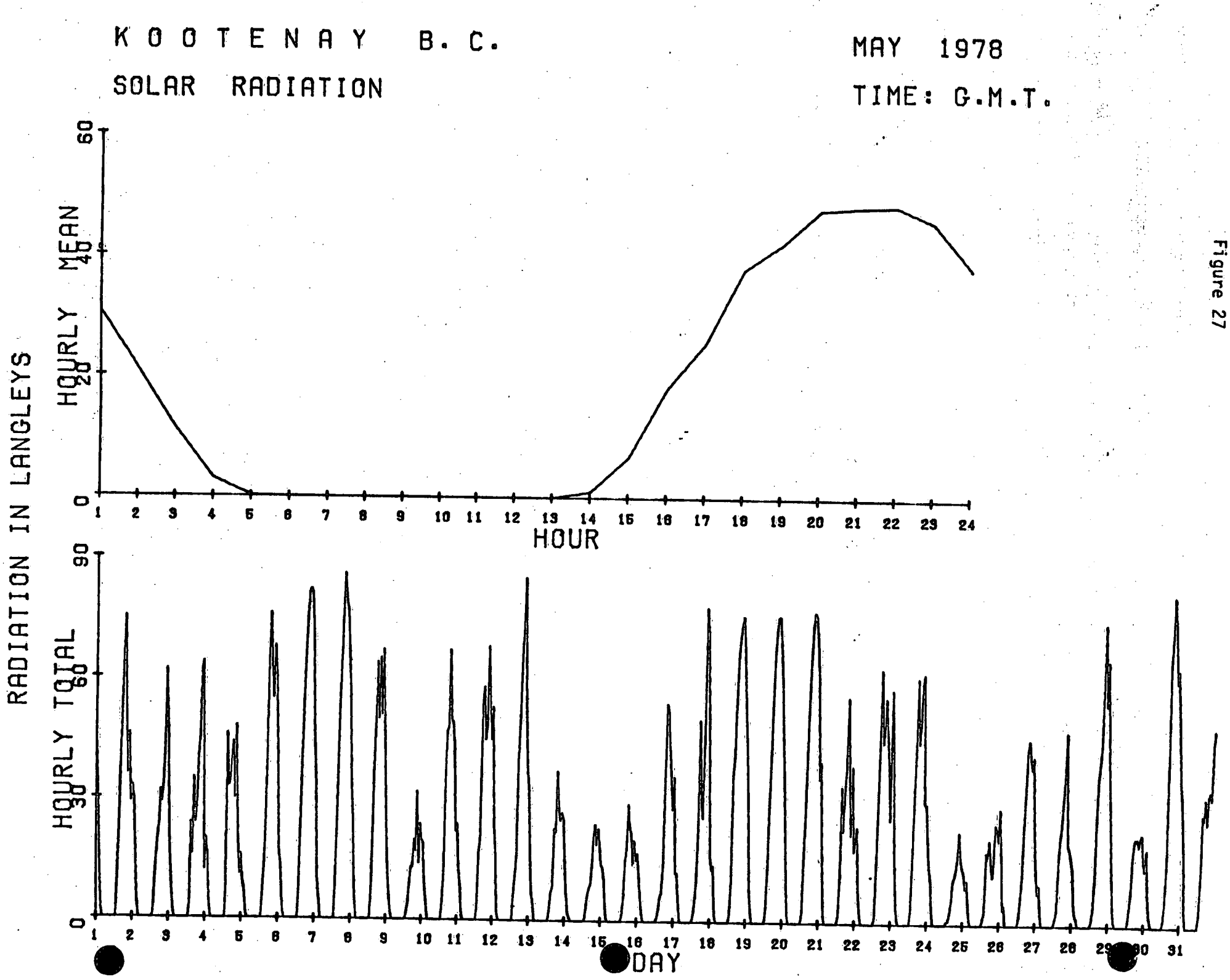

KOOTENAY B.C.
SOLAR RADIATION
MAY 1978
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 27

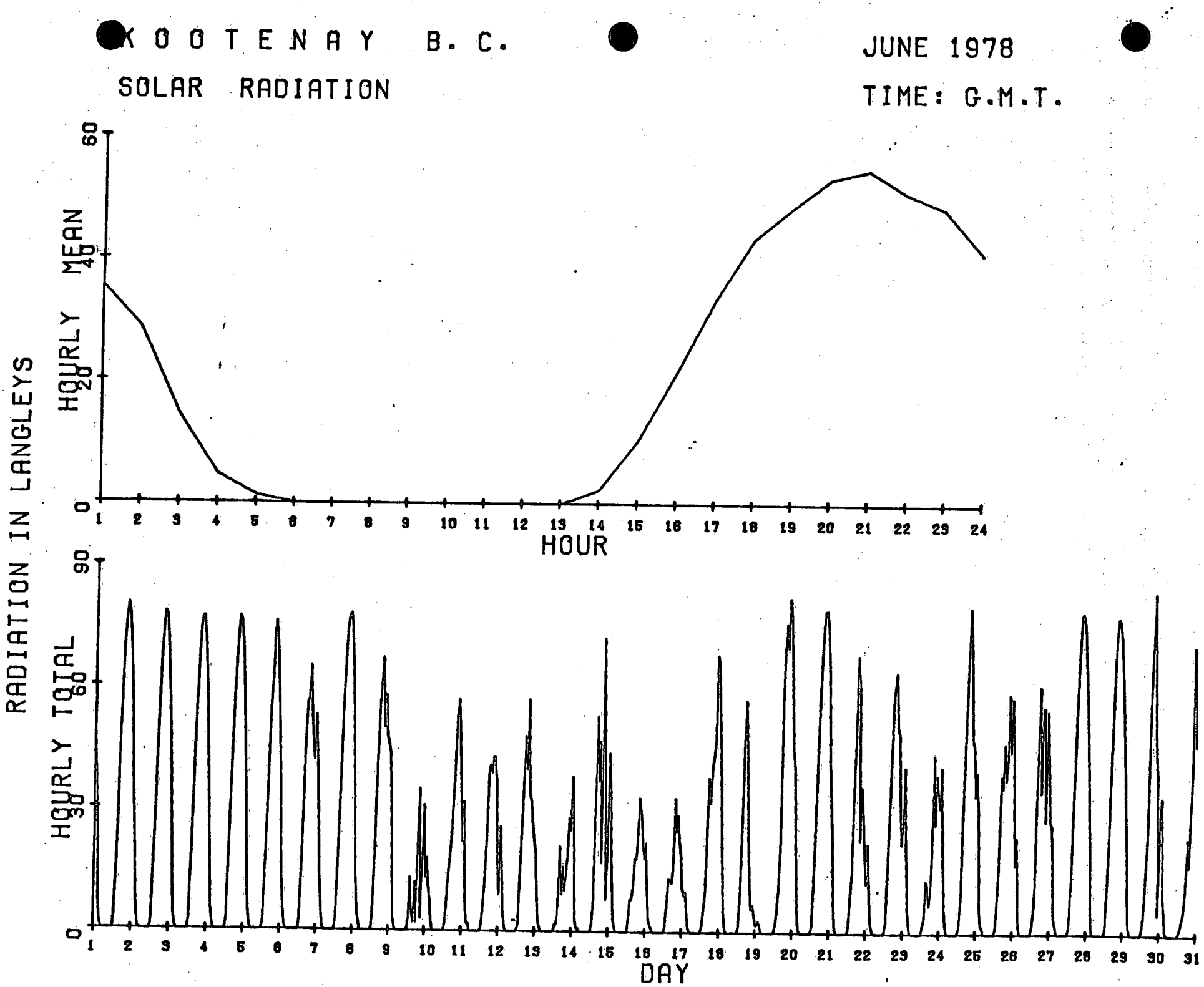

KOOTENAY B. C.
JUNE 1978
SOLAR RADIATION
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 28

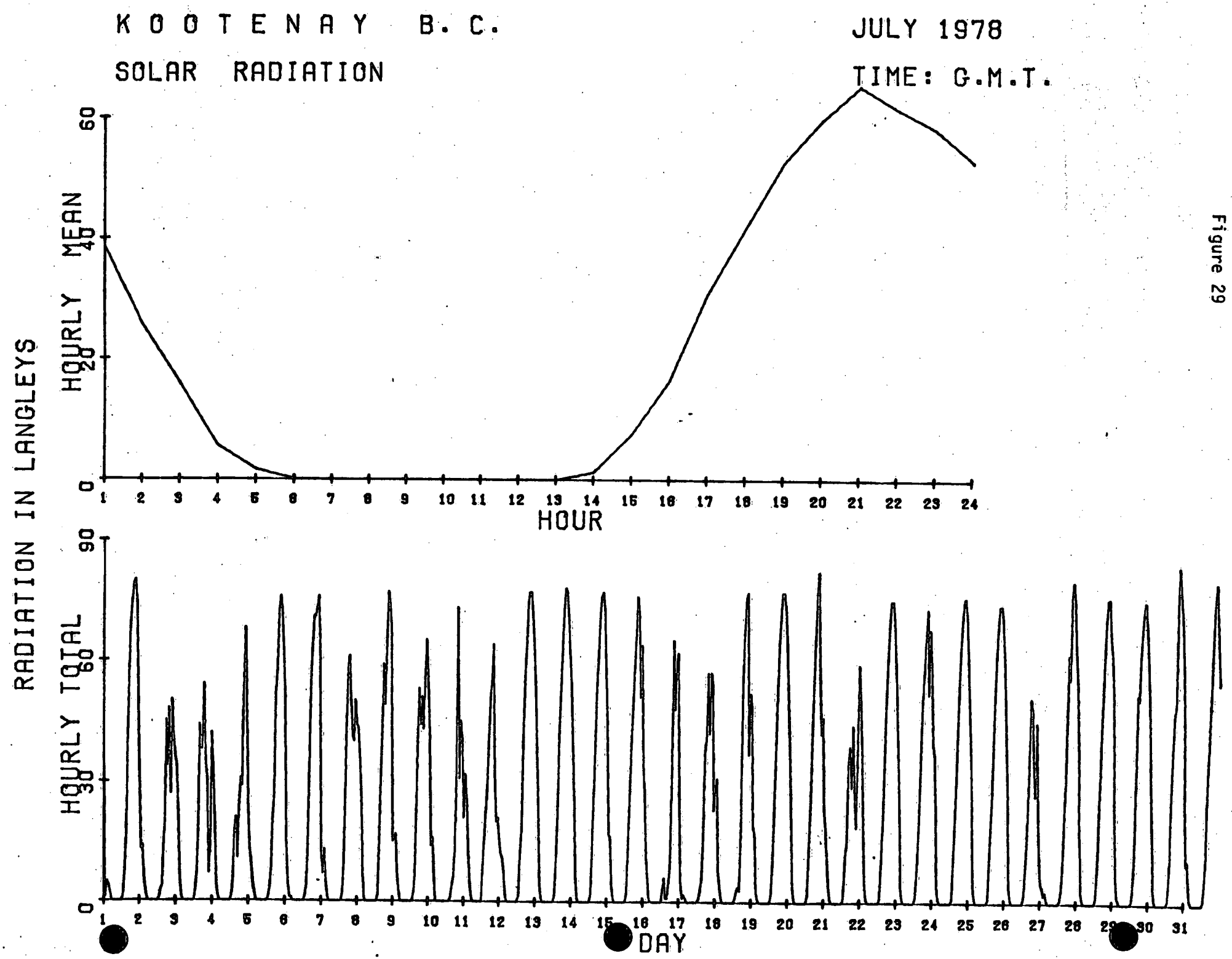

KOOTENAY B.C.
SOLAR RADIATION
JULY 1978
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

Figure 29

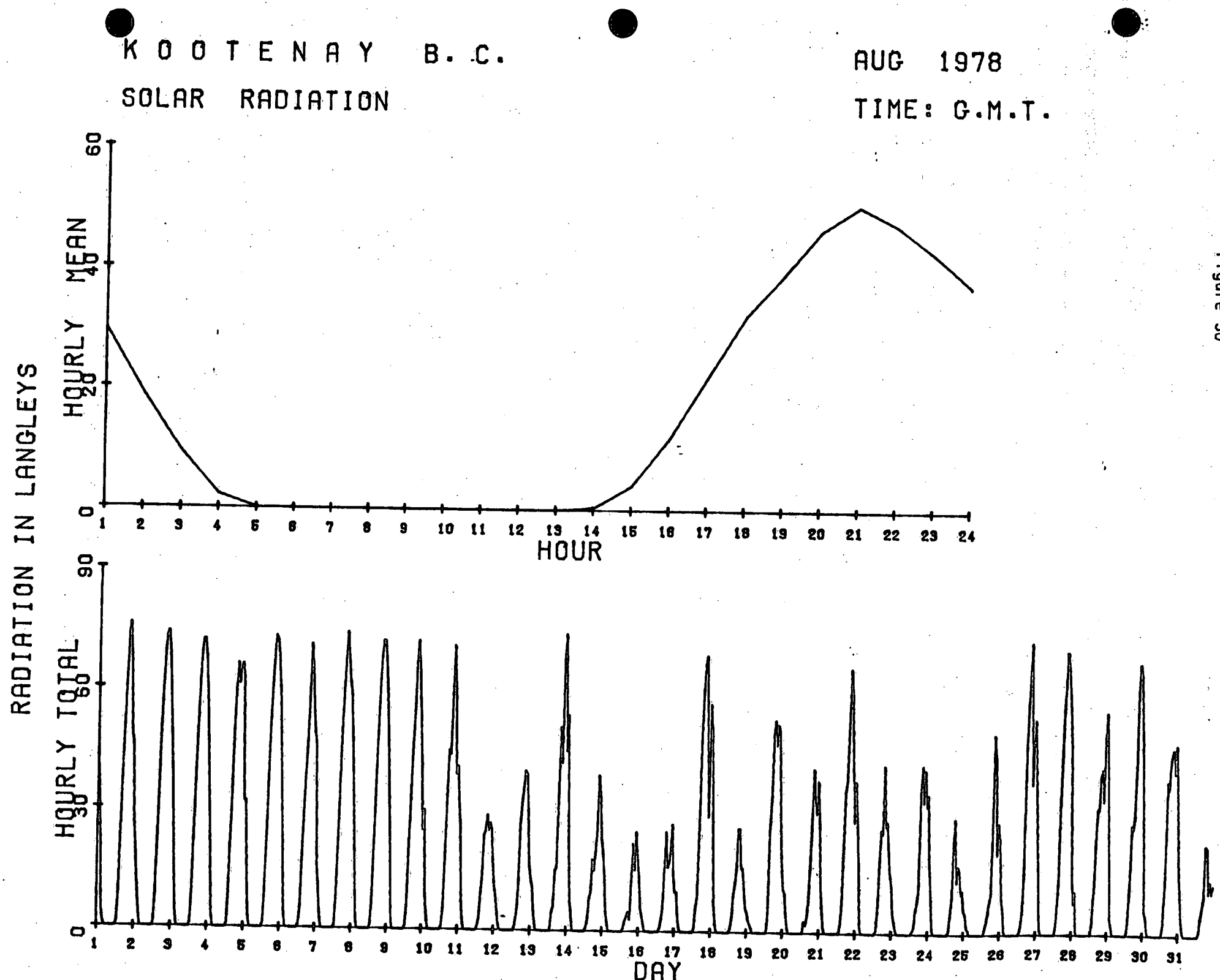
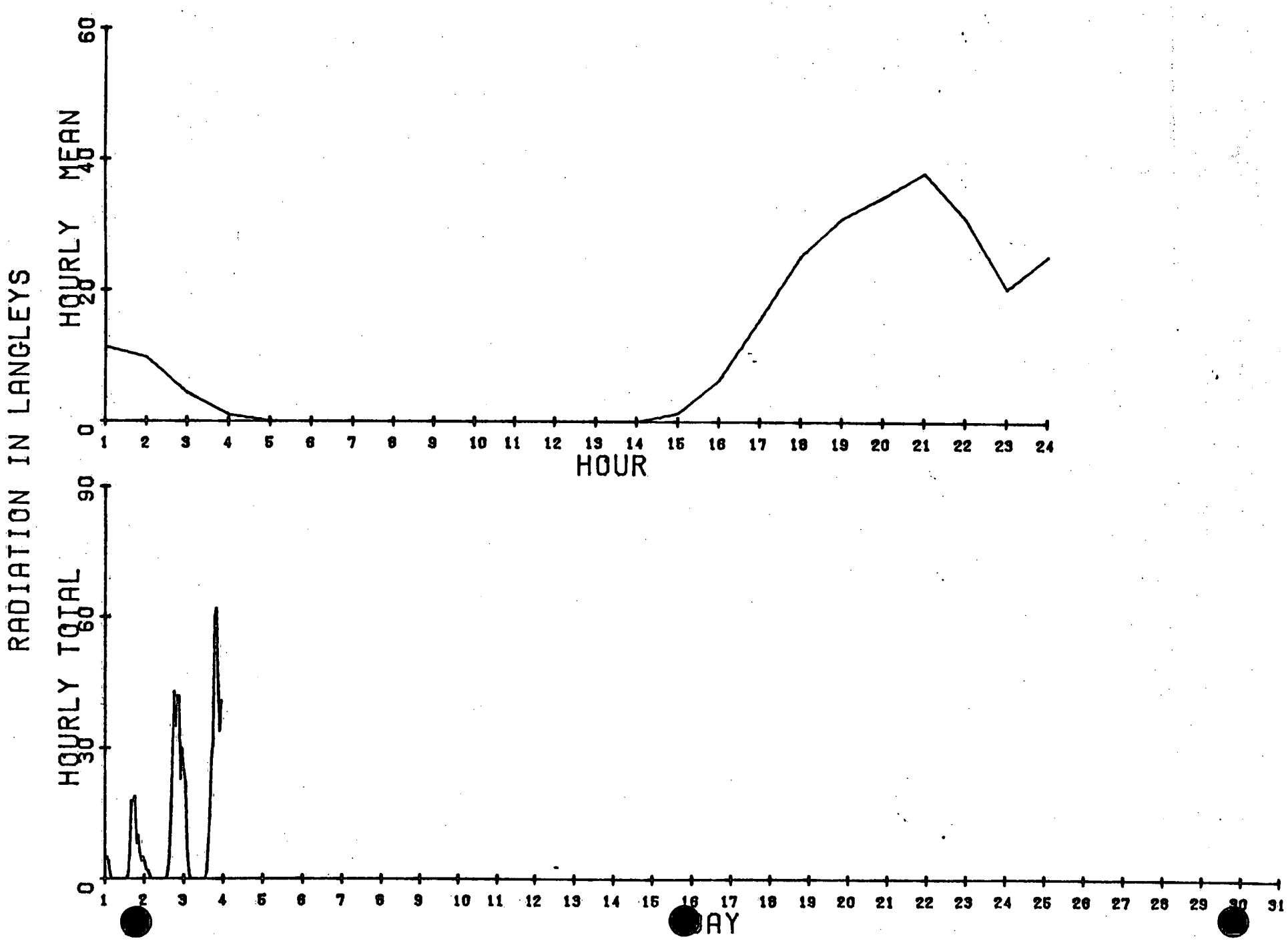

KOOTENAY B.C.
SOLAR RADIATION
AUG 1978
TIME: G.M.T.
RADIATION IN LANGLEYS
HOURLY MEAN
HOURLY TOTAL
HOUR
DAY

Figure 30

Figure 31


KOOTENAY B. C.
SOLAR RADIATION
SEPT 1978
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RADIATION IN LANGLEYS
HOURLY MEAN
HOUR
HOURLY TOTAL
DAY

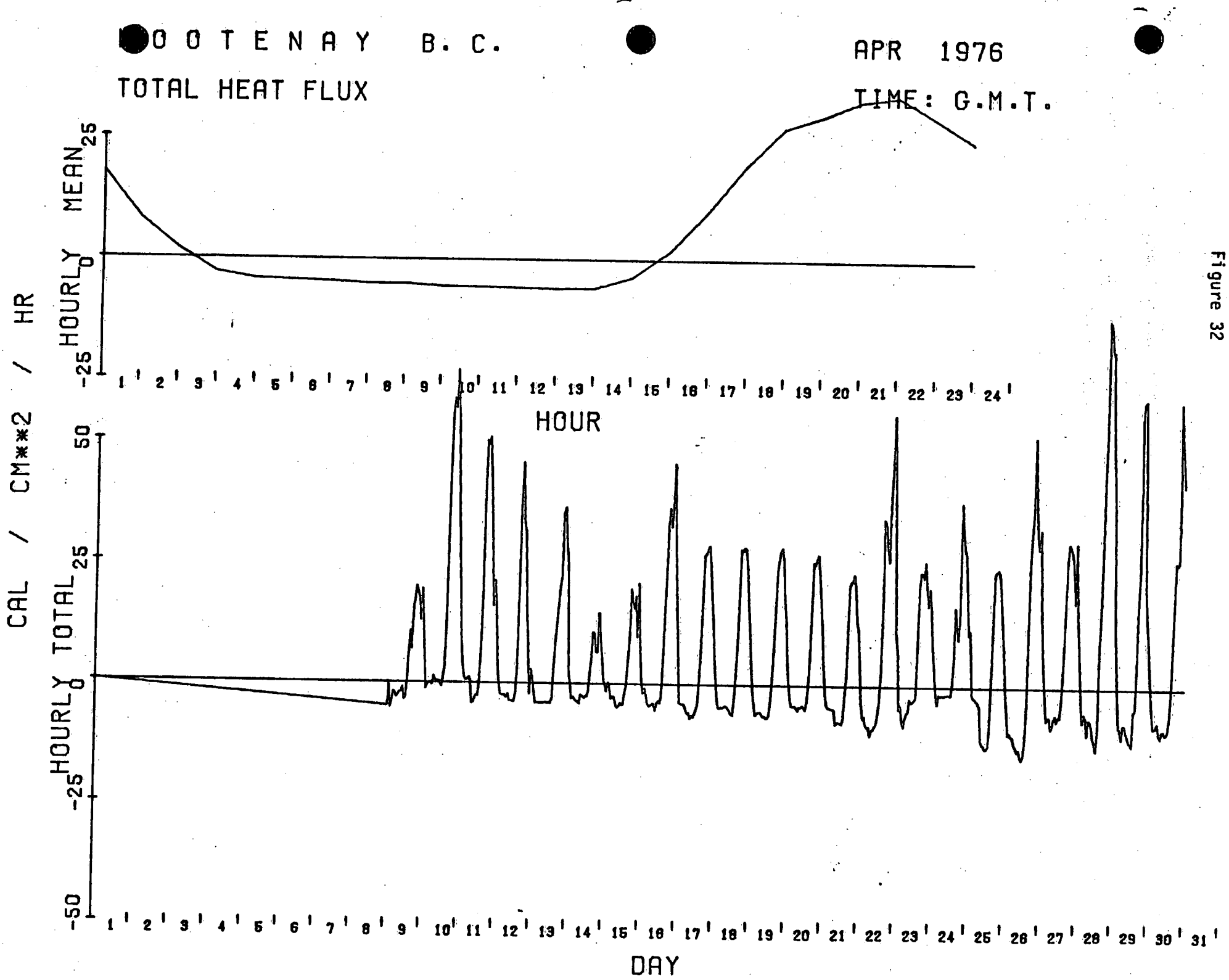

O O T E N A Y B. C.
APR 1976
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
25
0
-25
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
50
25
0
-25
-50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 32

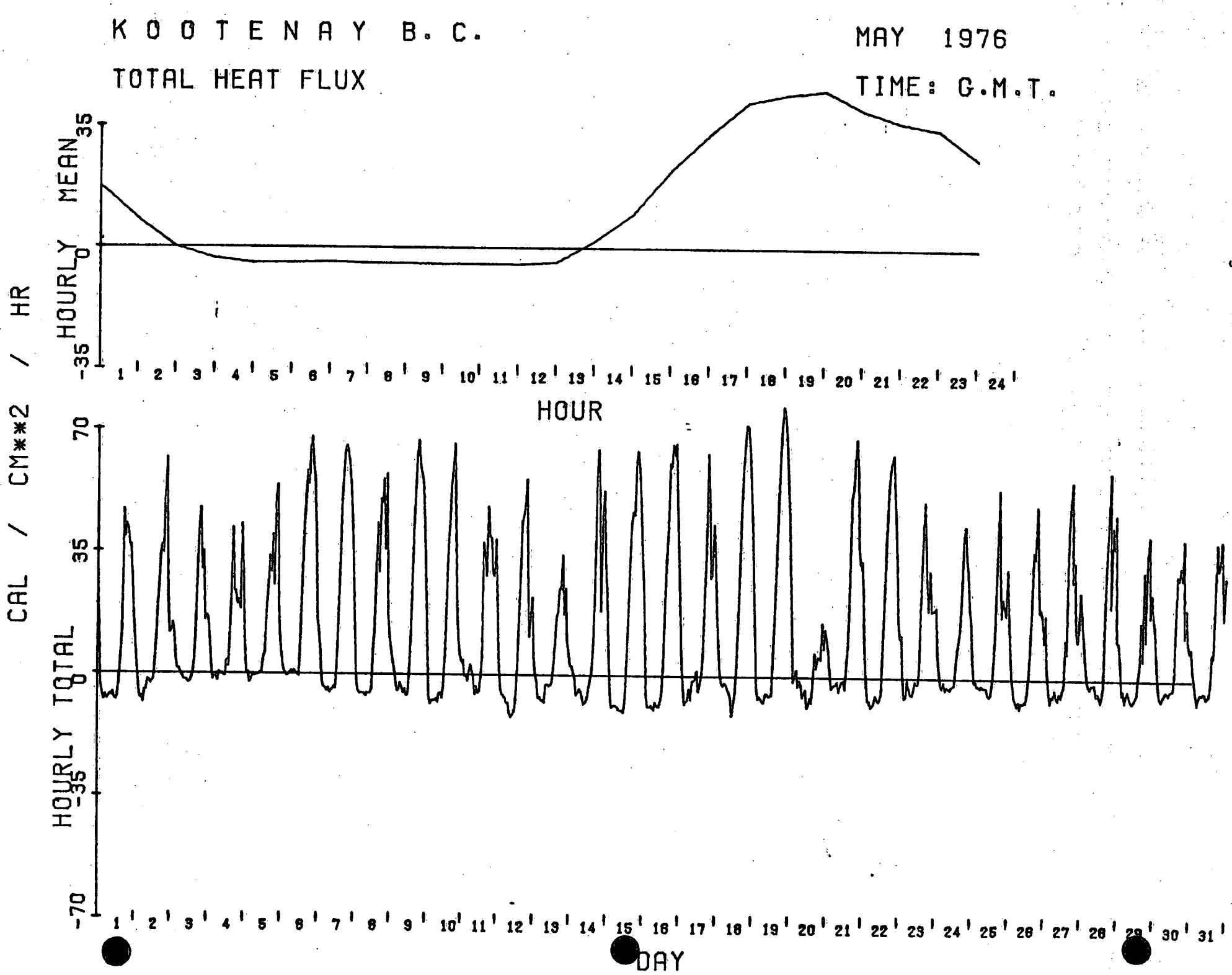

KOOTENAY B.C.
MAY 1976
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 33

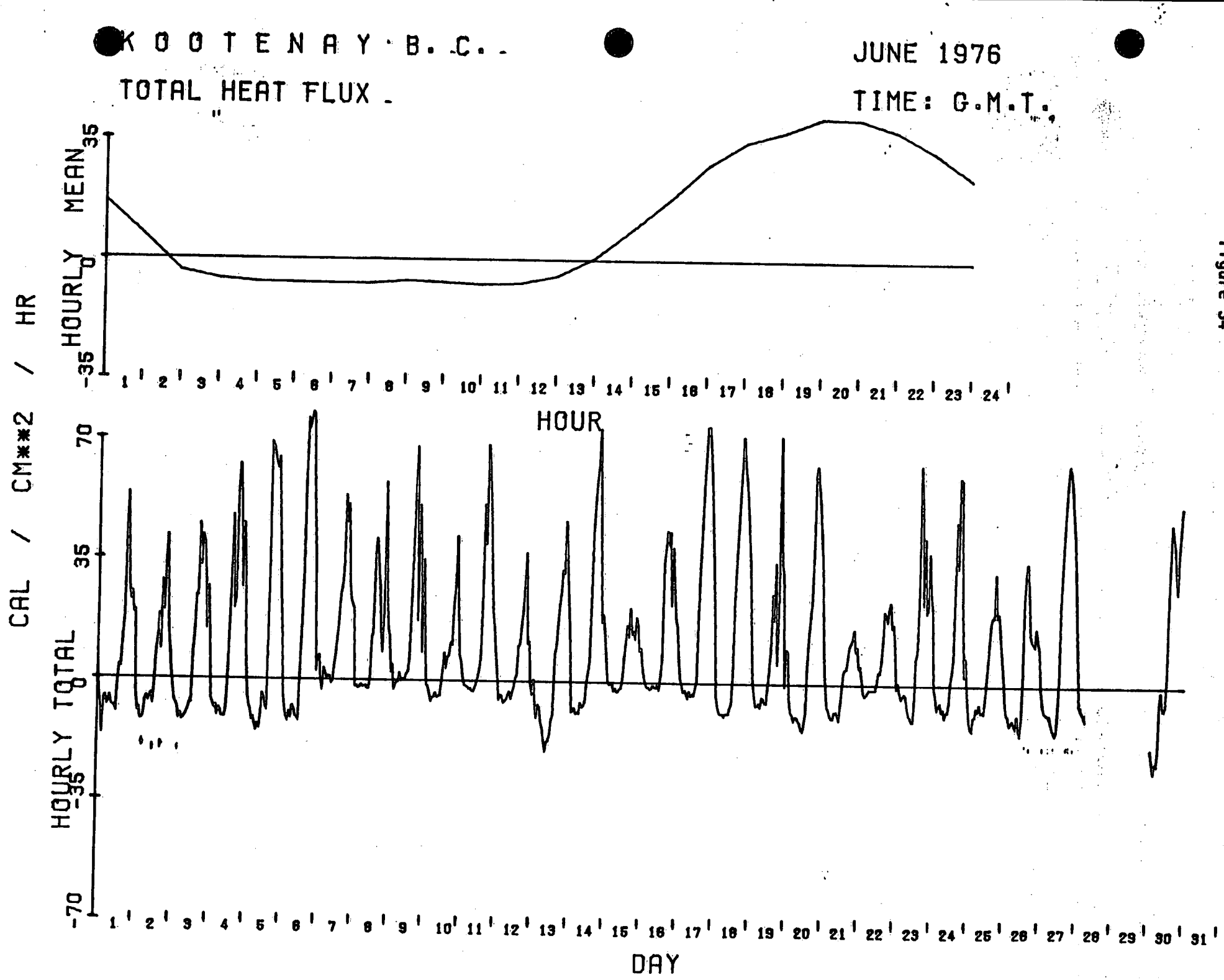

KOOTENAY B.C.
JUNE 1976
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
35
0
-35
CAL / CM**2 / HR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 34

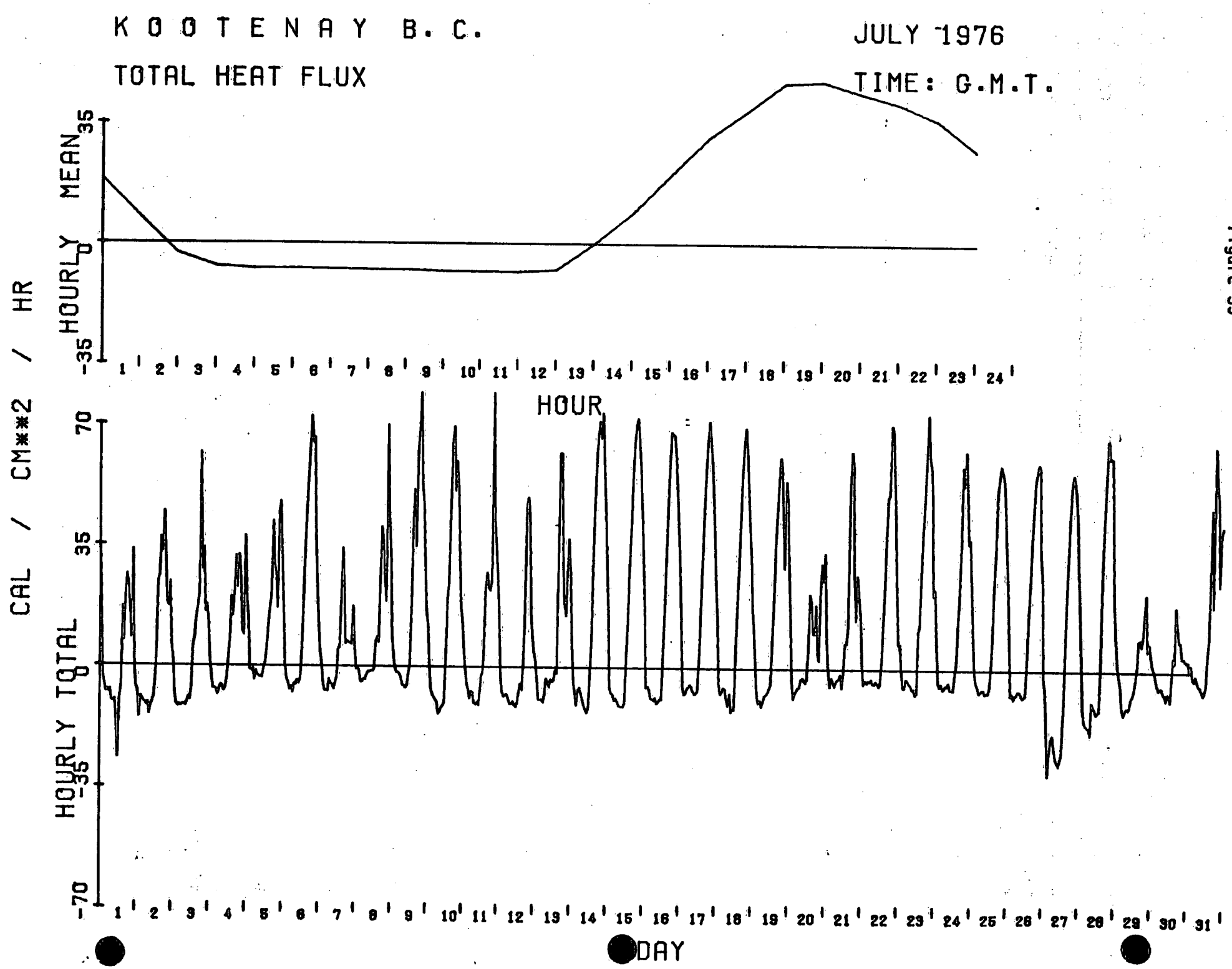

KOOTENAY B. C.
JULY 1976
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
CAL / CM**2 / HR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 35

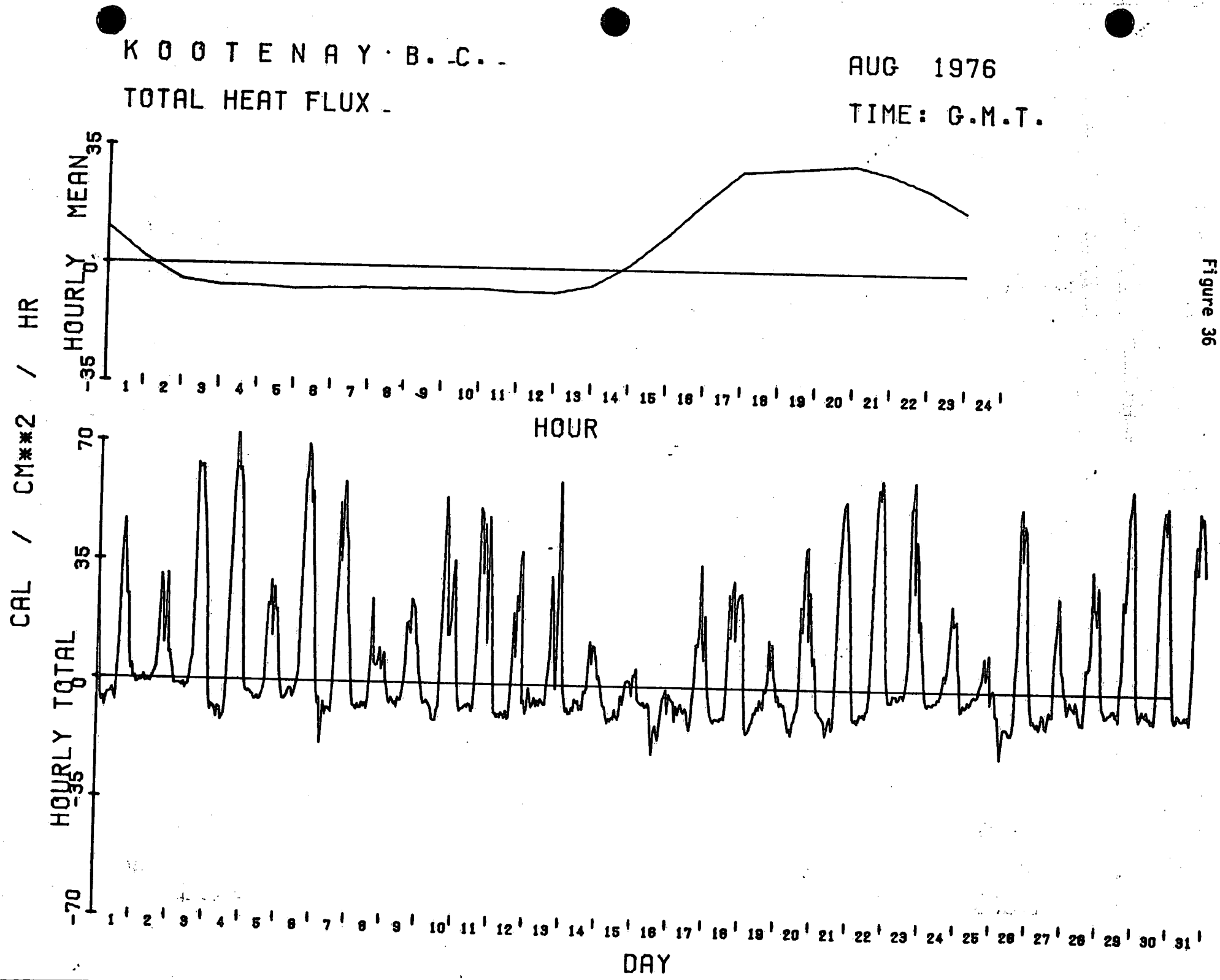

KOOTENAY B.C.
TOTAL HEAT FLUX
AUG 1976
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 36

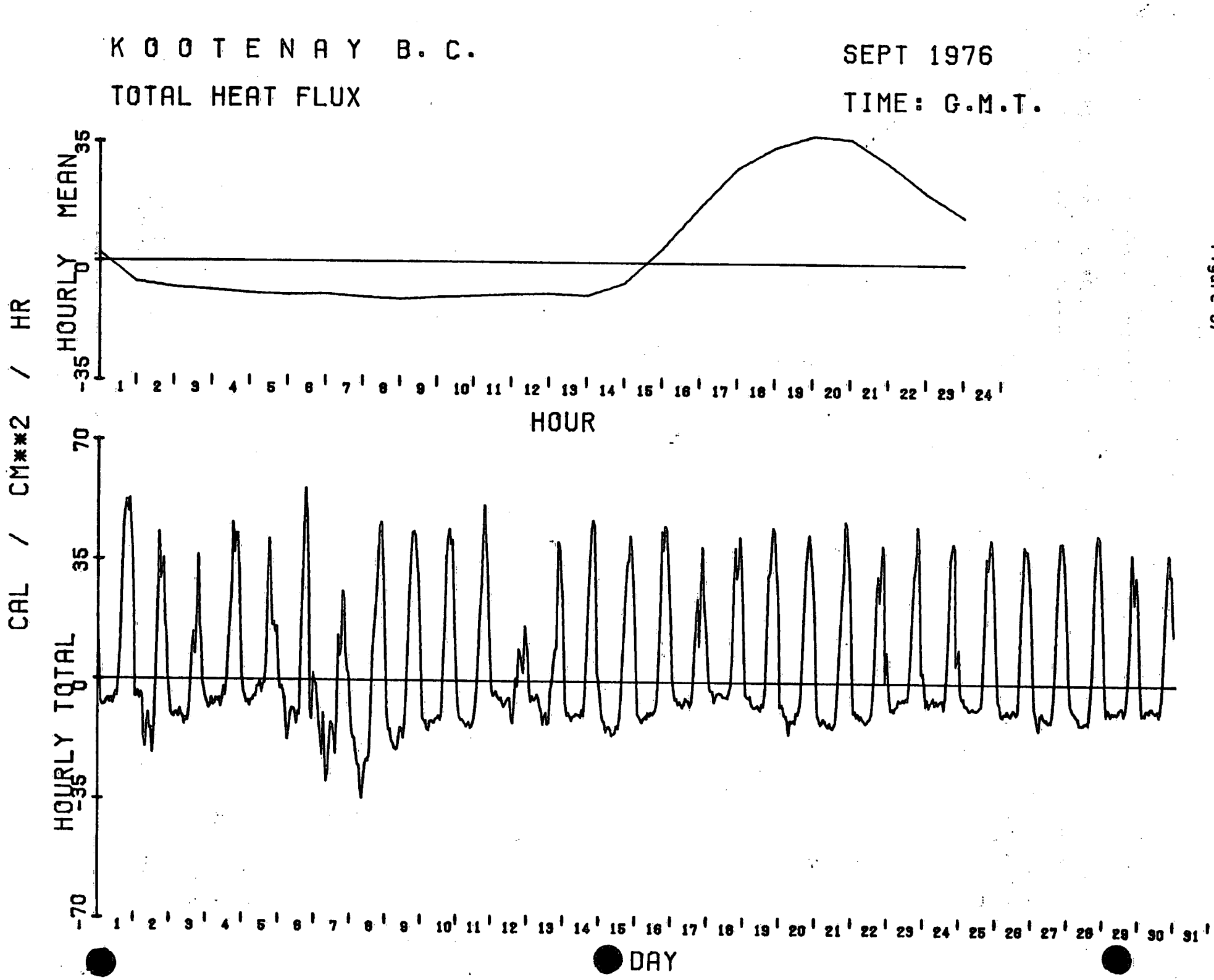

KOOTENAY B.C.
TOTAL HEAT FLUX
SEPT 1976
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 37

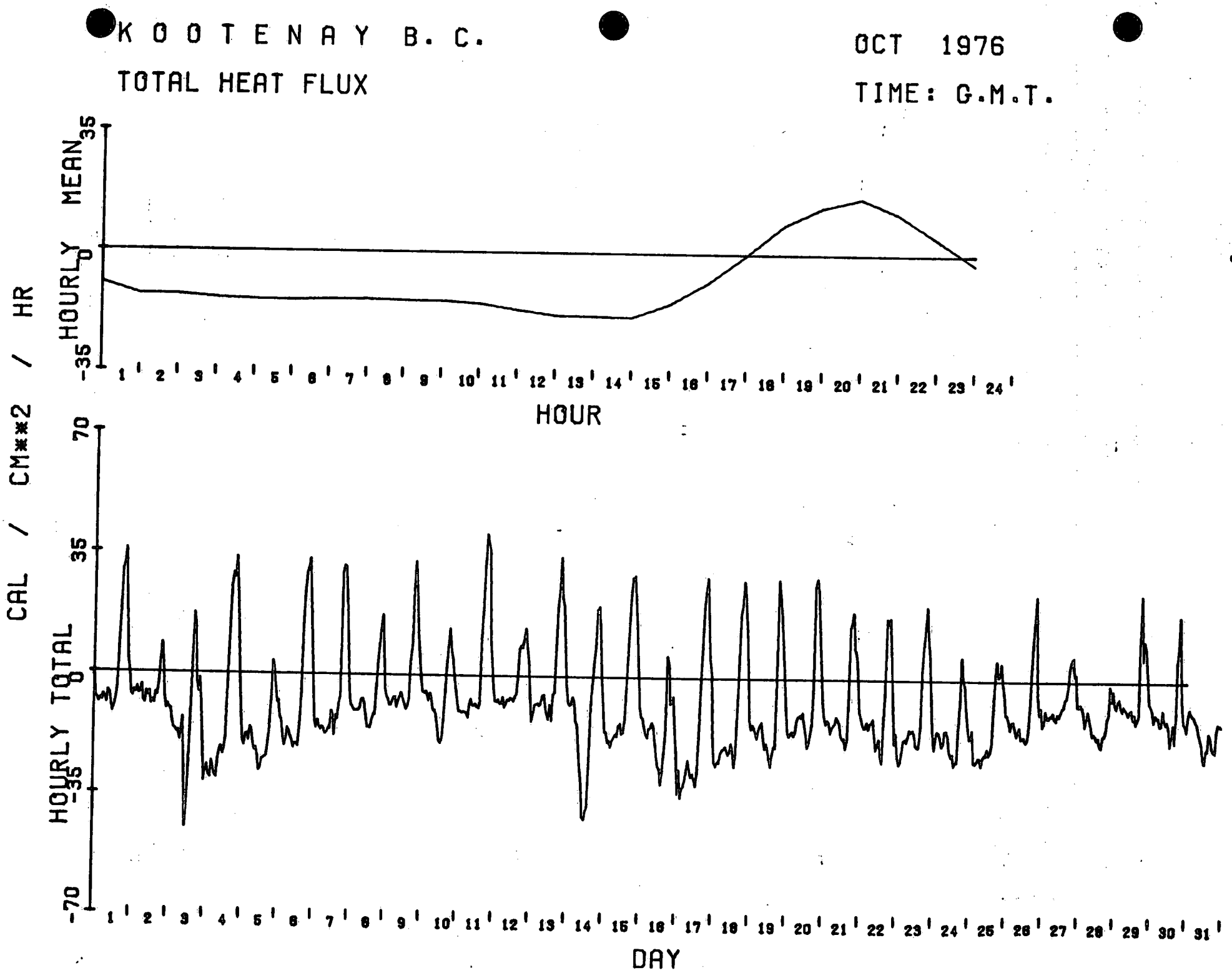

KOOTENAY B.C.
OCT 1976
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 38

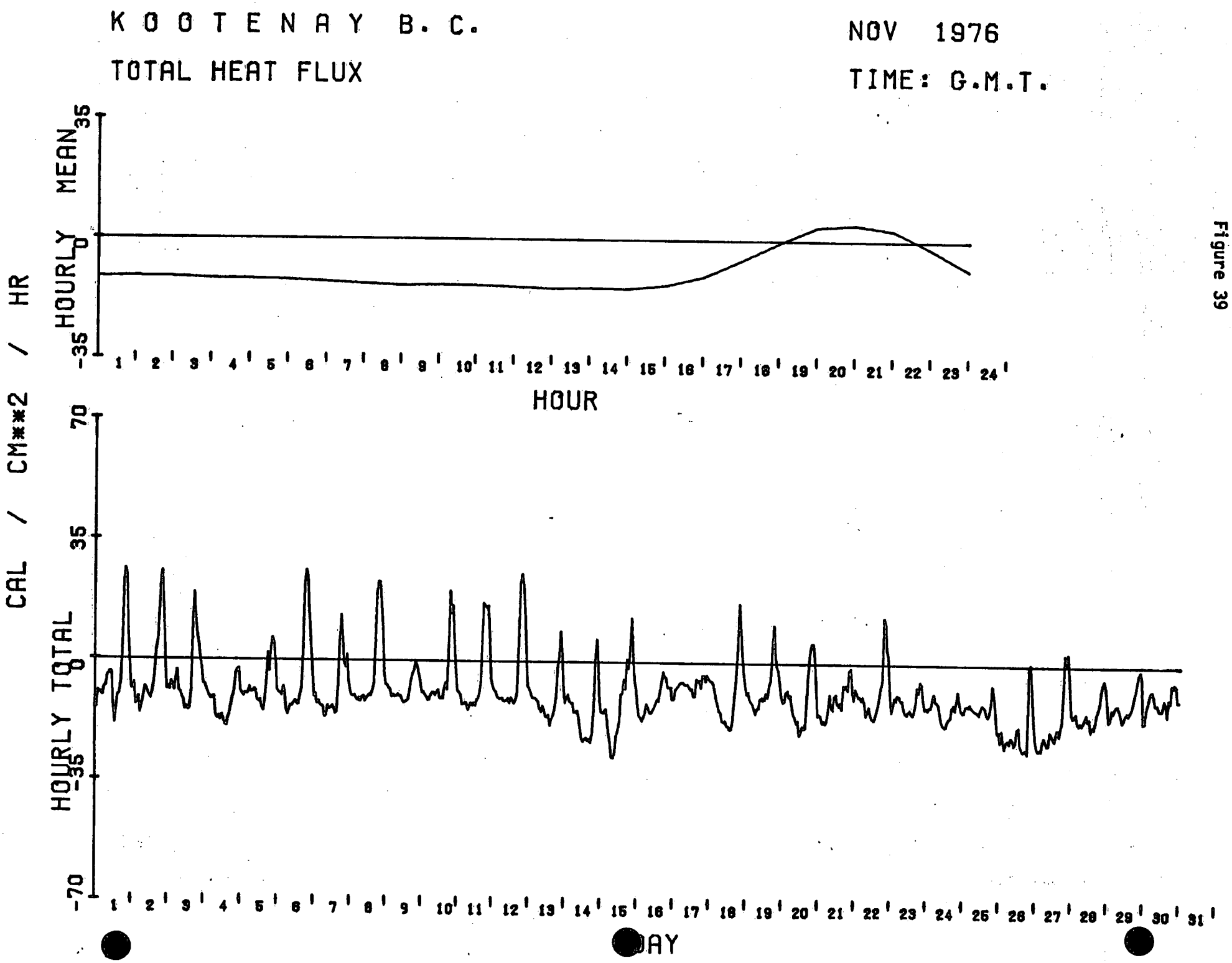

KOOTENAY B. C.
NOV 1976
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
CAL / CM**2 / HR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 39

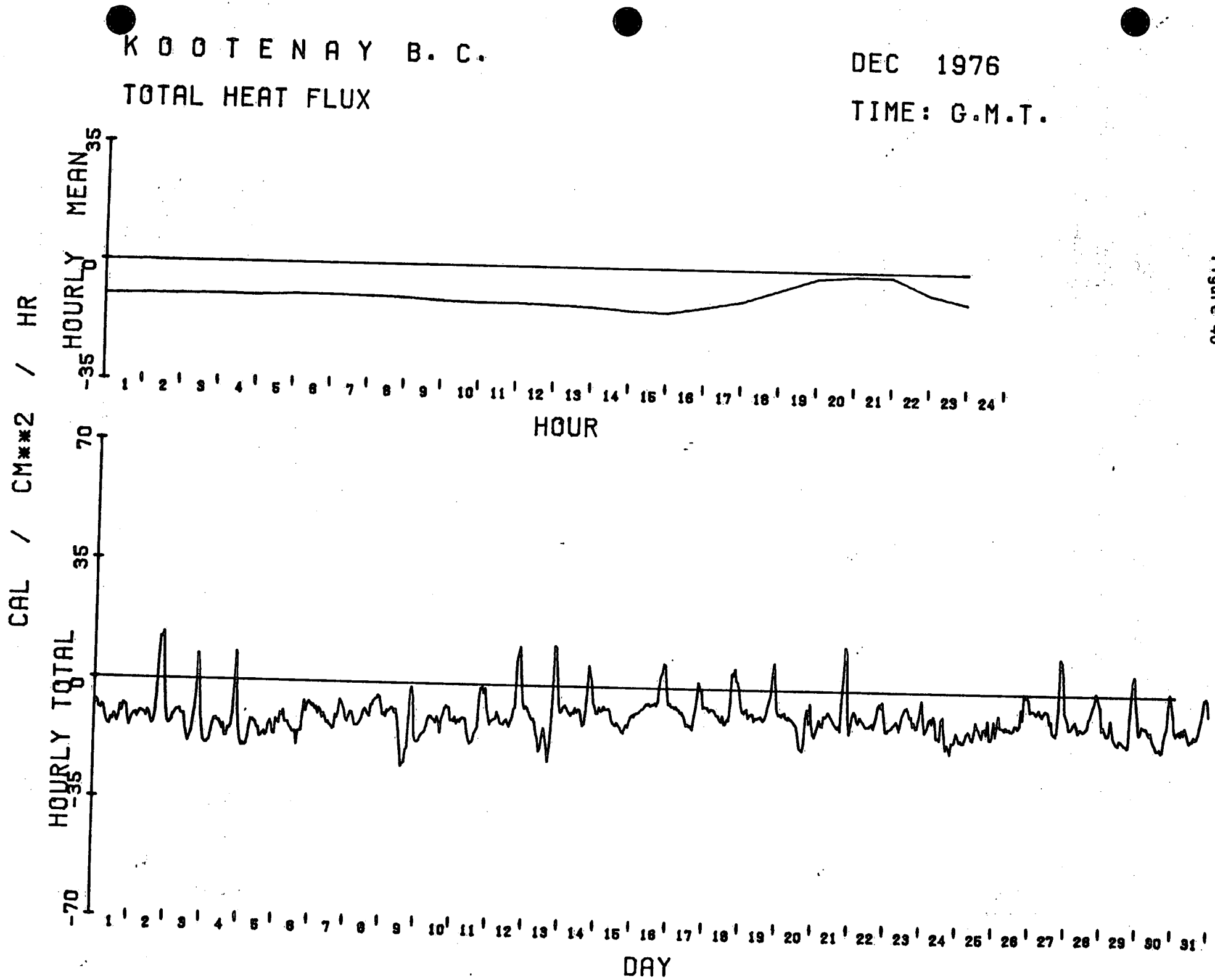

KOOTENAY B. C.
TOTAL HEAT FLUX
DEC 1976
TIME: G.M.T.
CAL / CM**2 / HR
HOURLY MEAN
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 40

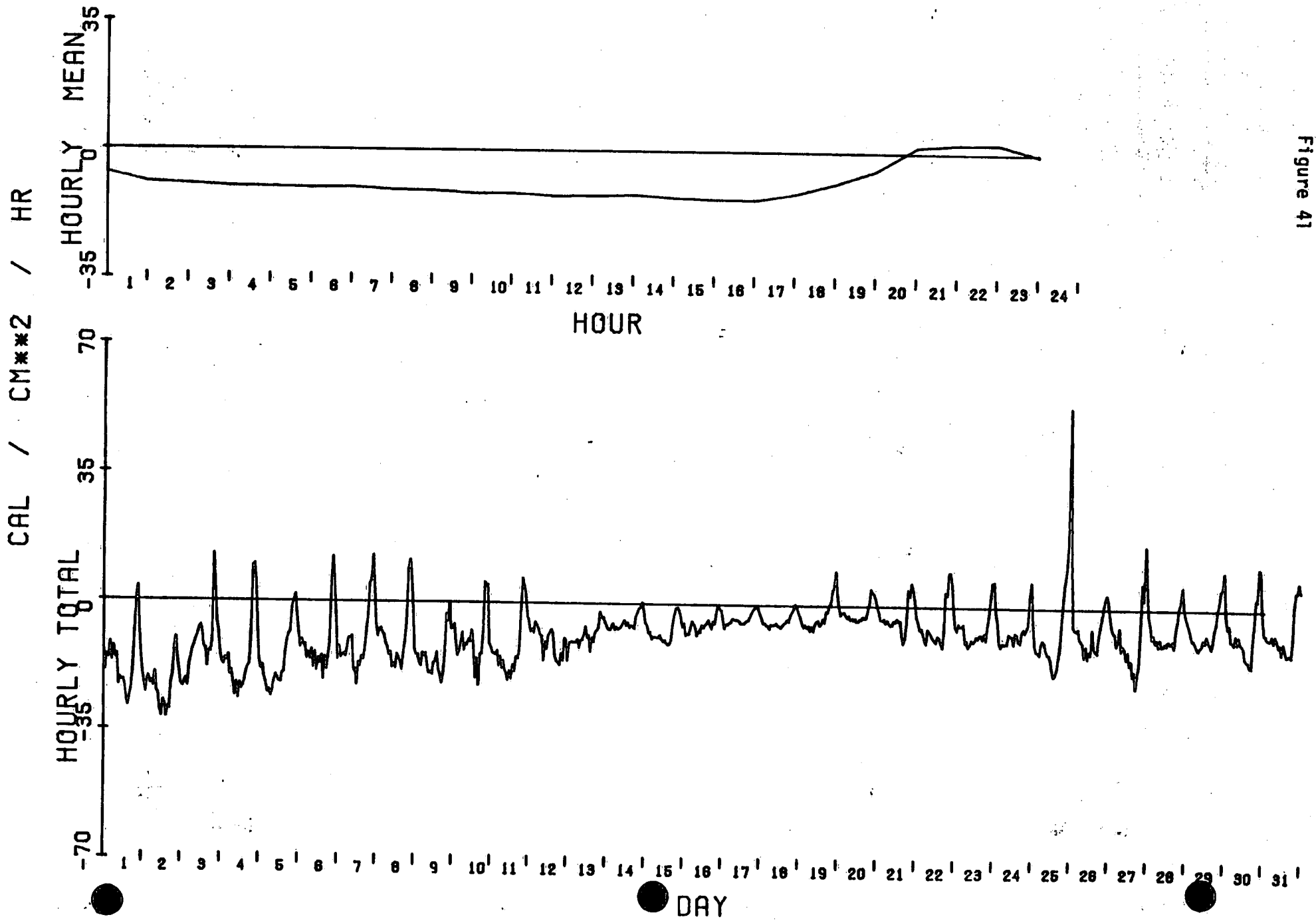

KOOTENAY B.C.
TOTAL HEAT FLUX
JAN 1977
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 41

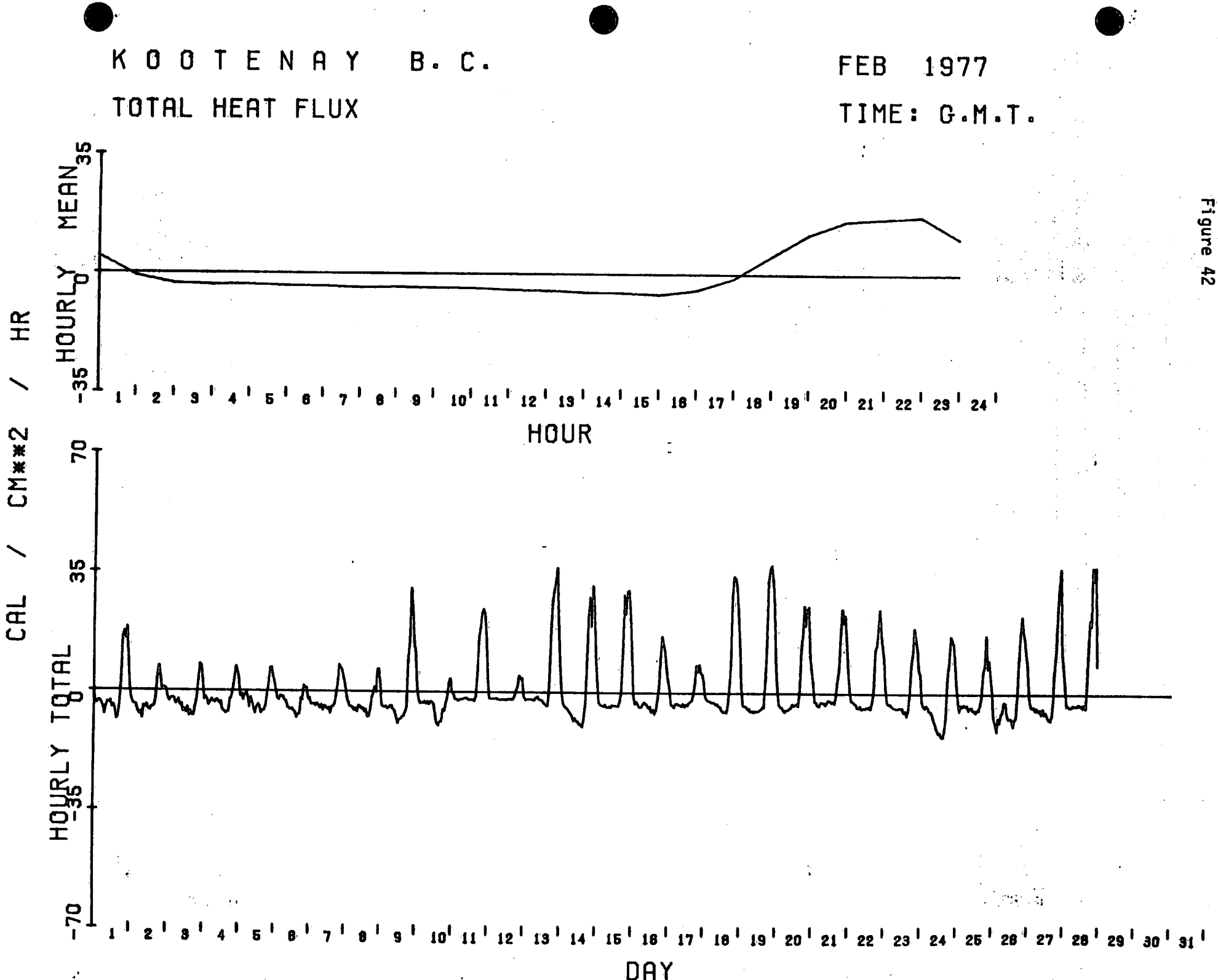

KOOTENAY B. C.
FEB 1977
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
35
0
-35
CAL / CM**2 / HR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 42

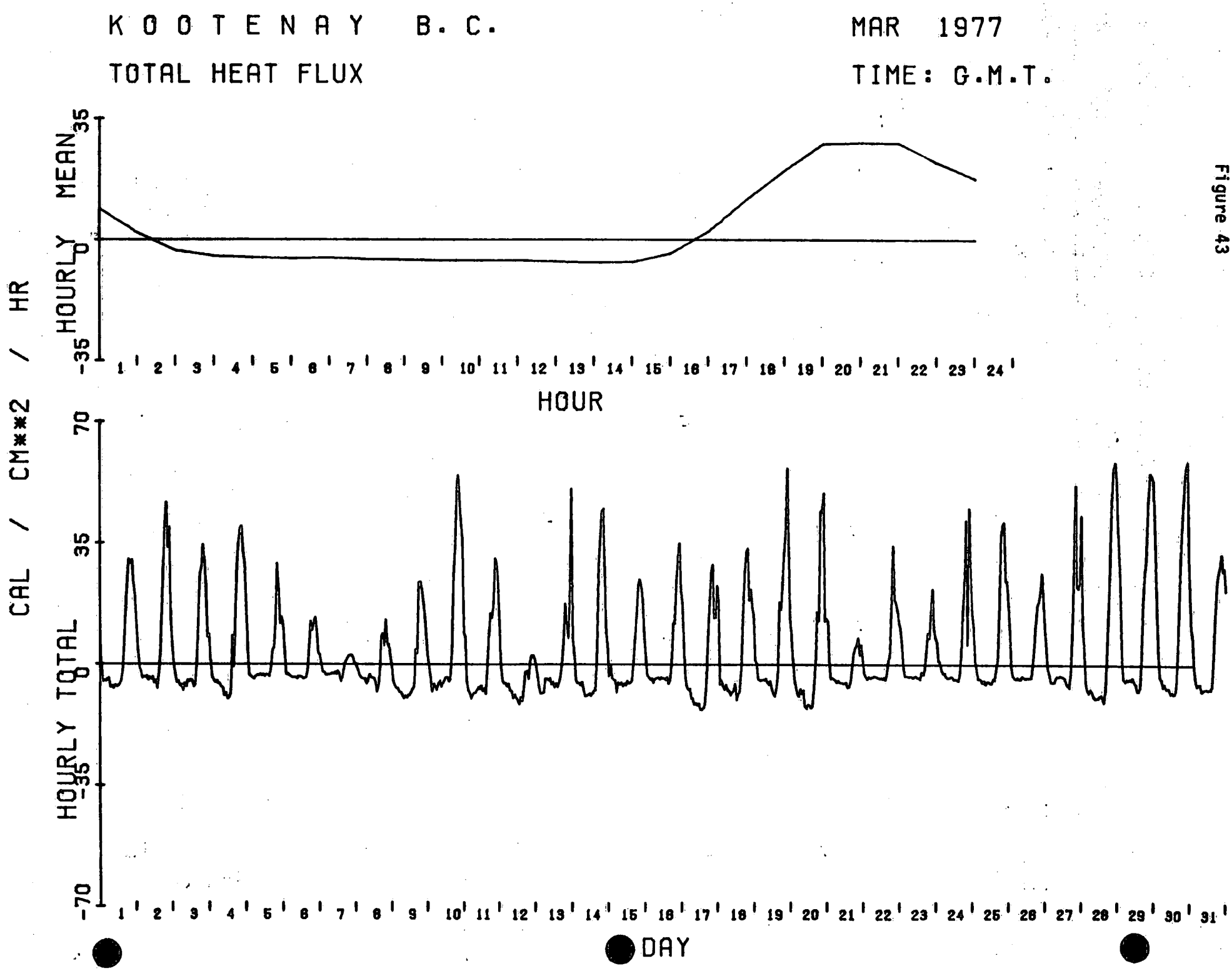

KOOTENAY B.C.
MAR 1977
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 43

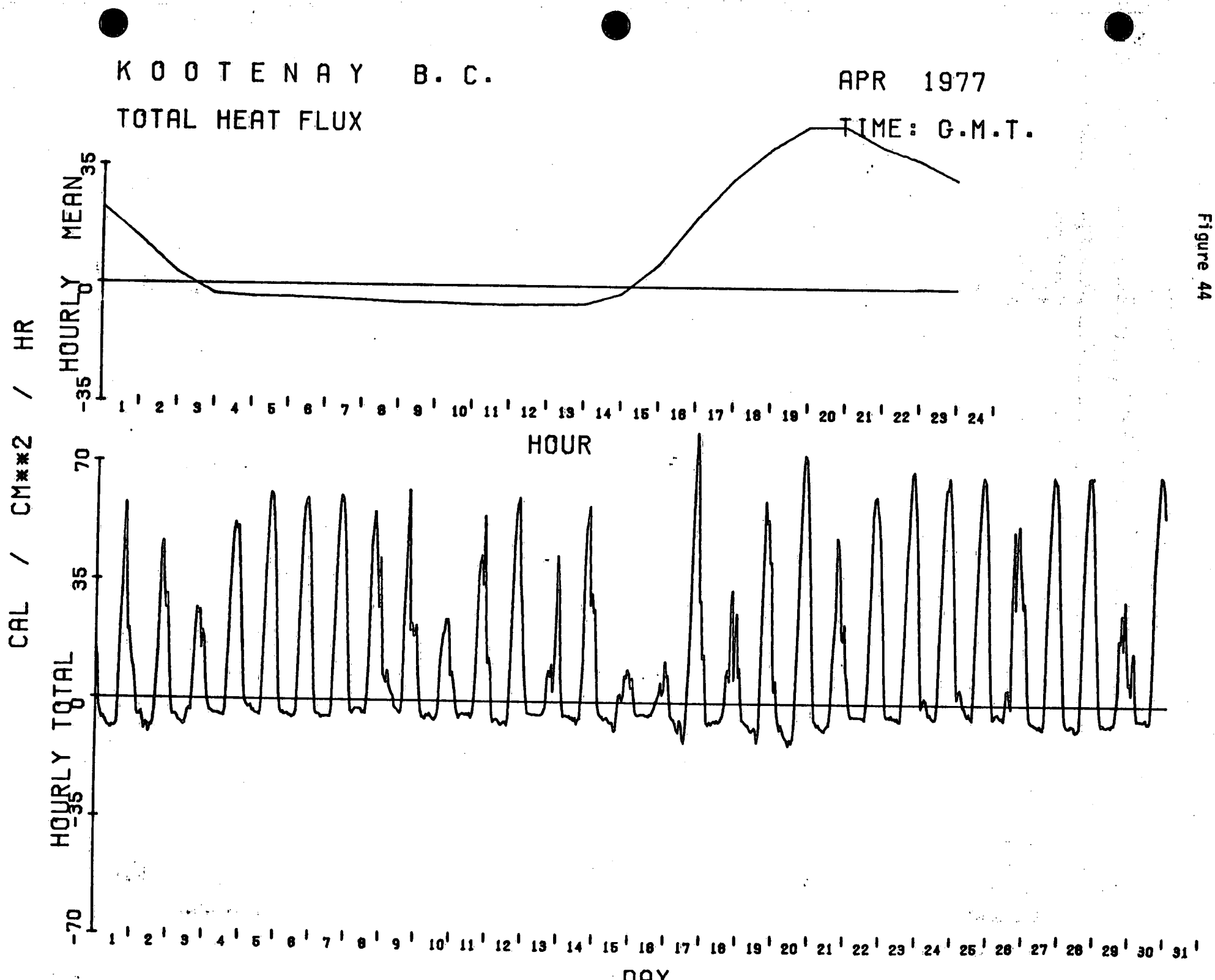

KOOTENAY B. C.
APR 1977
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
CAL / CM**2 / HR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 44

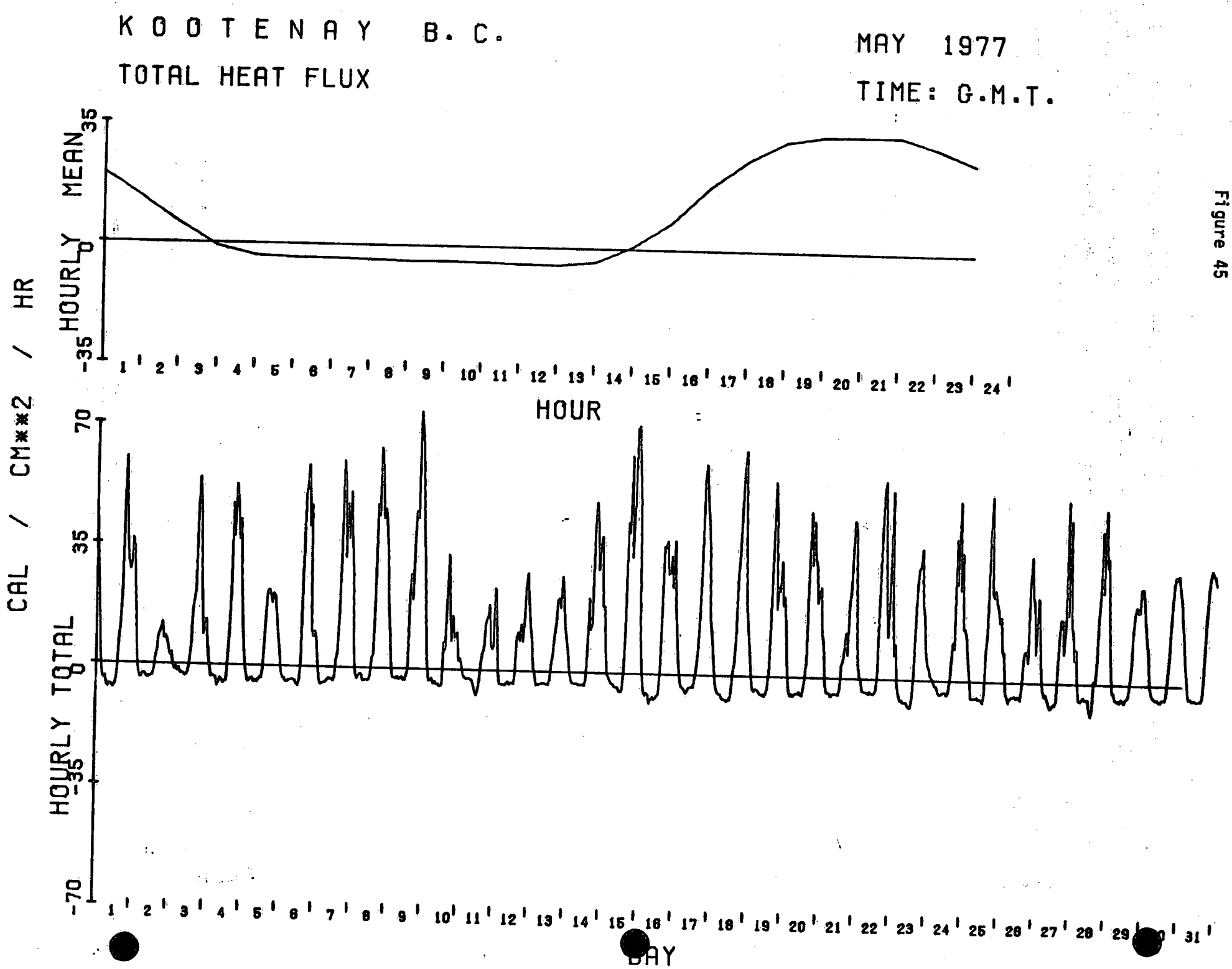

KOOTENAY B.C.
TOTAL HEAT FLUX
MAY 1977
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 45

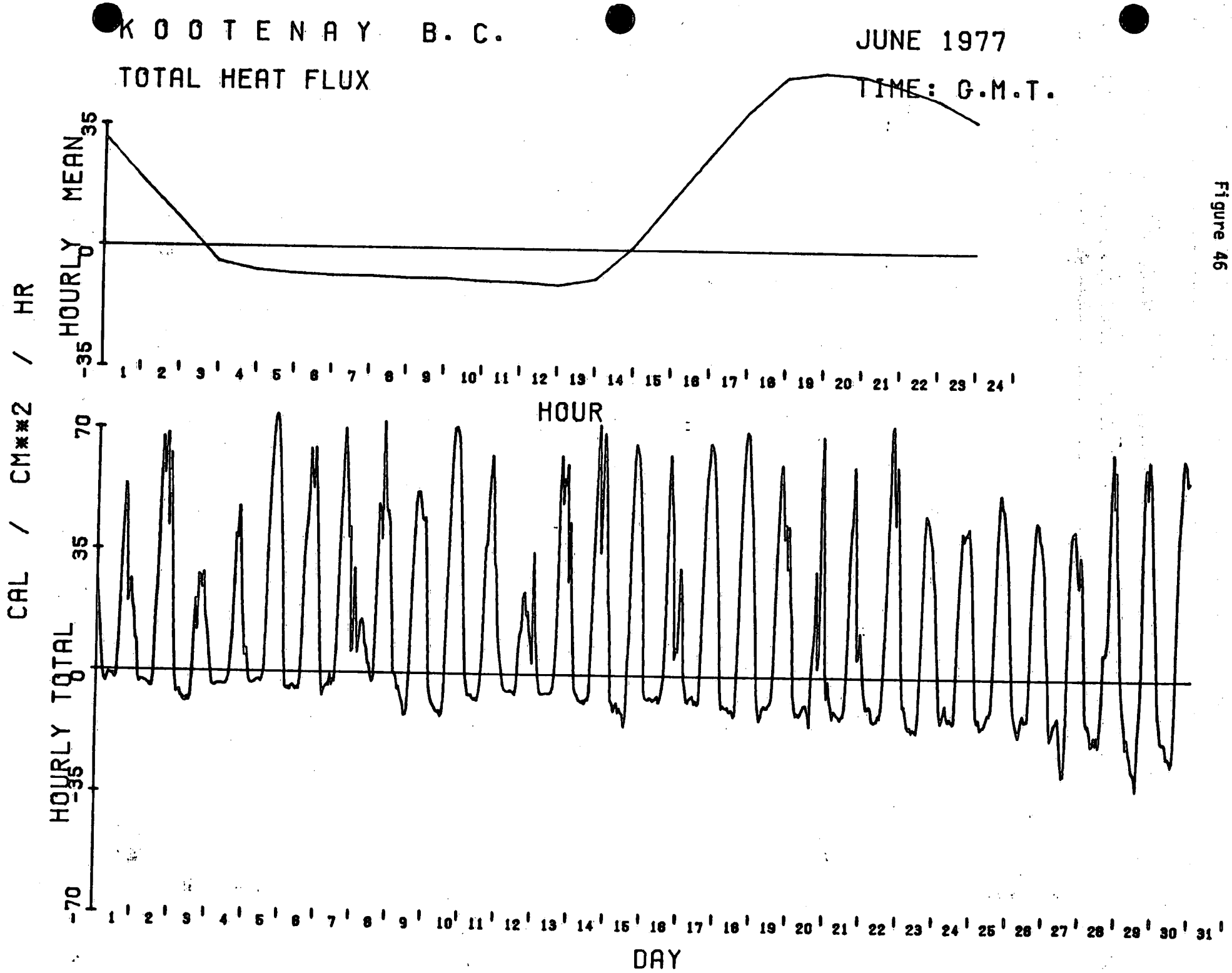

KOOTENAY B.C.
JUNE 1977
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
CAL / CM**2 / HR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 46

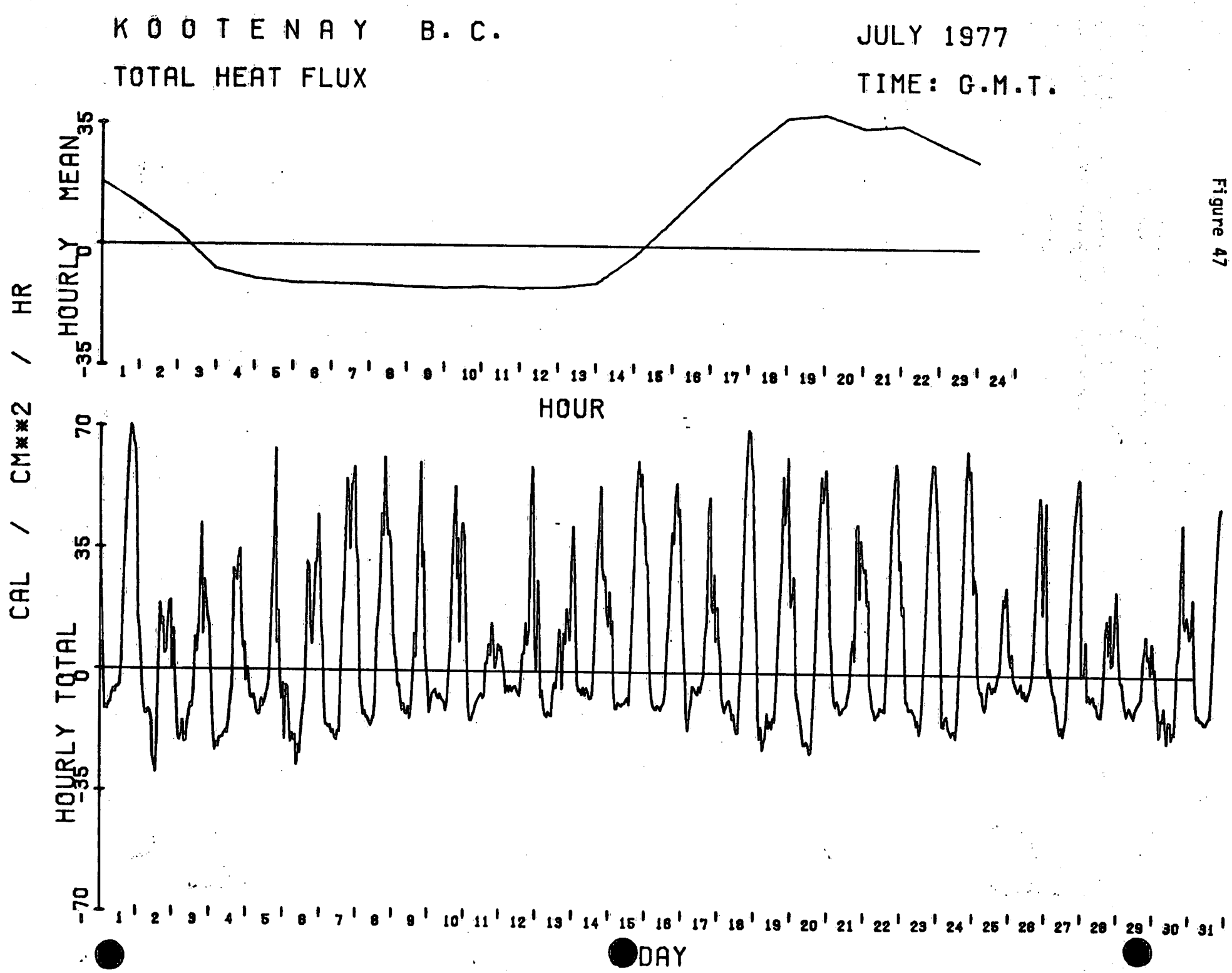

KOOTENAY B. C.
JULY 1977
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
35
0
-35
CAL / CM**2 / HR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 47

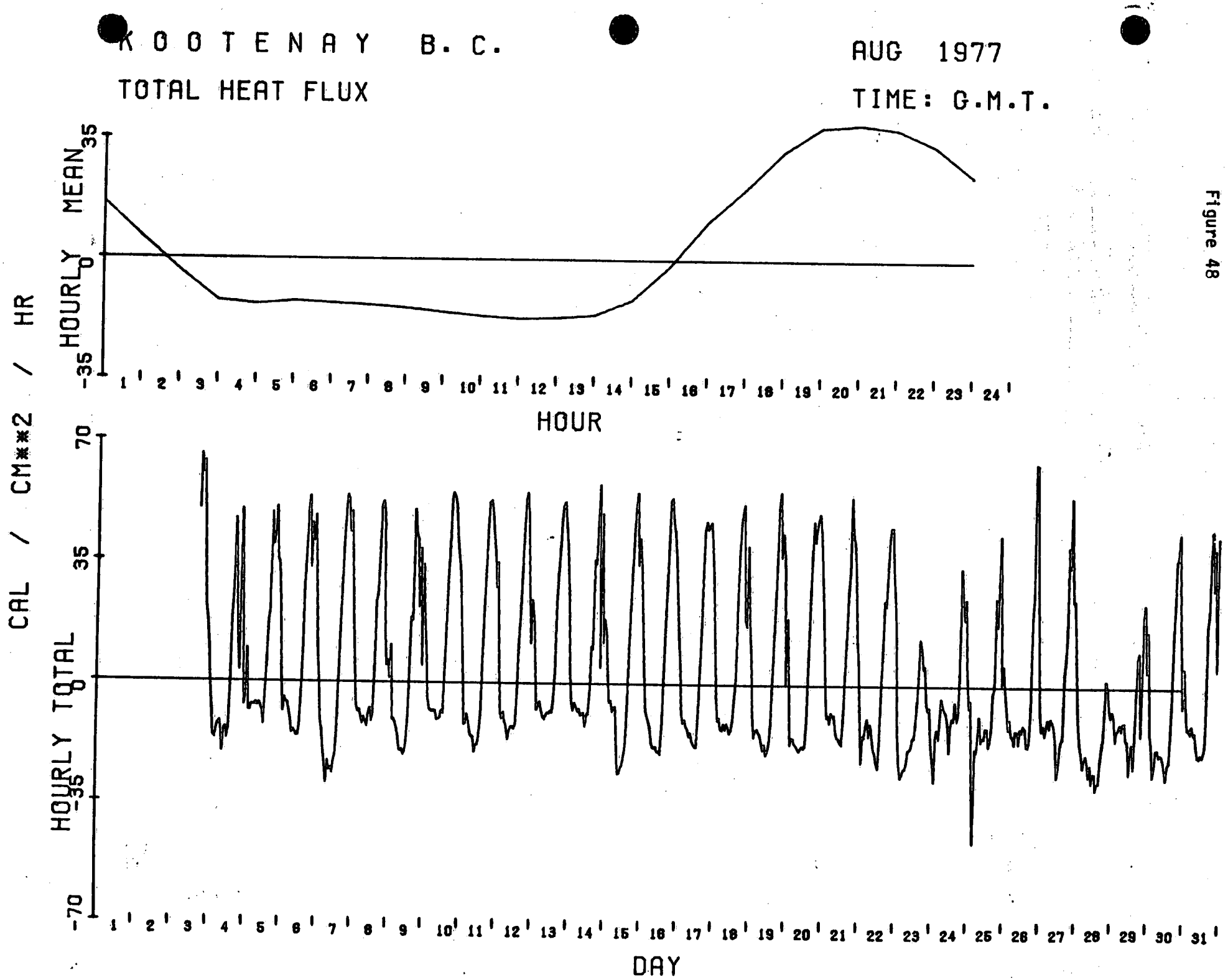

KOOTENAY B. C.
AUG 1977
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 48

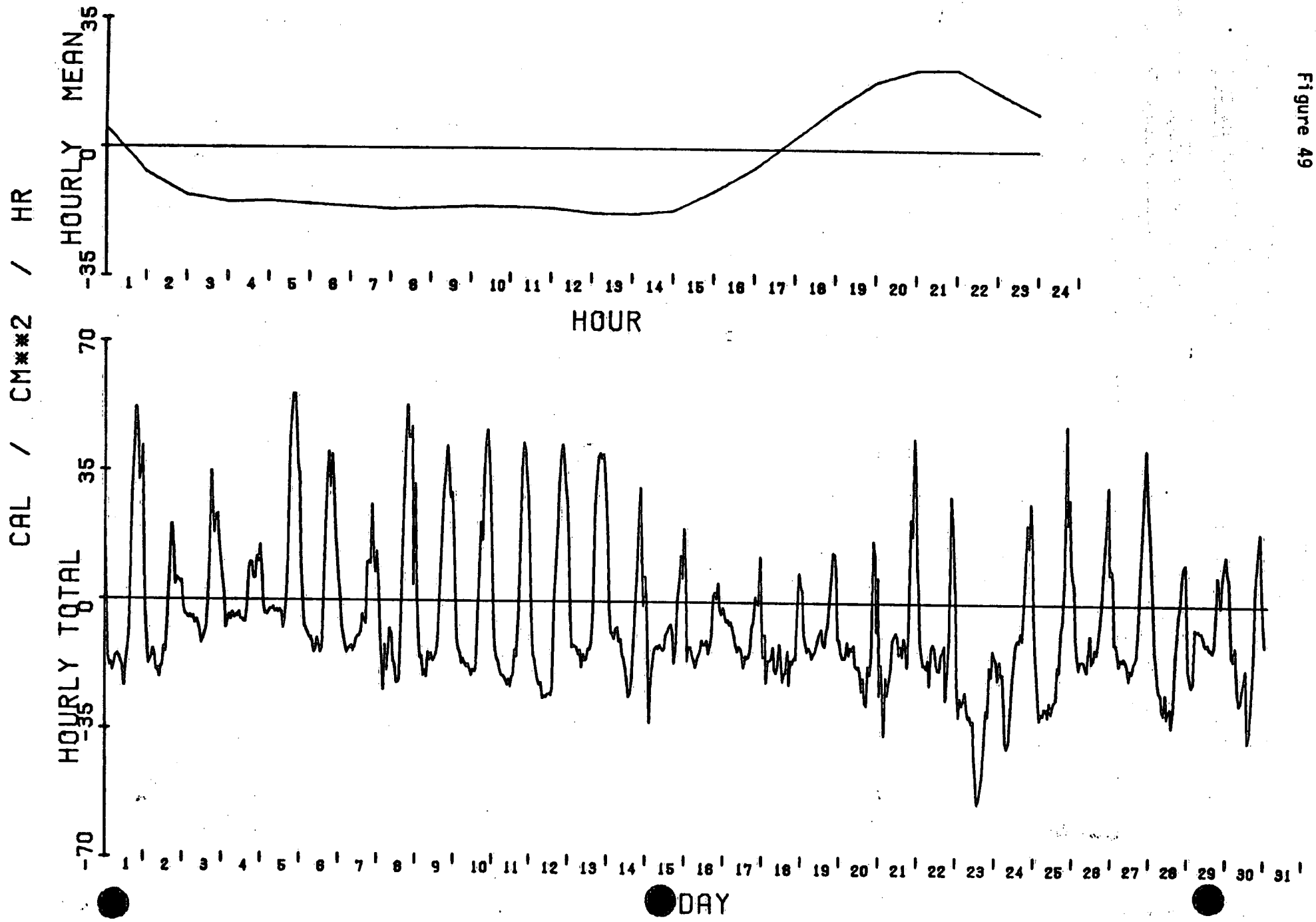

KOOTENAY B. C.
SEPT 1977
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
CAL / CM**2 / HR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 49

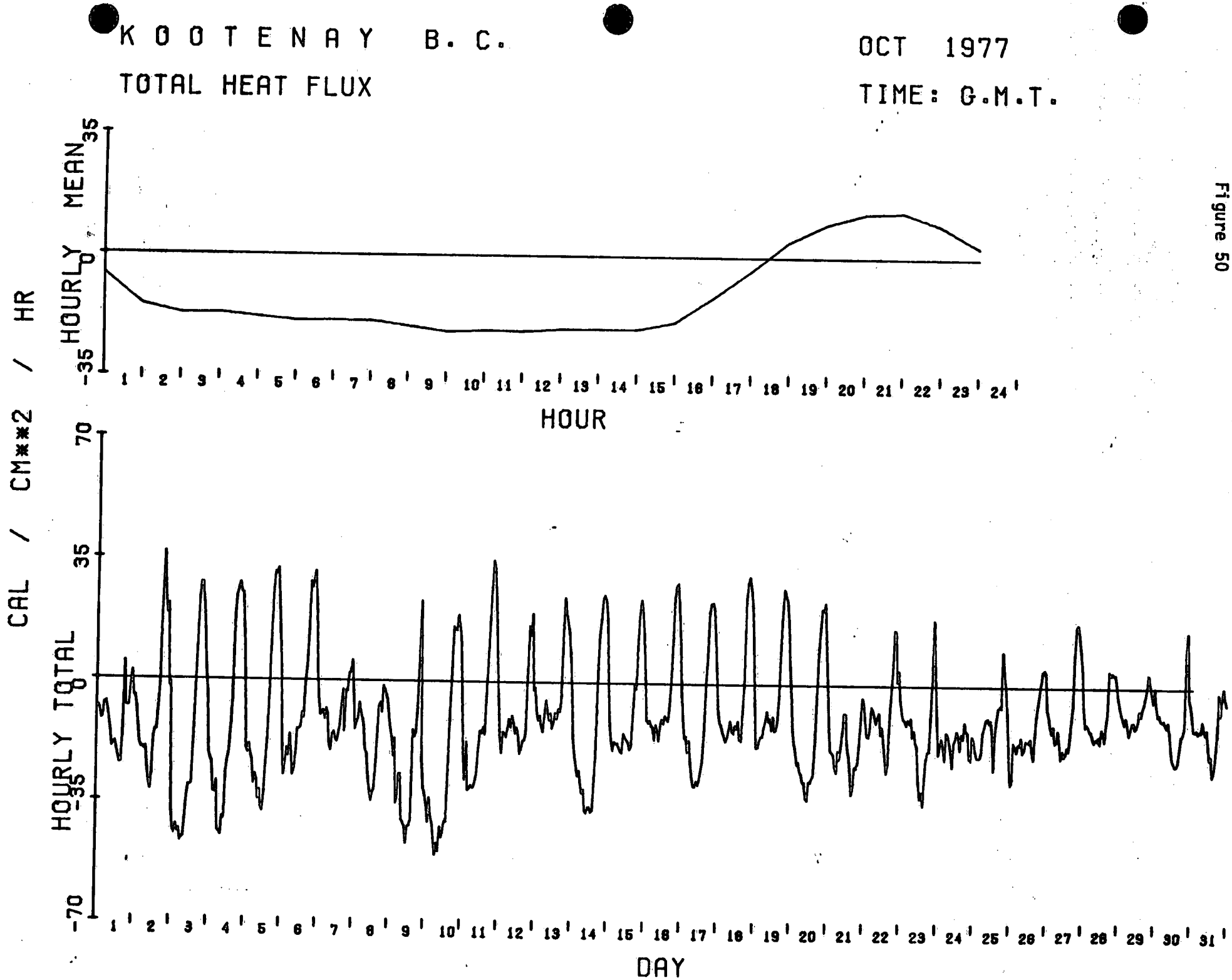

KOOTENAY B.C.
OCT 1977
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 50

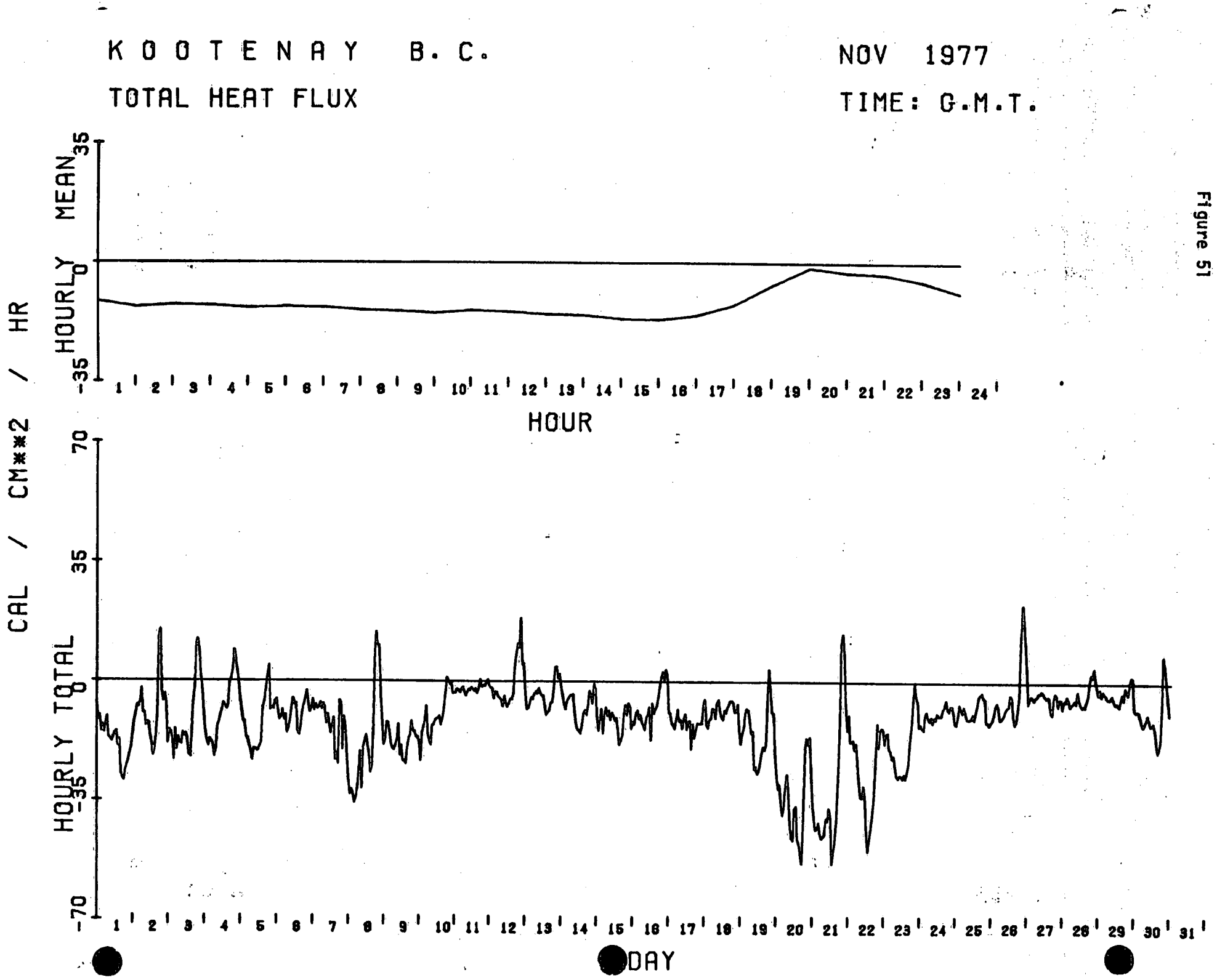
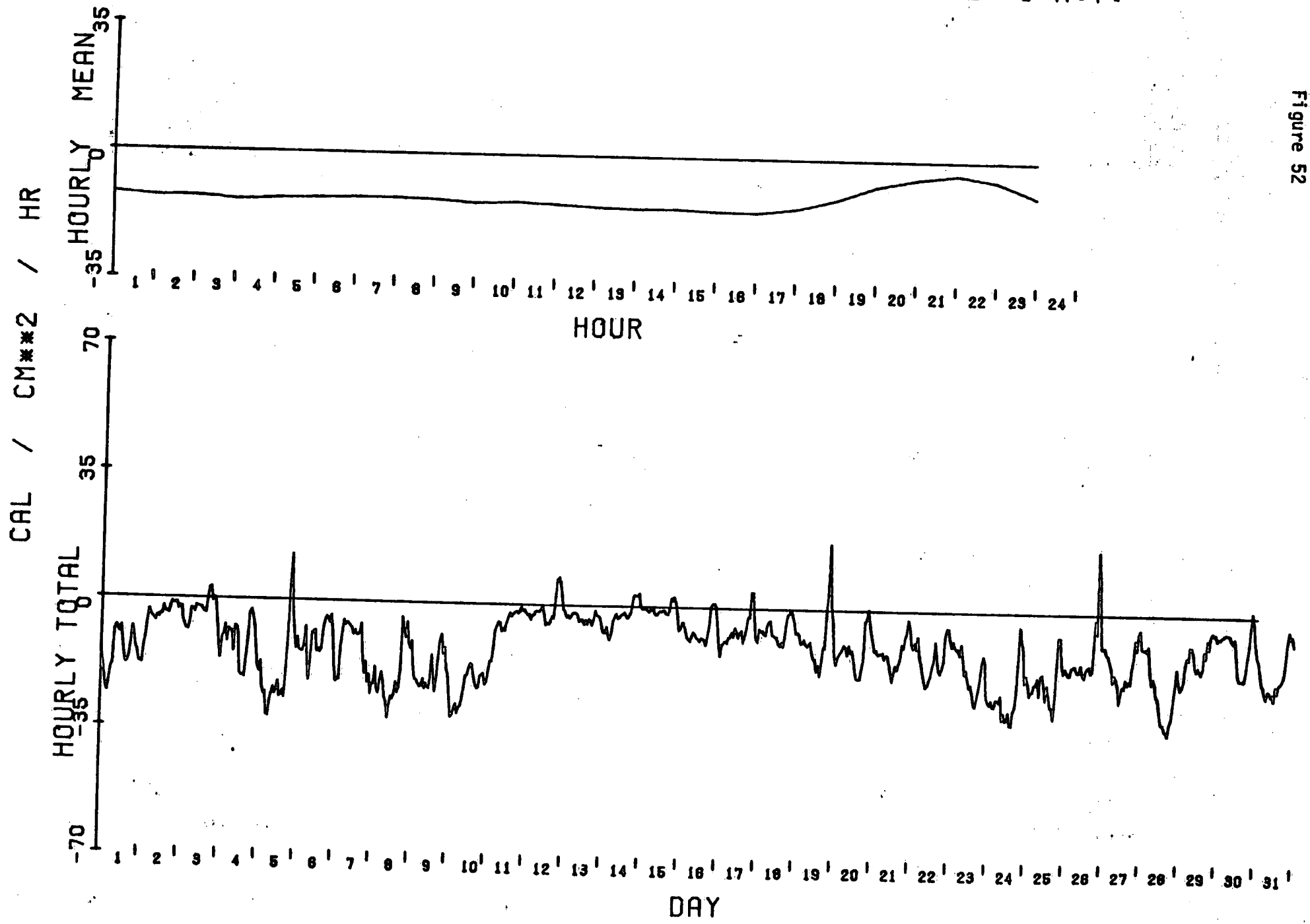

KOOTENAY B.C.
NOV 1977
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
35
0
-35
CAL / CM**2 / HR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 51

Figure 52


KOOTENAY B.C.
TOTAL HEAT FLUX
DEC 1977
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

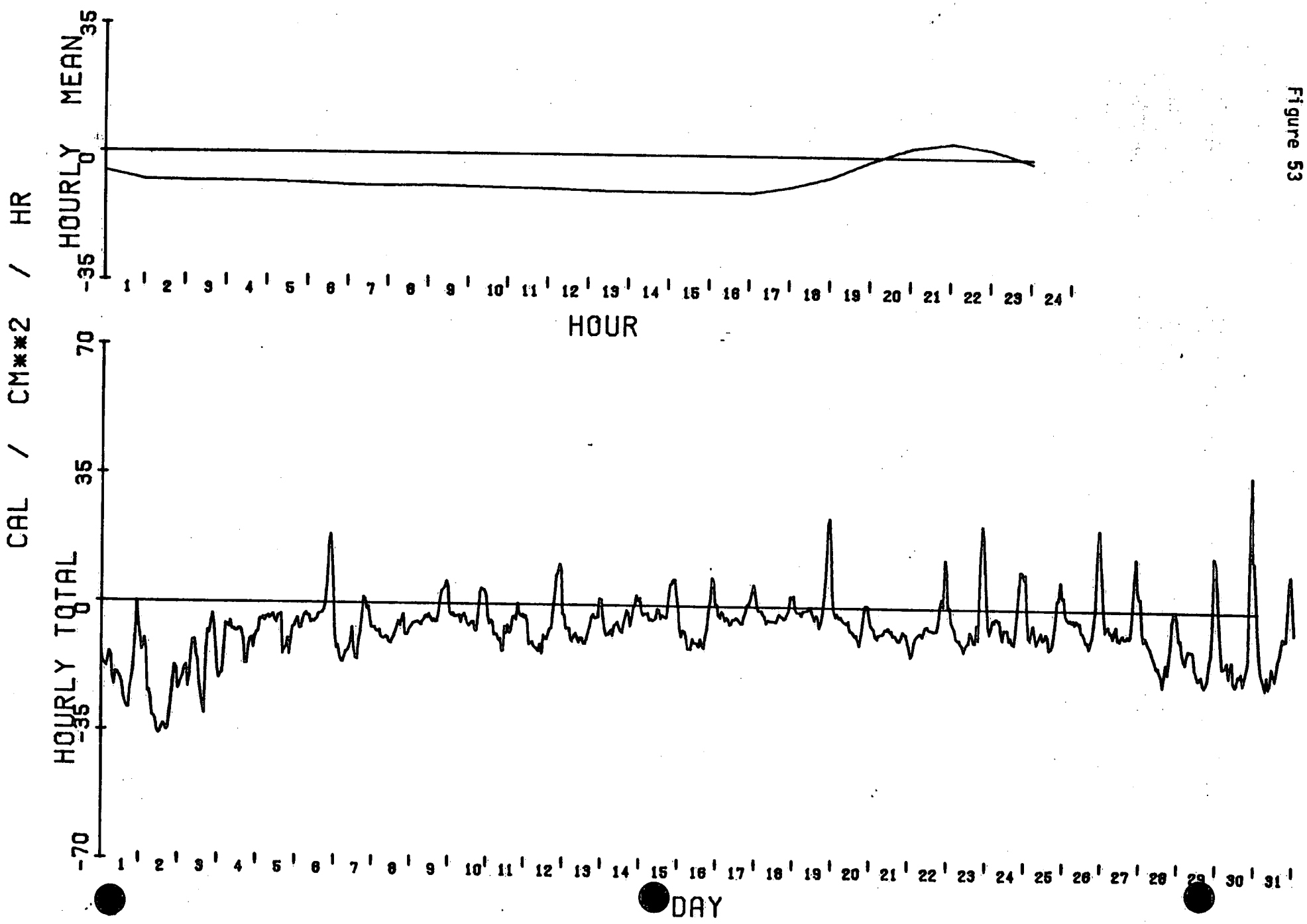

KOOTENAY B.C.
TOTAL HEAT FLUX
JAN 1978
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 53

KOOTENAY B. C.

FEB 1978

TOTAL HEAT FLUX

TIME: G.M.T.

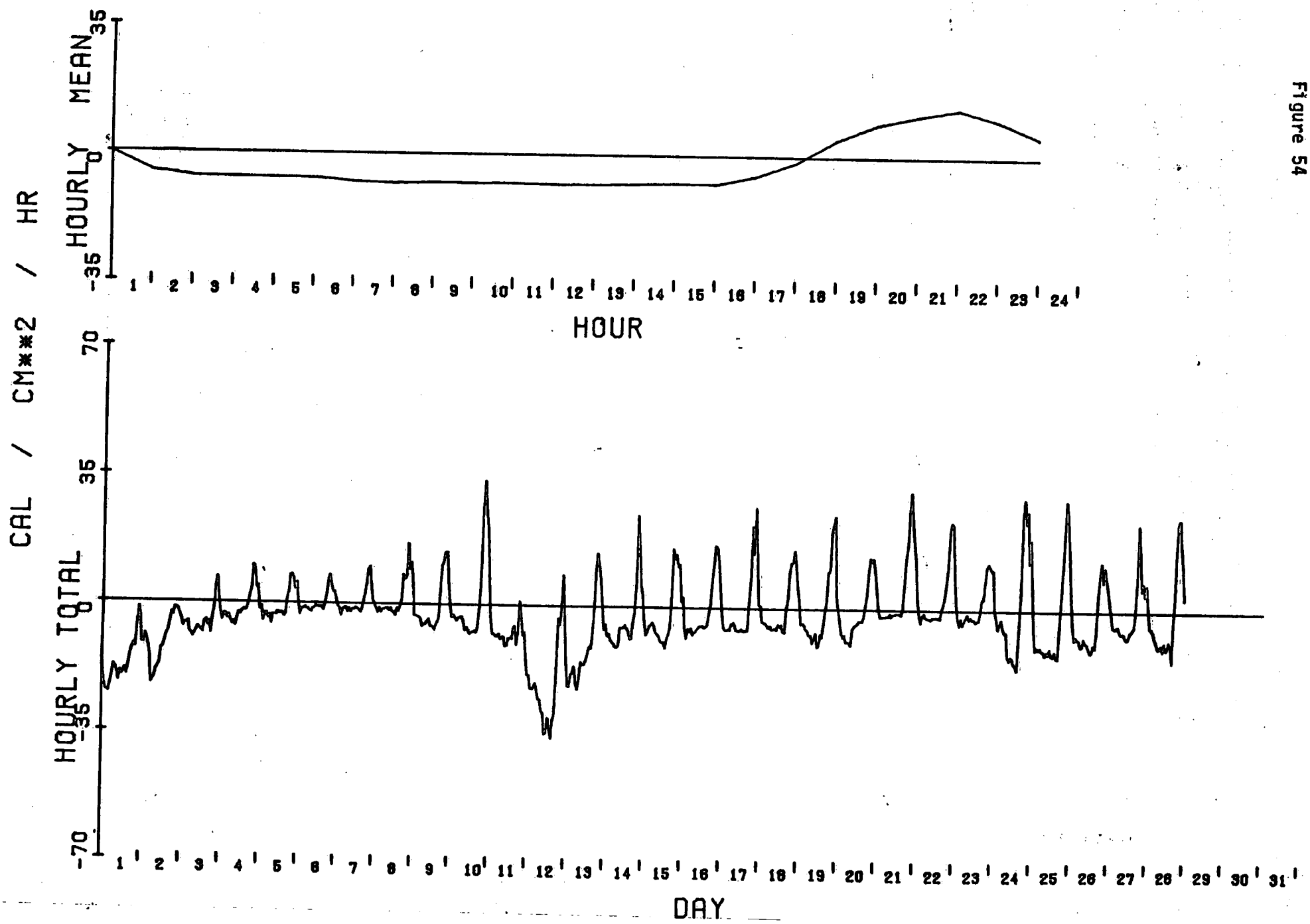


Figure 54

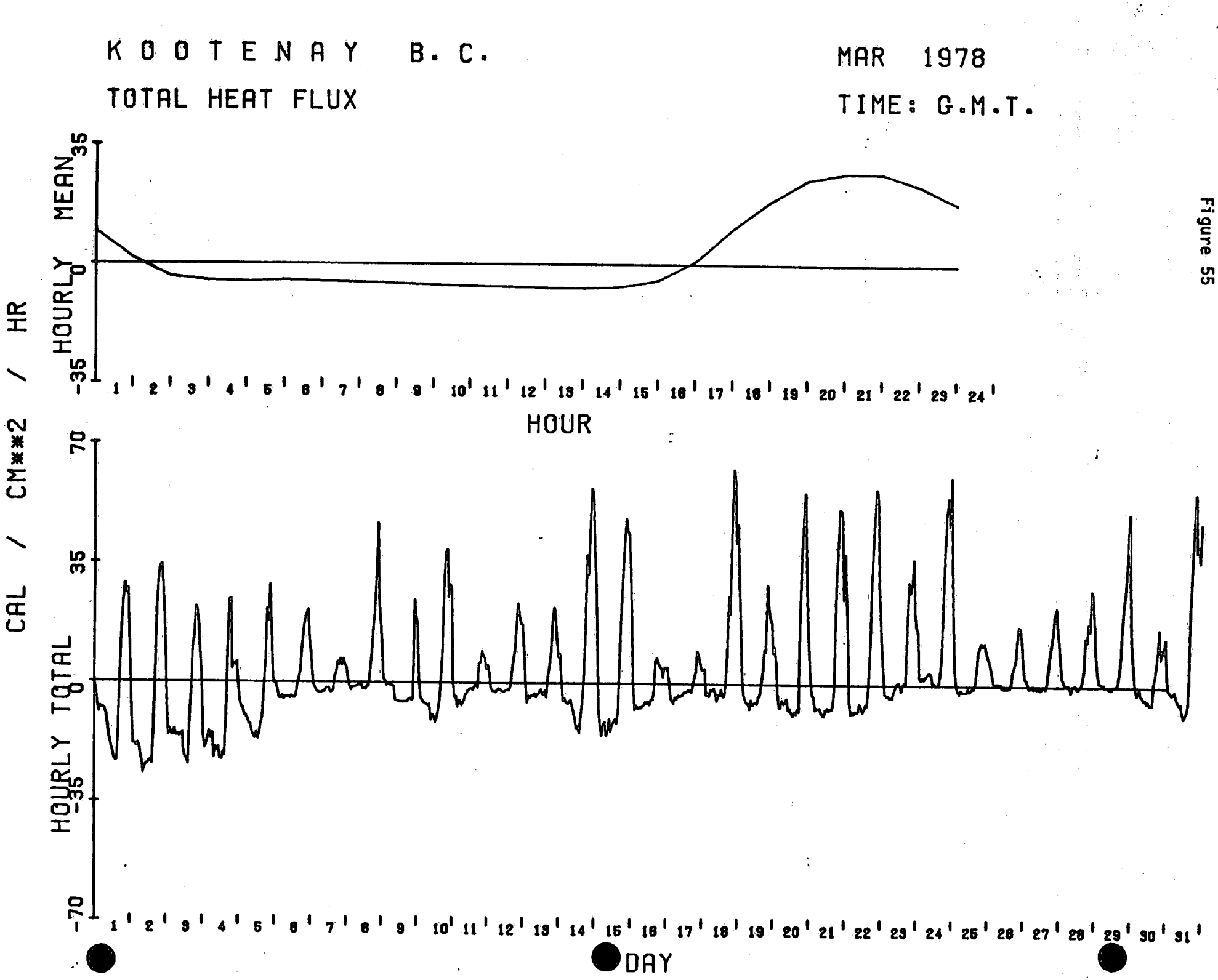

KOOTENAY B.C.
TOTAL HEAT FLUX
MAR 1978
TIME: G.M.T.
HOURLY MEAN
35
0
-35
CAL / CM**2 / HR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 55

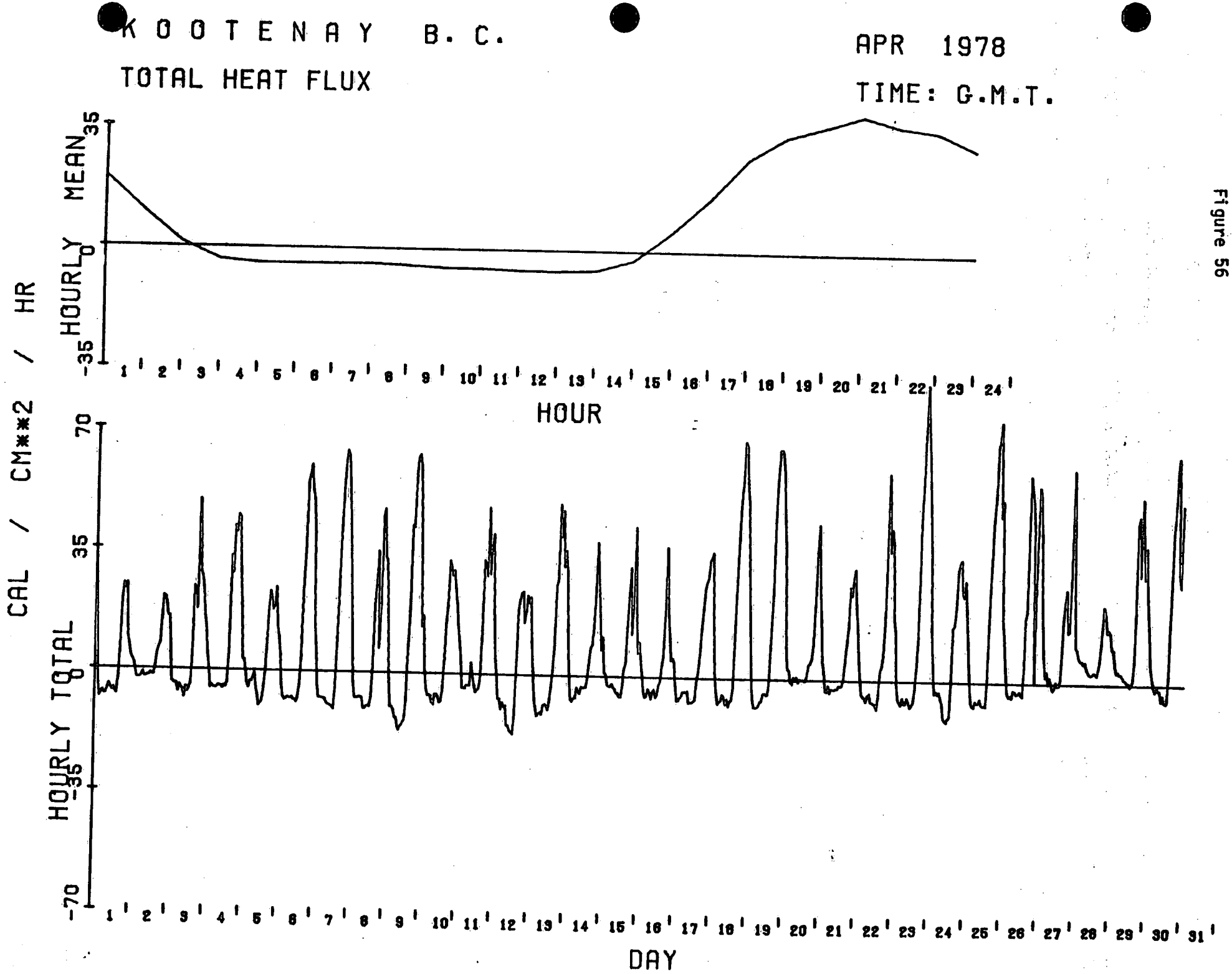

KOOTENAY B. C.
TOTAL HEAT FLUX
APR 1978
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 56

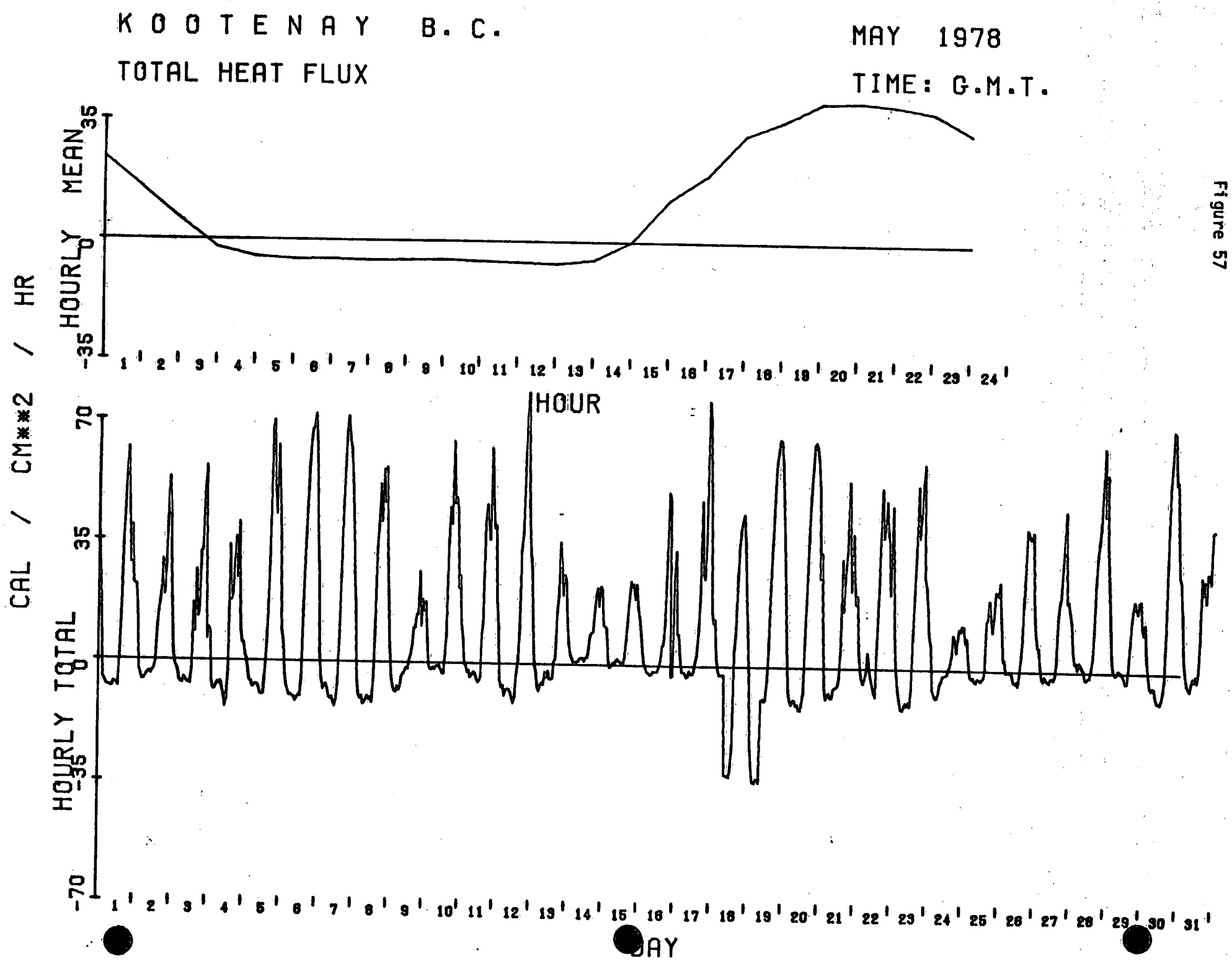

KOOTENAY B.C.
TOTAL HEAT FLUX
MAY 1978
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 57

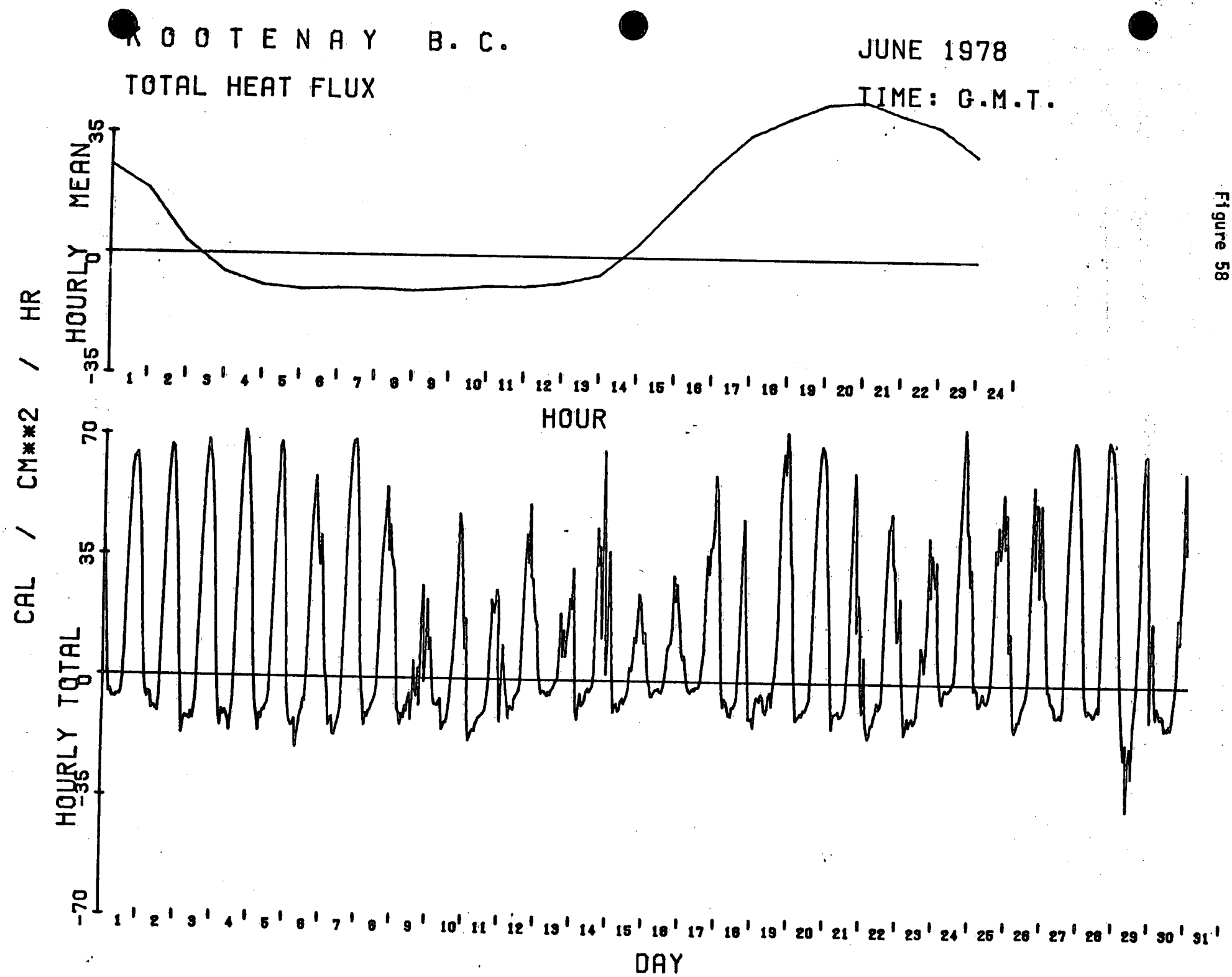

KOOTENAY B. C.
JUNE 1978
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
CAL / CM**2 / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 58

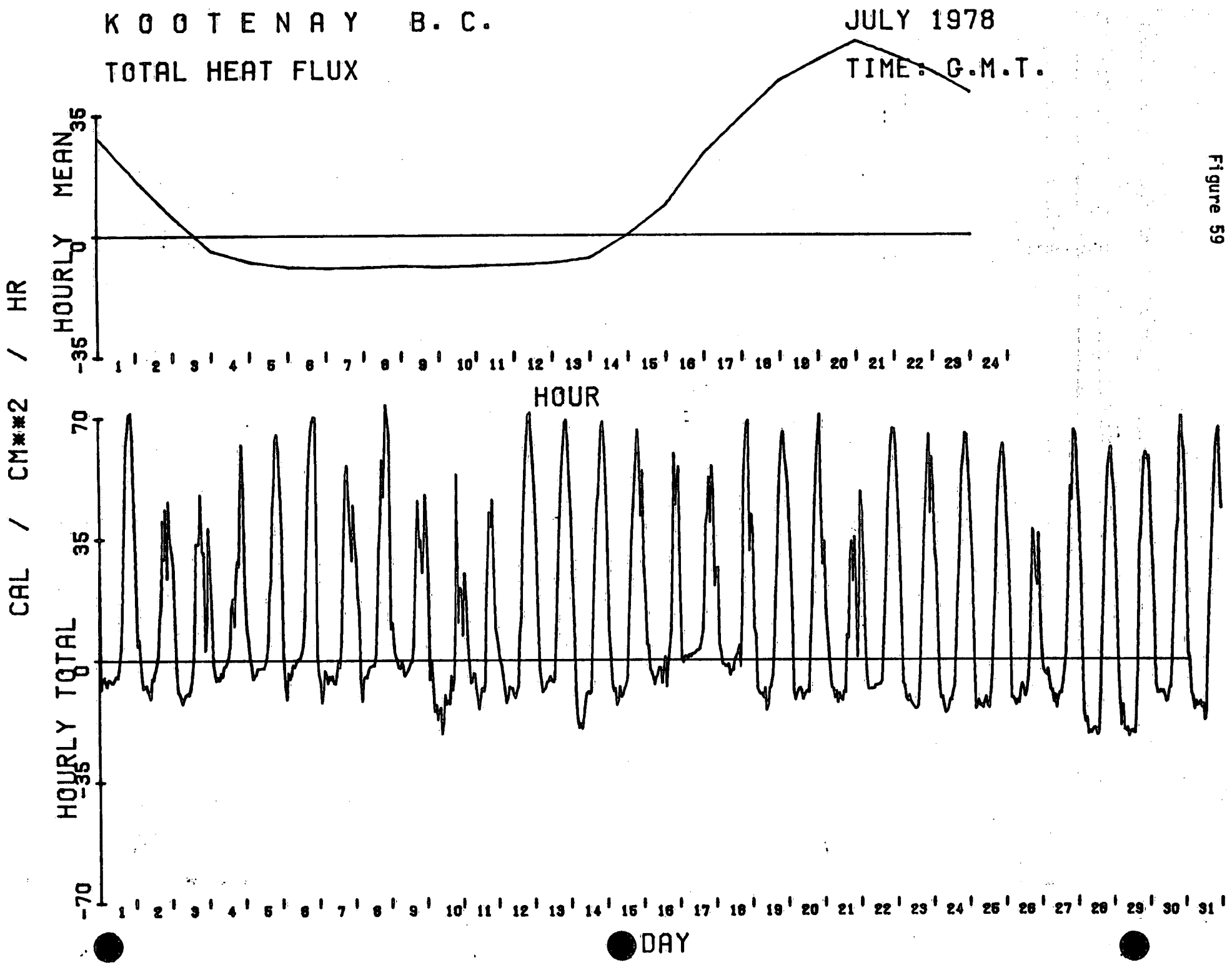

KOOTENAY B.C.
JULY 1978
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN / HR
35
0
-35
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL / CM**2 / CAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 59

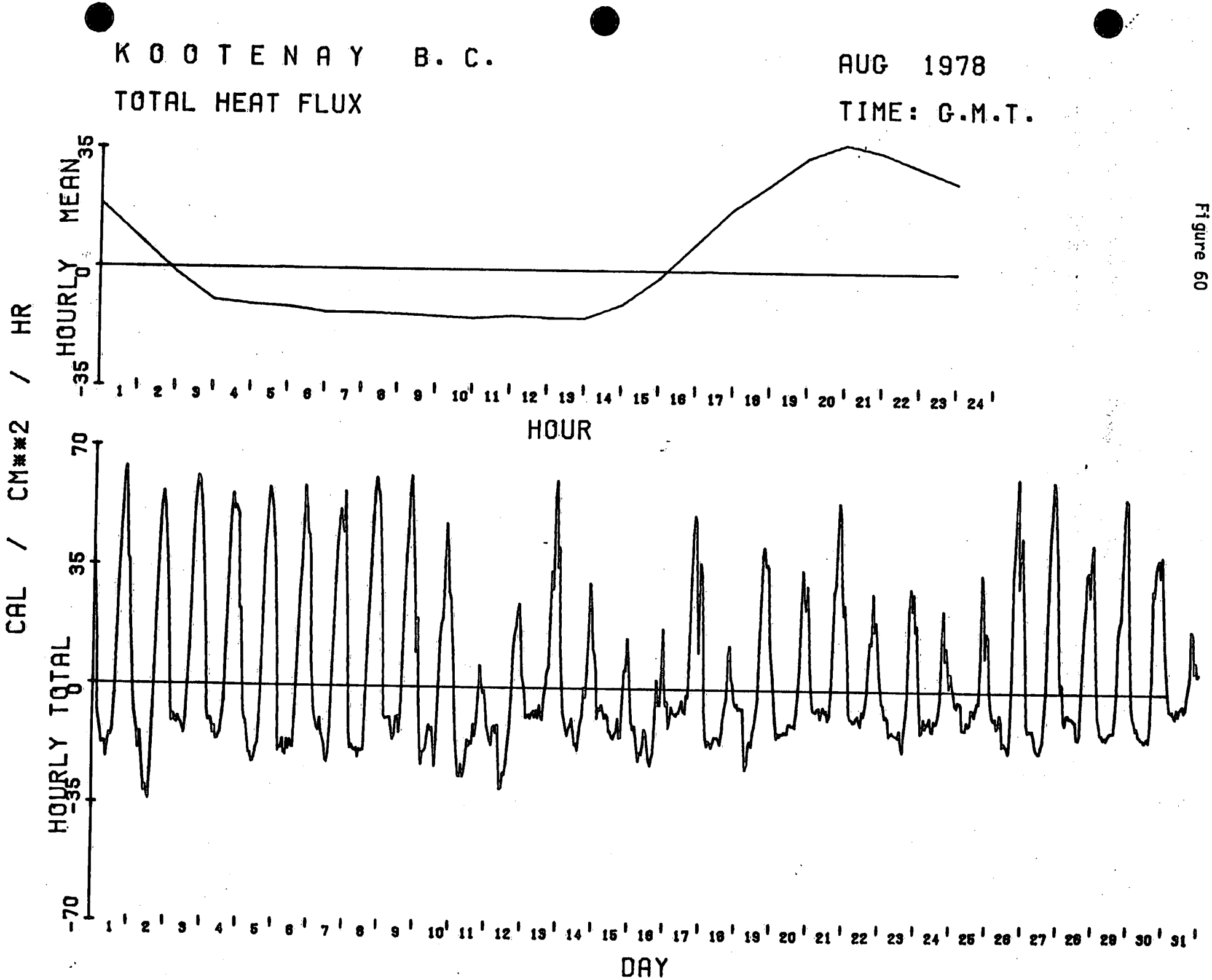

KOOTENAY B. C.
AUG 1978
TOTAL HEAT FLUX
TIME: G.M.T.
HOURLY MEAN
35
0
-35
CAL / CM**2 / HR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR
HOURLY TOTAL
70
35
0
-35
-70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY

Figure 60

K O O T E N A Y B. C. SEPT 1978

TOTAL HEAT FLUX TIME: G.M.T.

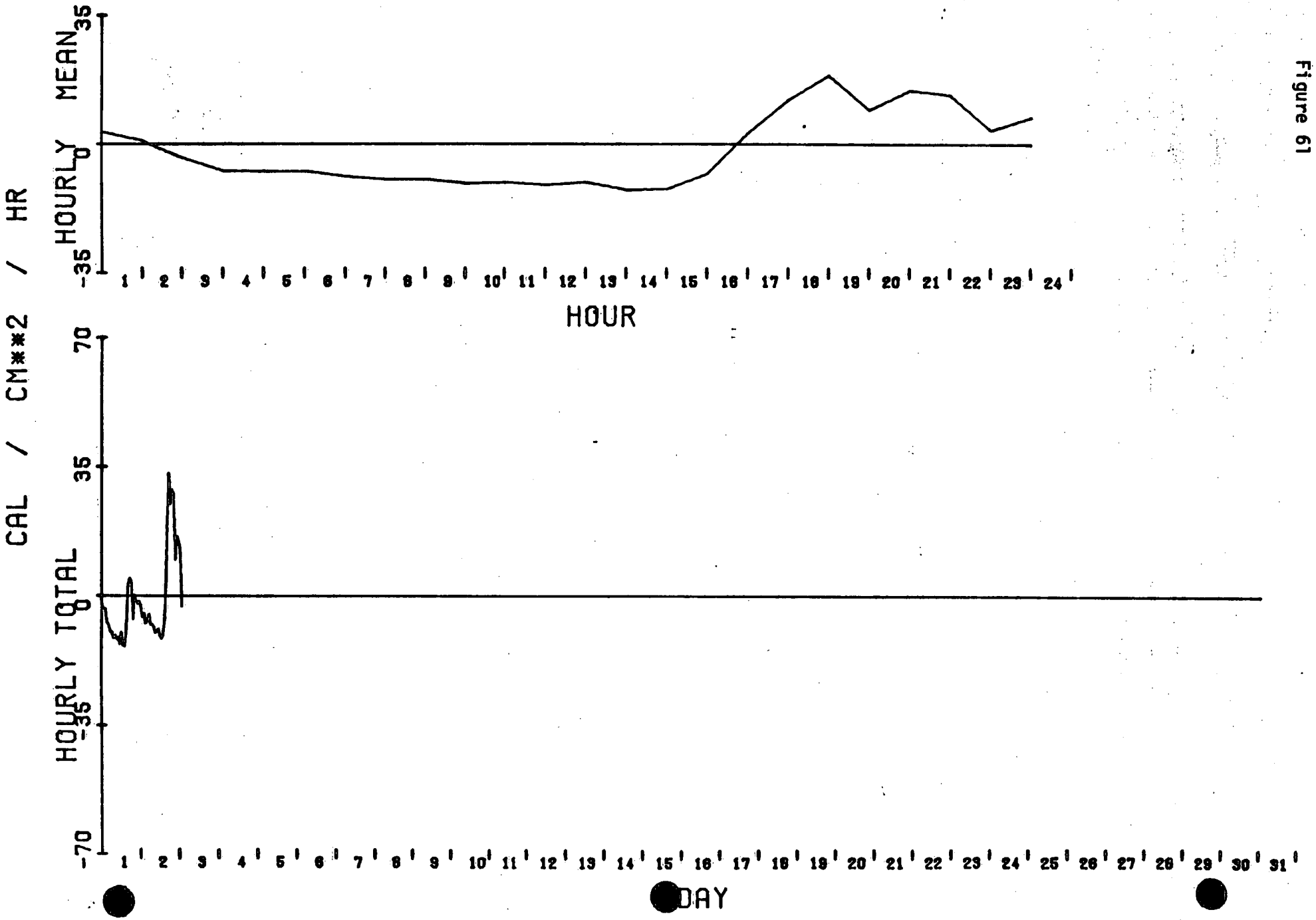


Figure 61

Figure 62

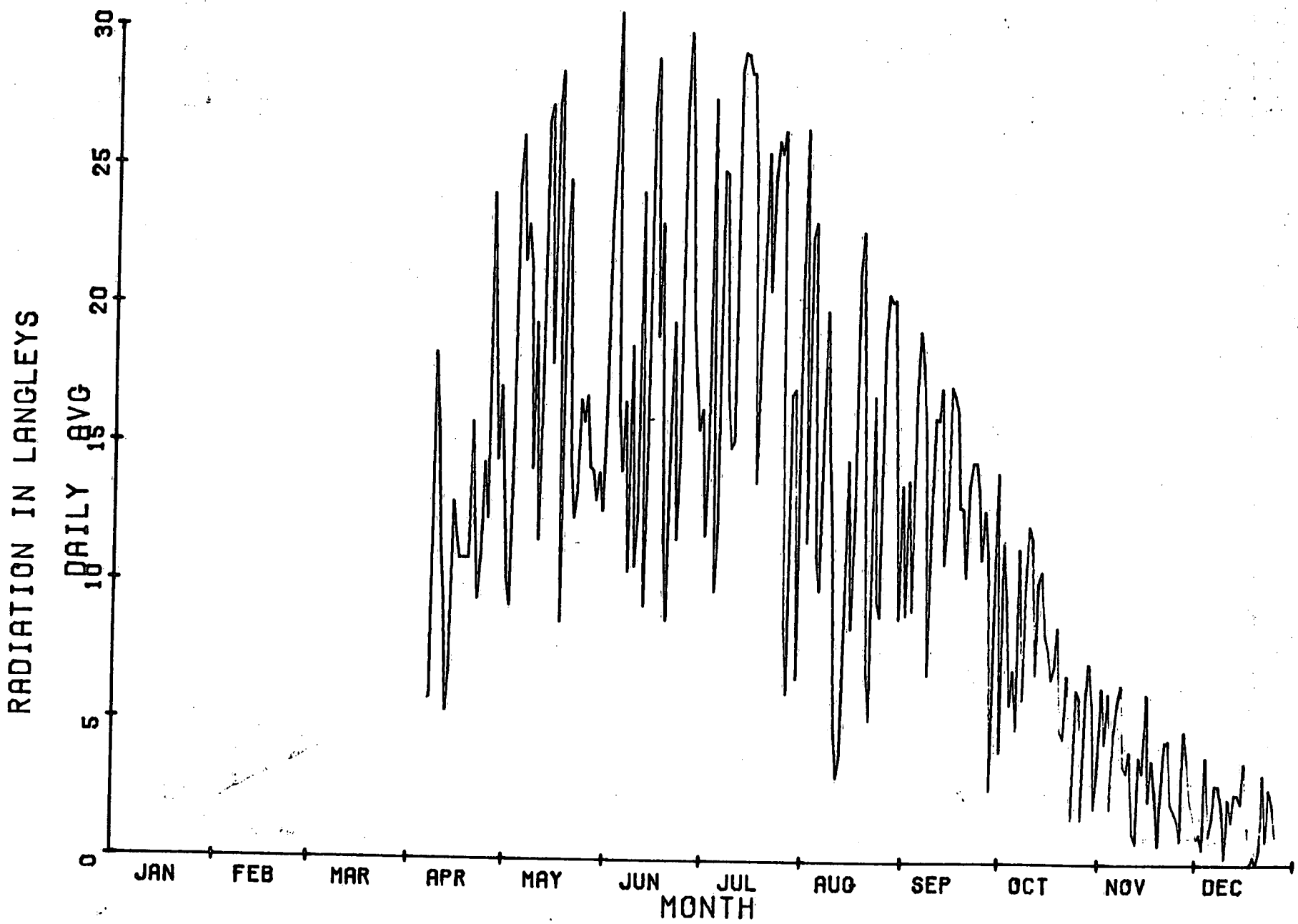

KOOTENAY B. C.
SOLAR RADIATION
ANNUAL 1976
TIME: G.M.T.
RADIATION IN LANGLEYS
DAILY AVG
0
5
10
15
20
25
30
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH

Figure 63

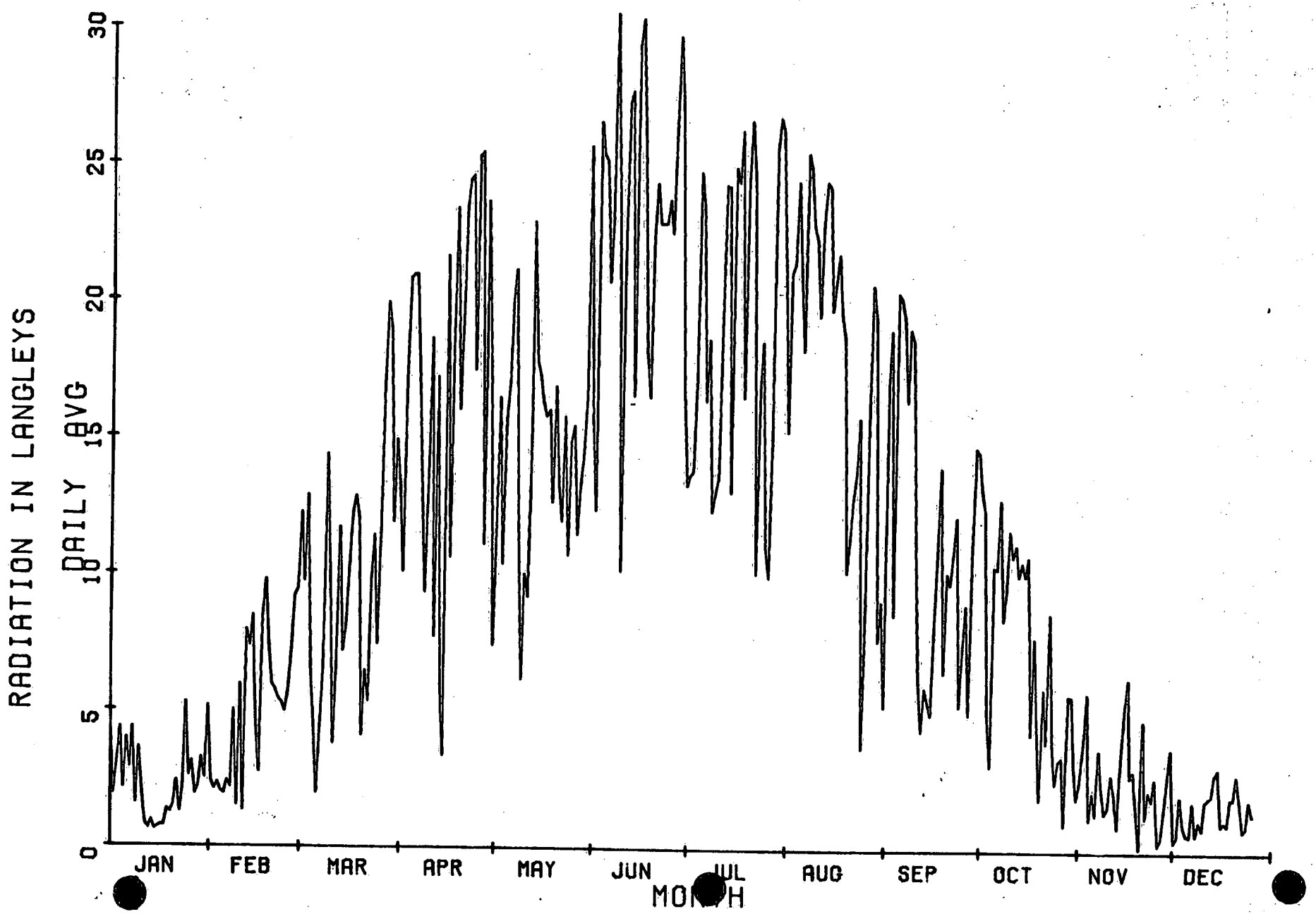

KOOTENAY B.C.
SOLAR RADIATION
ANNUAL 1977
TIME: G.M.T.
RADIATION IN LANGLEYS
DAILY AVG
0
5
10
15
20
25
30
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH

Figure 64

KOOTENAY B. C.

SOLAR RADIATION

ANNUAL 1978

TIME: G.M.T.

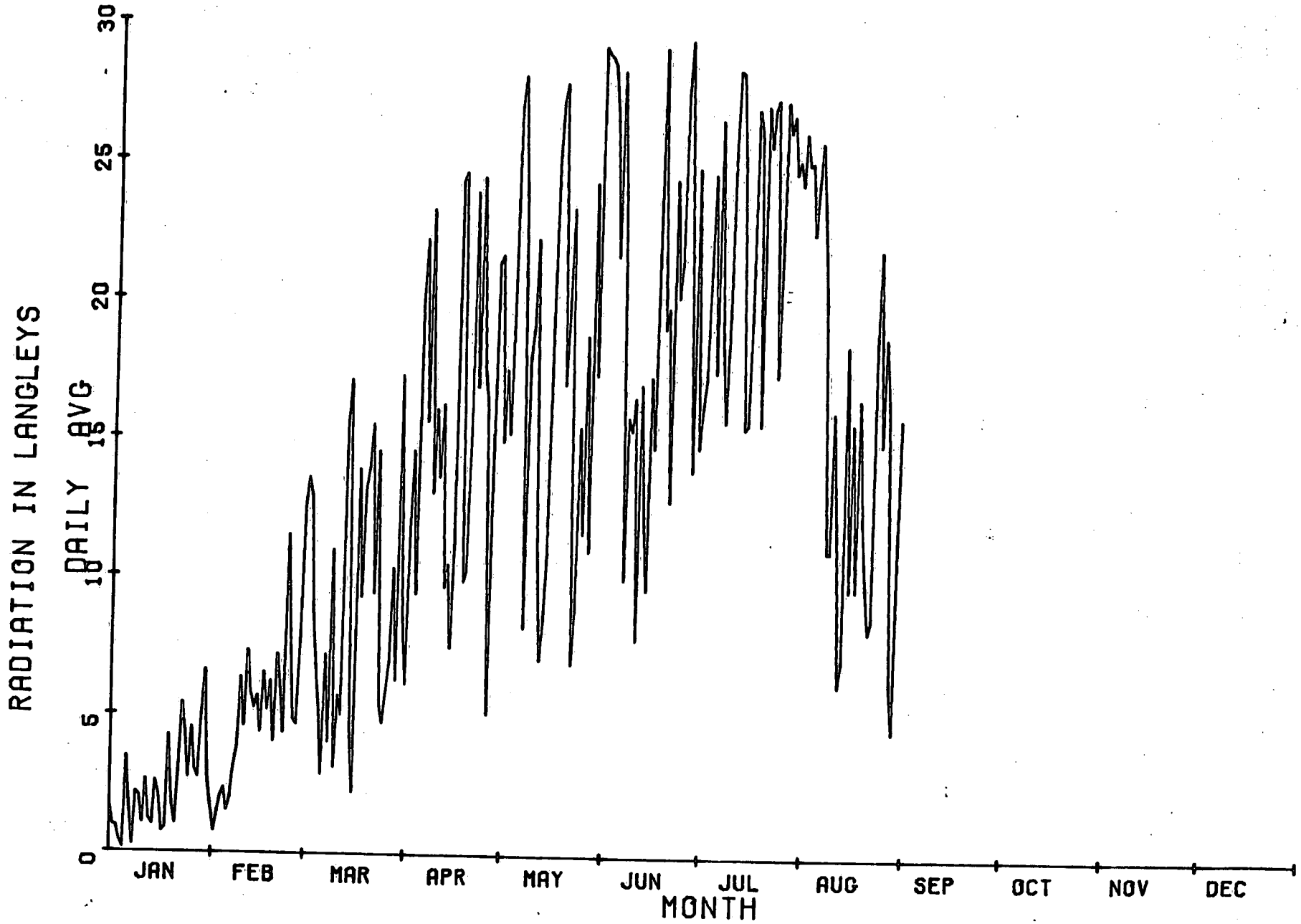
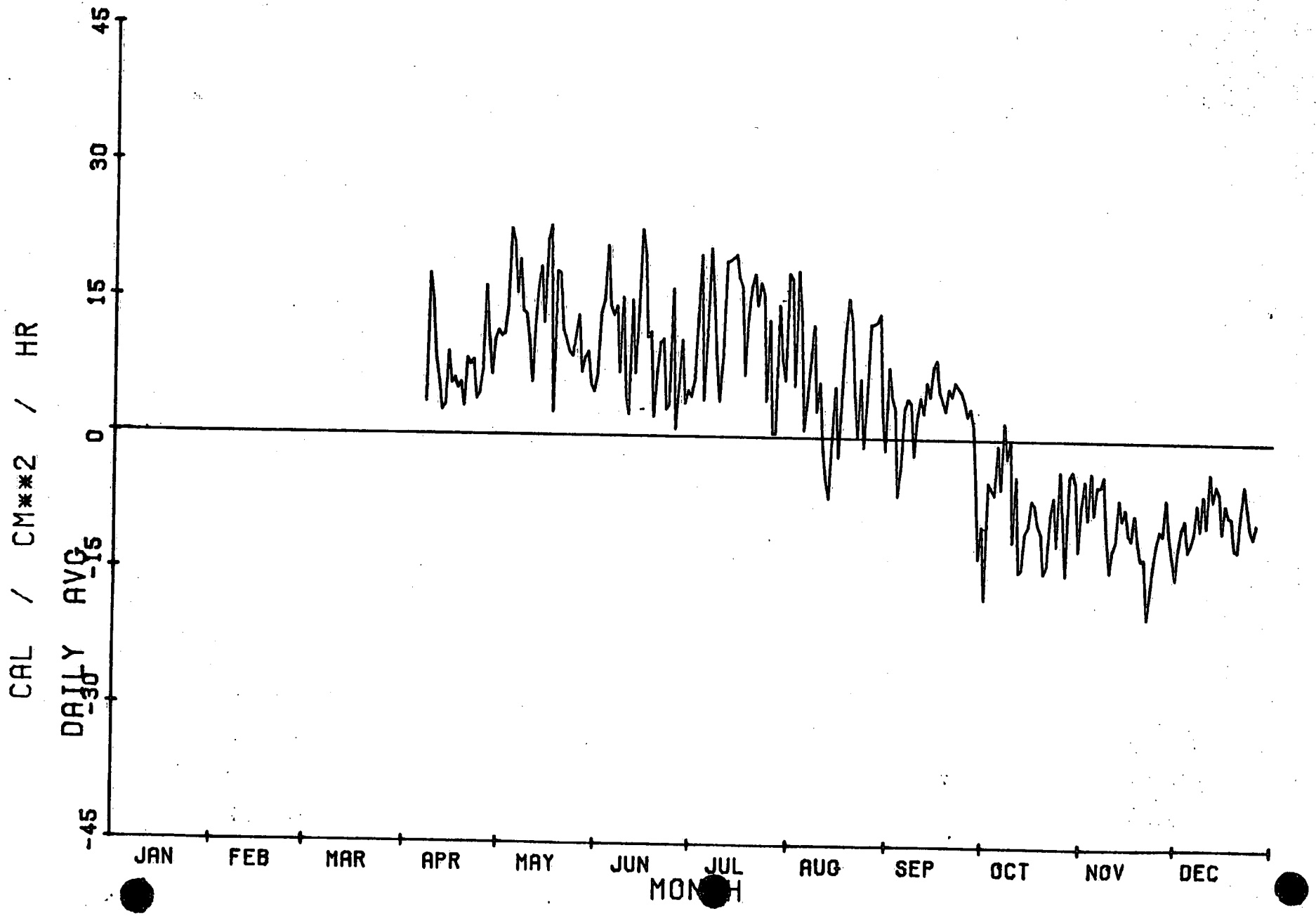


Figure 65


KOOTENAY B. C.
TOTAL HEAT FLUX
ANNUAL 1976
TIME: G.M.T.
CAL / CM**2 / HR
DAILY AVG
45
30
15
0
-15
-30
-45
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH

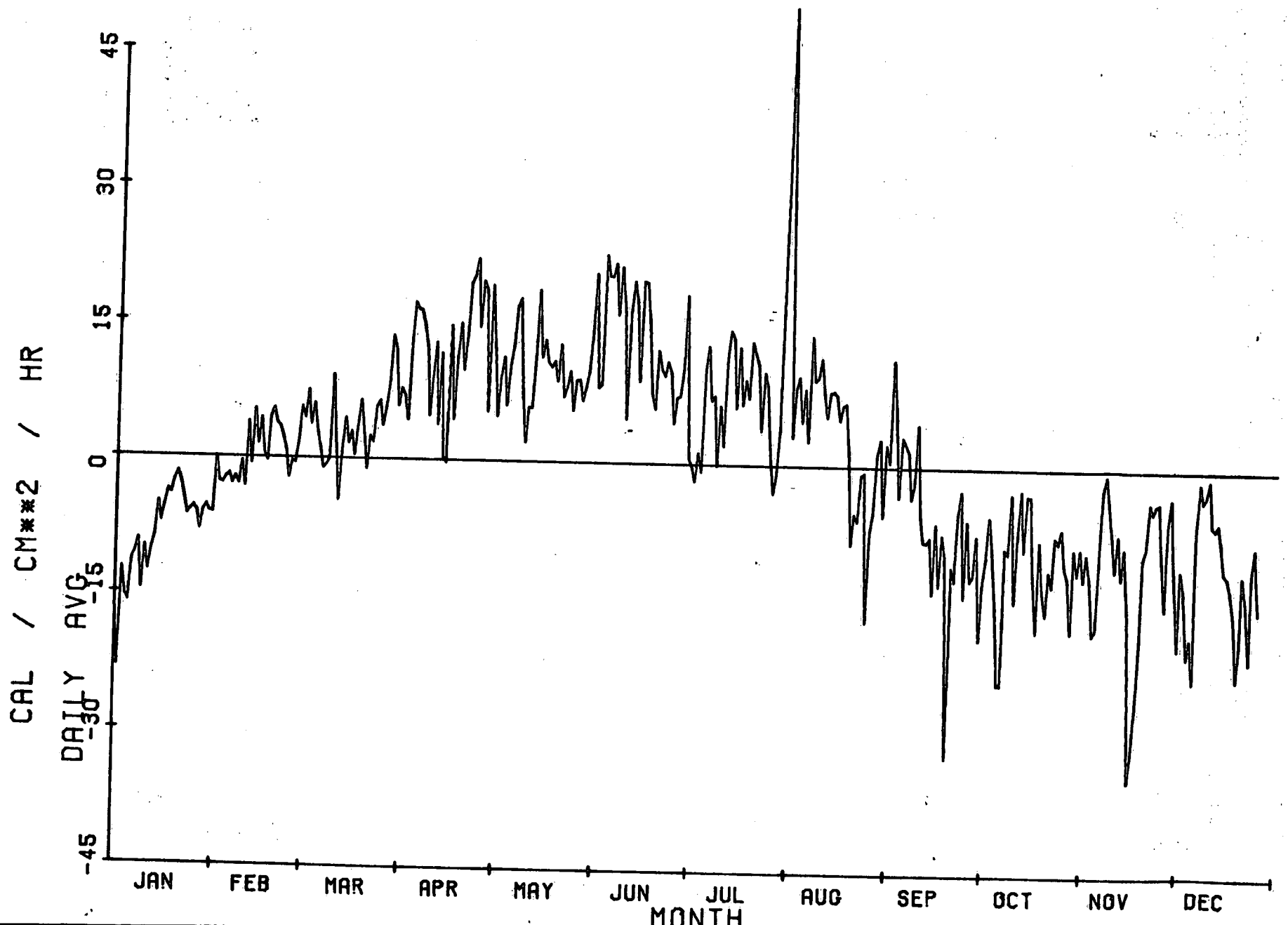
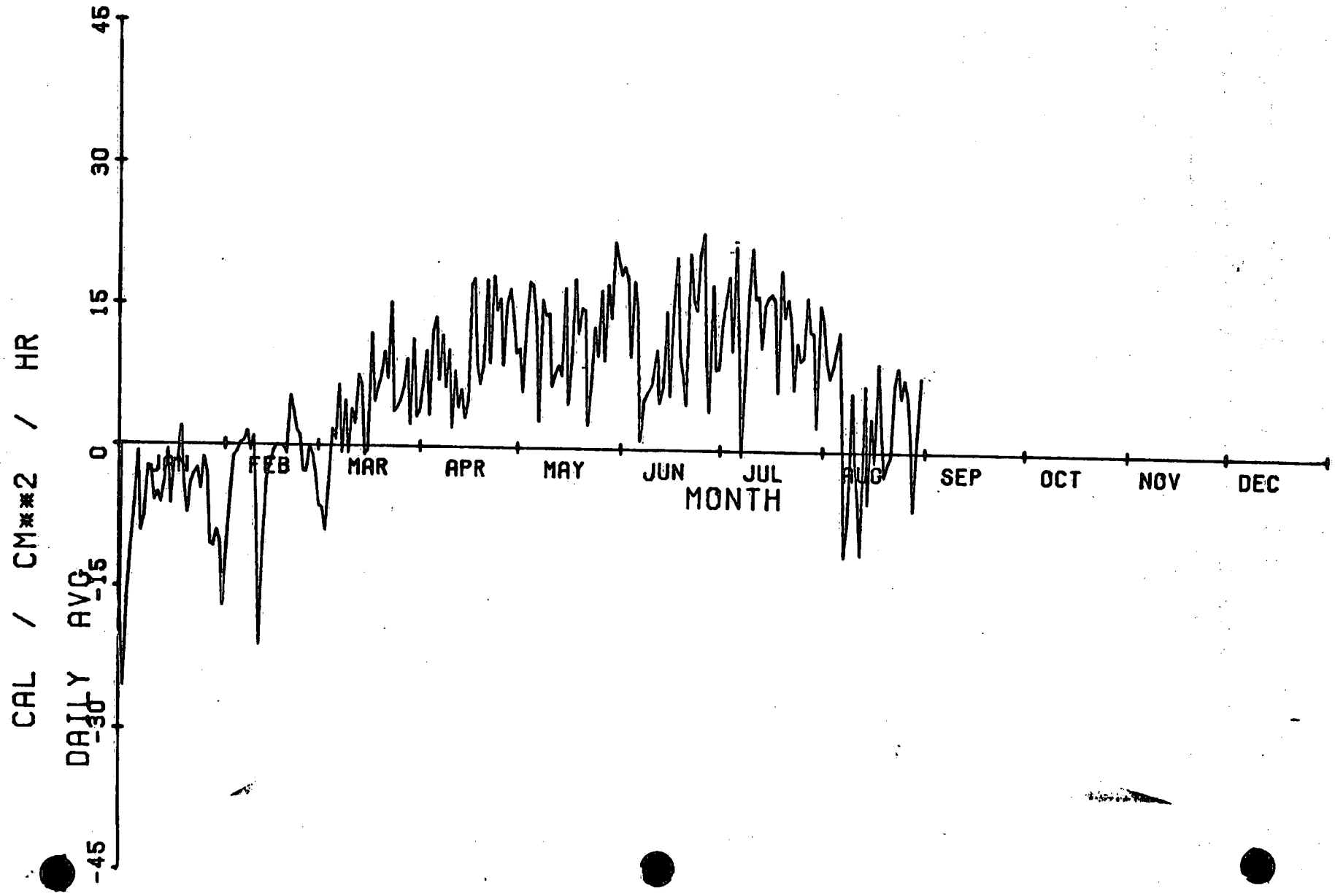

KOOTENAY B. C.
TOTAL HEAT FLUX
ANNUAL 1977
TIME: G.M.T.
CAL / CM**2 / HR
DAILY AVG
45
30
15
0
-15
-30
-45
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH

Figure 66

Figure 67


KOOTENAY B. C.
TOTAL HEAT FLUX
ANNUAL 1978
TIME: G.M.T.
CAL / CM**2 / HR
DAILY AVG
45
30
15
0
-15
-30
-45
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH