THERMOGRAPH RECORDS IN ROOMS OF SOME LONDON DWELLING-HOUSES THROUGHOUT THE YEAR 1935-36 AND THEIR COMPARISON WITH TEMPERATURES RECORDED IN OUT-DOOR METEOROLOGICAL STATIONS

By C. G. JOHNSON, B.Sc., Ph.D.

Department of Entomology, London School of Hygiene and Tropical Medicine

(With Plates X and XI and 4 Figures in the Text)

CONTENTS

I. Introduction

Work on the ecology of the bed-bug, *Cimex lectularius* L., has led to a search for records of temperatures of dwelling-houses in Great Britain. Much information on house temperatures already exists; it has been collected mainly by engineers, physicists and hygienists interested in the effects of heat on building materials or in relation to the bodily comfort of man. But for the ecologist concerned with insect populations in dwelling-houses few data, apart from those of Mansbridge (1936)[1], giving a picture of the fluctuations of air temperature of rooms throughout the year, or even for certain seasons, appear to have been published.

With the ecology of the bed-bug in view continuous thermograph records for the year 1935–36 were made in several rooms in Kensington, London. It is because other investigators may find them useful that these records are here published alone and uncorrelated with the activity of a particular organism. A knowledge of house temperatures may also prove valuable to fumigators when making laboratory tests or conducting the fumigation of houses at different times of year.

Obviously, all the charts cannot be published; neither can the exact

[1] Mansbridge, G. H. (1936). A note on the resistance to prolonged cold of some insect pests of stored products. *Proc. R. ent. Soc. Lond.* (A), **11** (6–12): 83–6.

https://doi.org/10.1017/S0022172400011050 Published online by Cambridge University Press

requirements of future workers, perhaps in other than entomological fields, be anticipated. Consequently, mean temperatures for intervals of less than 5 days (except here and there) over long periods are not given in this paper. The original thermograph charts are, however, filed in the Department of Entomology, London School of Hygiene and Tropical Medicine, where they may be consulted.

These records were collected with the full knowledge that the temperature around bed-bugs in a wall or bedstead may not be the same, at any instant, as that recorded on a thermograph in the same room. Nevertheless, a study of micro-climates may now be made with some knowledge of the fluctuations of the general air temperature of rooms as a guide; quite possibly some form of standardization of micro-climatic temperatures in relation to temperatures as measured by thermographs or thermometers in the general space of the room may be made.

II. METHODS

Thermographs were adjusted over a range of approximately 10–40° C. at the commencement of the investigations and were checked after running for 6 months. A maximum and a minimum thermometer were placed with each thermograph, their bulbs (except in the case of No. 8) underneath the bi-metallic element. These thermometers had been standardized with an N.P.L. standard thermometer. The thermometers were read at the beginning of each week, when the thermograph chart was replaced. Thermographs were placed a few inches away from a wall.

Mean monthly temperatures were calculated by halving the sum of the mean maximum and mean minimum temperatures for the month. Daily maximum and minimum temperatures were corrected from the weekly readings of the maximum and minimum thermometers before summation. This weekly method of correction has certain disadvantages, and it would have been better, had circumstances permitted, to have made a daily correction of the maximum and minimum chart temperatures. The results in this paper could, of course, have been obtained by the use of the thermometers alone; thermographs were used since daily readings of thermometers could not be obtained and because a chronological record of daily fluctuations was desired.

Mean temperatures of 5-day periods were obtained in a similar manner to monthly means. In cases where there were 31 days in the month the mean temperature for the last 6 days was taken. When, by an occasional accident, records for less than 30 days were obtained for the month, then the mean for the odd three or four temperatures is given; two odd readings were neglected. Each month, therefore, except July for thermograph No. 9, begins with a mean value for the first 5 days.

It is perhaps advisable to regard each mean temperature for the 5-day periods as accurate to 0·5° C. The graphs in Text-figs. 3 and 4 have been drawn to a finer limit of accuracy only in order to keep the dots well spaced.

III. Description of the rooms investigated

In addition to investigating the temperatures in the rooms of different houses it is also desirable to know about the temperatures in different rooms of the same house. Therefore five thermographs were placed at different levels throughout an occupied house (No. 54 Palace Gardens Terrace, Kensington, W.).

Description of the rooms and space where temperature observations have been made, at No. 54 Palace Gardens Terrace, W.

General description of house (Pl. X, figs. 1 and 2).

The house might be called a typical upper-middle-class house of 80 or 90 years ago—one of a long row with small garden areas behind. The front of the house faces west. The house really constitutes a thin slice, "a room and a passage wide" through the row—so that party walls comprise more area than outside walls and windows. It has a half-basement and three storeys above this. The depth of the house is only two rooms. The outside wall, carrying the windows, is 12 in. thick at the ground floor and 10½ in. thick at the first floor. The roof is nearly flat, covered with thick lead, underneath which is a lining (felt?) and a ½ in. boarding.

There will be very little heat emitted into the house from the hot-water system. There is a slow combustion water heater in the kitchen, with the storage cylinder for hot water close beside it, so there is practically no hot water circulation through the house. When a bath is required (on the top floor) the whole of the cool water filling the pipe from basement to bathroom has to be drawn off and the pipe warmed up before hot water will flow into the bath. I was told that it takes a long time to obtain hot water in the bathroom. This means that the only heat supplied to the house from the basement kitchen must pass through the floors, or up the kitchen stairs, as hot air.

There appeared to be only one open coal fire in general use—that in the sitting-room adjoining the study (ground floor) and separated from this study by large folding doors. No temperature records were taken in this sitting-room.

The following are the general characteristics of the rooms and places in which the temperatures were recorded.

Basement dining-room. Cubic content 2000 cu. ft. (*plus* a bay window). Window glass area 26·5 sq. ft. Recording instrument (No. 1) on shelf 7 ft. above the floor on a side wall pierced by door into passage.

One gas fire, 9 radiants, in wall opposite instrument; in use at meal times during winter.

Study, ground floor (front). Cubic content, 2950 cu. ft. (*plus* a bay window). Window glass area 53 sq. ft. Recording instrument (No. 2) 7½ ft. above the floor, on a shelf (see Pl. X, fig. 2) on a party wall opposite to the door.

There is a gas fire, 9 radiants, also in this wall. The inner end of the room is closed by large wooden folding doors.

Bedroom (1) *first floor* (*front*). Cubic content 2300 cu. ft. (*plus* bay window). Window glass area 42 sq. ft. Recording instrument (No. 3) inside the hollow ornamental top of a wardrobe (7 in. sides), and 6½ ft. above the floor. Wardrobe against the inner wall of the room. The room was occupied at night.

Dressing-room second floor (*back*). Cubic content 880 cu. ft. Window glass area 17·7 sq. ft. Recording instrument (No. 4) on a shelf against inner wall, next to the door and 5 ft. above floor. One small coal fire-place, not used during investigations, 10 in. across front.

Roof space. The instrument (No. 5) was placed in the narrow space between the nearly flat roof (already described) and the ceiling joists of the top landing; it was approximately 1½ ft. from the inner surface of the roof. There were two trap doors, both closed, one leading into this space and the other leading on to the roof. As already stated, there are no hot pipes, cisterns, or other direct sources of heat in this space.

Description of rooms where temperature observations have been made at Wornington Road, Oakworth Road, and Dalgarno Gardens, North Kensington, London

Wornington Road (Pl. XI, fig. 1).

These houses stand in a long row of houses of old appearance. Their age may be up to 100 years. Both houses are narrow "slices" through the block, two rooms in depth and one room and a stairway wide. There is no hot water system. The three floors above ground and the basements are let into tenements in each house.

No. 196. Here the room examined was a bed-sitting room on the second (top) floor and overlooking the Great Western Railway.

Cubic contents: 960 cu. ft.

Window glass area: 14·3 sq. ft.

Outside wall: 9½ in. thick.

The room contained a small gas cooker (two burners, grill and oven) besides a small coal cooking range. Recording instrument 6 ft. 9 in. above floor, on top of a cupboard and about 4 ft. directly above the gas cooker.

No. 198. The room in this house was also a bed-sitting room on the same floor as that just described but on the other side of the house, overlooking Wornington Road. Being at the head of the stairs this room was slightly the larger. It contained a small coal stove similar to that last mentioned, but no gas cooker. The gas cooker in this instance was placed on the top landing.

Cubic contents: 1280 cu. ft.

Window glass area: 15·5 sq. ft.

Recording instrument: 3 ft. 2 in. above the floor at side of chimney.

Outside wall: 9½ in. thick.

50 *Oakworth Road* (Pl. XI, figs. 3 and 4).

The house, a Council house, is about 12 years old and stands, with the north, east and south walls exposed, on a corner.

The bedroom investigated is on the first floor and has one outside wall facing south. The other three walls separate the room from the next house, a landing and a bedroom.

Cubic contents: 1100 cu. ft.

Window area: 15·7 sq. ft.

Outside wall: 10½ in. thick.

The room contained a small fireplace, 1 ft. wide, which was never used.

The bedroom has no part of the hot water system in it; all hot water is stored in a tank in the room beneath. The bedroom investigated was considered by the occupant to be the warmest bedroom in the house.

The recording instrument was placed on a shelf above a curtained recess 6 ft. 9 in. from the floor (Pl. XI, fig. 4).

No. 30, *Block W. Sutton Dwellings, N.W.* 10 (Pl. XI, fig. 2).

This was a third (top) floor bedroom in a block of buildings 7 years old. The tenant of a neighbouring flat who had been there since the buildings were opened, told us that she found the sitting rooms draughty (doors opened into outside stairs and did not appear to fit very well).

One would expect this bedroom never to be very cold because both the party walls comprising its sides contained "Servall Minor" combined coal fires and cookers operating in two adjoining living rooms, so that considerable heating by conduction may be expected.

Cubic contents: 947 cu. ft.

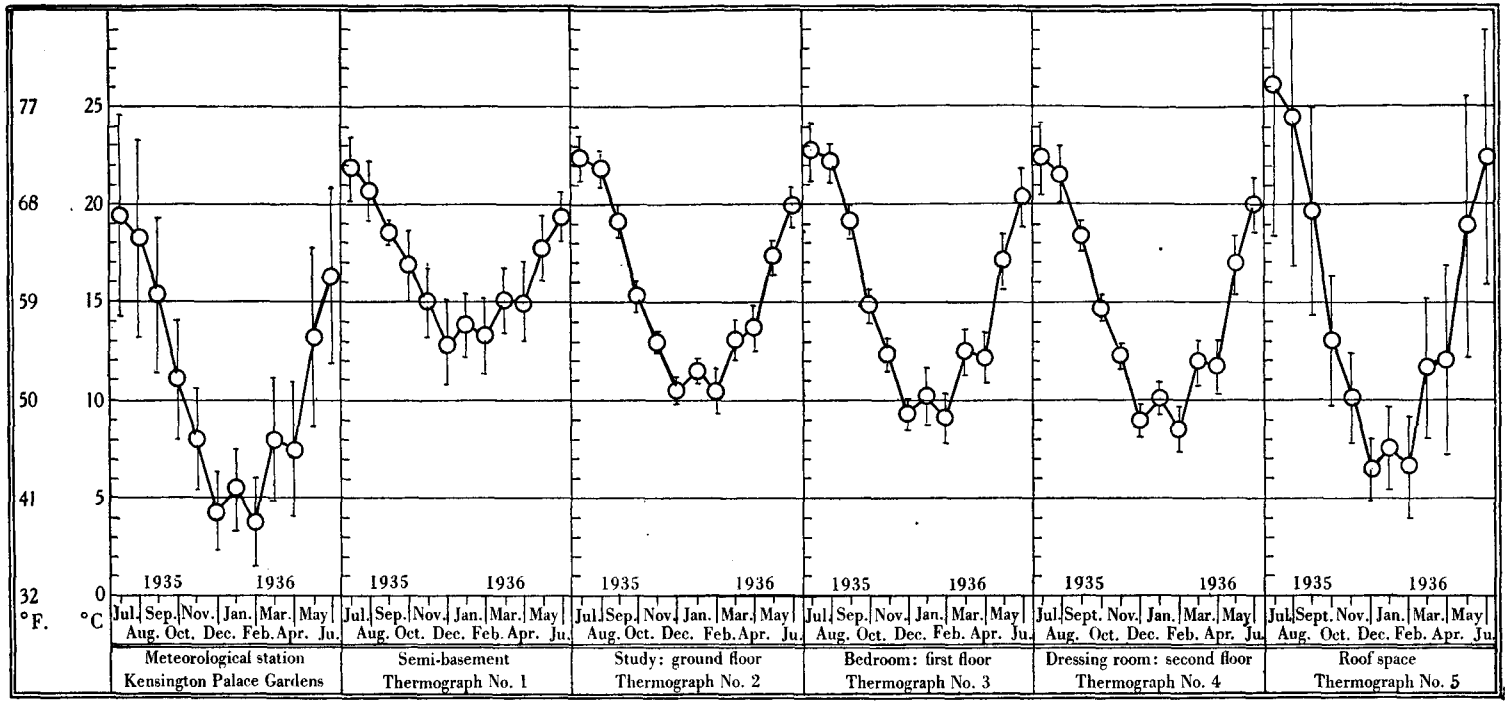
Window area: 12 sq. ft.

Height of recording instrument: 3 ft. 3 in.

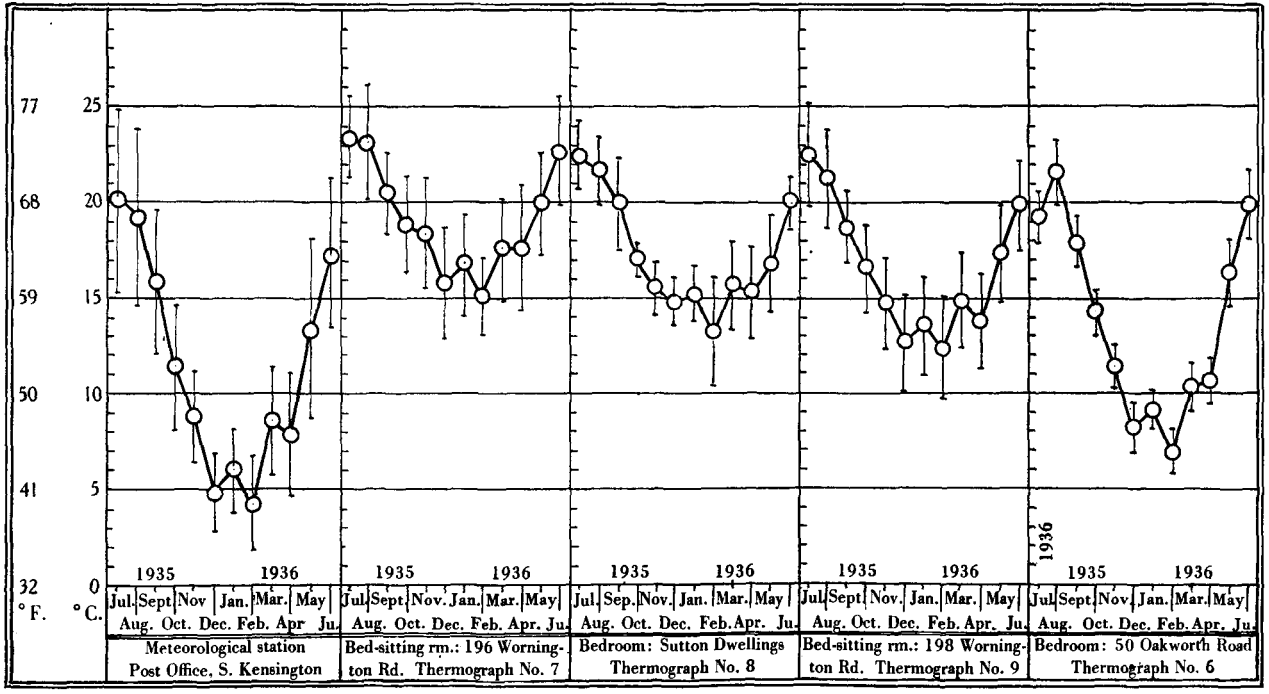
IV. Discussion of results

Many more records, from other types of room and from different parts of the same room will have to be collected and analysed before generalizations on room temperatures can be made with surety. Nevertheless, a few facts stand out and will now be mentioned.

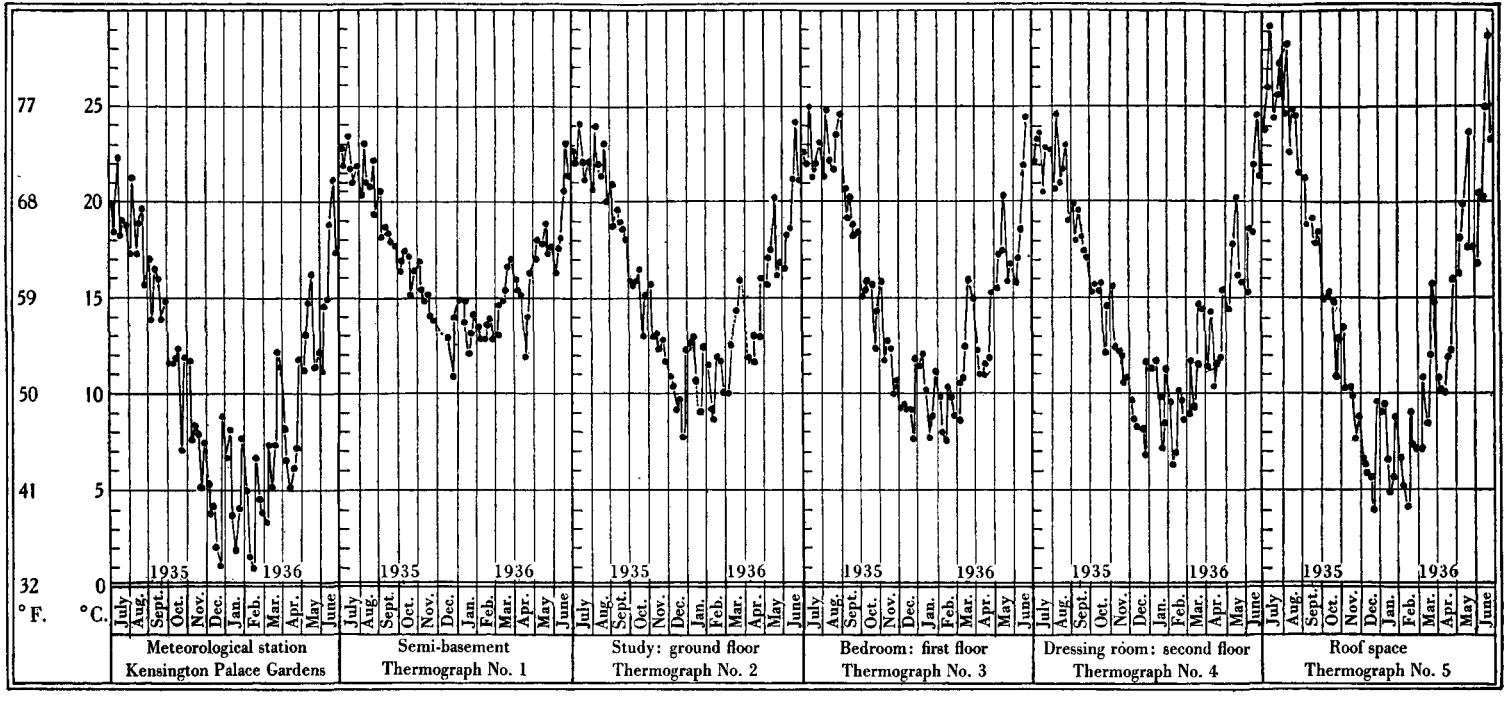
Considering first the house in Palace Gardens Terrace, and inspecting the monthly means for the rooms investigated (Text-figs. 1 and 3), the most obvious fact is the great similarity shown between the records of the study on the floor slightly above ground level, the bedroom on the first floor, and the dressing-room on the second floor. The records are more similar from room to room in the summer than in the winter, and it is really only the months December to April which show a markedly higher mean temperature, amounting to some 1·5° C. (2·7° F.) in the lowest room. This is probably due to the fire, which was occasionally alight there in the colder weather, and perhaps also to the



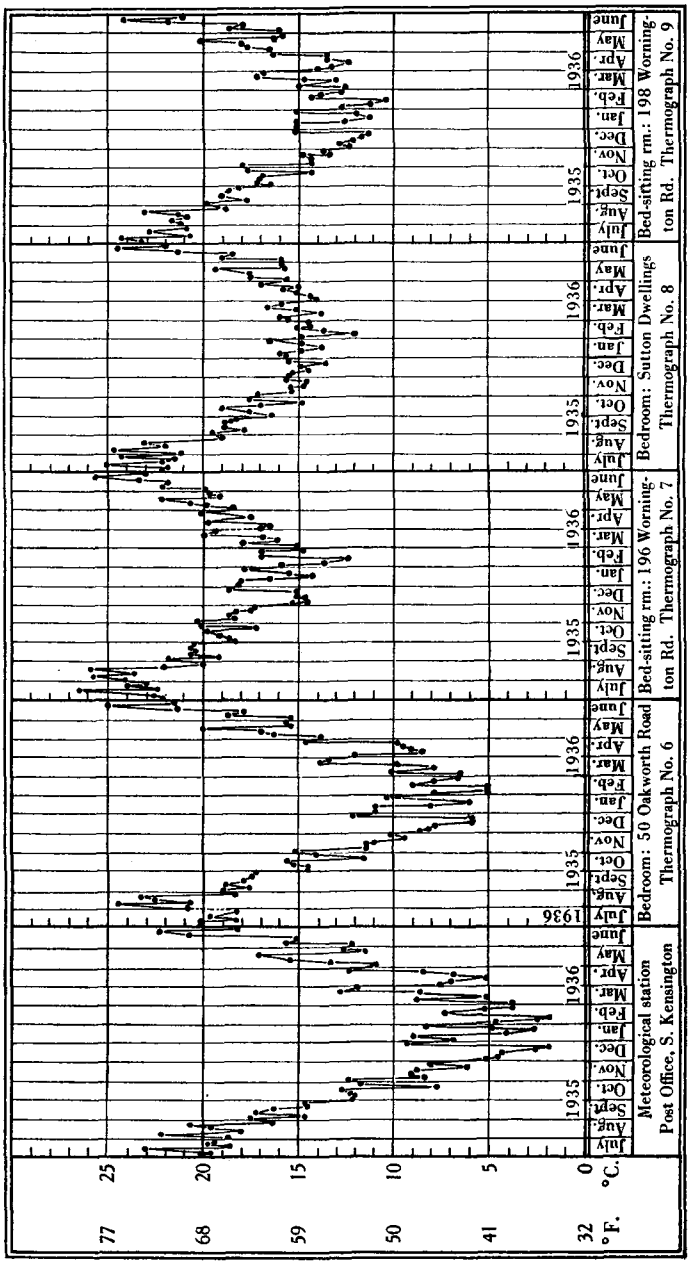
Text-fig. 1. Showing mean monthly temperatures and mean maximum and mean minimum monthly temperatures in the rooms of 54 Palace Gardens Terrace for 1935–36. Circles indicate mean monthly temperatures. Vertical lines through circles indicate mean maximum and mean minimum monthly temperatures.



Text-fig. 2. Showing mean monthly temperatures and mean maximum and mean minimum monthly temperatures in the rooms of various houses in Kensington for 1935–36. Circles indicate mean monthly temperatures. Vertical lines through circles indicate mean maximum and mean minimum monthly temperatures.



Text-fig. 3. Showing the temperatures in rooms of 54 Palace Gardens Terrace for 1935–36 expressed as means for 5-day periods. A dotted line shows where a mean temperature has been omitted.



Text-fig. 4. Showing the temperatures in rooms of various houses in Kensington for 1935–36 expressed as means for 5-day periods. A dotted line shows where a mean temperature has been omitted.

https://doi.org/10.1017/S0022172400011050 Published online by Cambridge University Press

warm basement room below. The basement tends to have a lower mean temperature in summer and autumn and a higher mean temperature in the winter and spring than the other rooms in the house which were studied. Also, the excursion from the monthly mean is normally greater in the basement than in any of the other rooms, except in the roof space. It is in the roof space that greatest fluctuations from the monthly mean occur, and the monthly means themselves show both higher summer and lower winter temperatures than any of the other rooms in the house; as noted above, this space contains no direct source of heat.

Comparing the temperatures within the house with those taken in a Stevenson's screen in an open space, over grass, in Kensington Palace Gardens, about $\frac{1}{4}$ mile away (the meteorological station at Exhibition Road is about 1 mile distant), all the rooms show a higher mean temperature for any one month than that taken in the screen. Moreover, the differences from the screen temperatures are greater towards the lower parts of the house. The mean monthly temperatures of the basement vary from about 3 to 10° C. (5·4 to 18·0° F.) higher than the corresponding monthly means from the screen; and the differences between screen and room temperatures are greater in winter and spring than in summer and autumn, for all rooms except for the roof space, where the differences are greater in spring and summer than in autumn and winter.

Turning now to the results from other houses, it is seen at once that the bedroom in Oakworth Road (No. 6), which never had a fire in it, is very similar to the second floor room of the house in Palace Gardens Terrace; while the two bed-sitting rooms show much higher winter temperatures than the bedrooms in Oakworth Road or Palace Gardens Terrace; summer temperatures differ little on the whole between all these rooms. The bed-sitting room (No. 7) with a gas-stove was the warmest room investigated.

Thermograph No. 8 was in a bedroom on the top floor of a block of flats, and although the room had no fire during the year, it opened into a living room which had a fire during the winter; both party walls of the bedroom contained fireplaces. This room has a graph intermediate between the two bed-sitting rooms, and shows a high general temperature—especially when it is remembered that the thermograph in the bed-sitting room (No. 7) was about 4 ft. above a gas-stove.

The meteorological screens at Kensington Palace Gardens and at the Post Office, Exhibition Road, Kensington, were within a radius of about 2 and 3 miles respectively from the houses in Wornington Road, Oakworth Road and Dalgarno Gardens. The greater differences between room and screen temperatures occurred in the winter months. Differences as much as 11° C. (19·8° F.) are found between room and screen monthly mean temperatures for the bed-sitting room with gas-stove (thermograph No. 7) for January. It is interesting to note that the next greatest differences between mean monthly temperatures of room and screen do not occur with the other bed-sitting room, but with the bedroom of the flat in Sutton Dwellings (thermograph No. 8). The bedroom in

Oakworth Road (thermograph No. 6), although showing a slightly greater difference from the screen temperature in winter, has only a 3° C. (5·4° F.) higher monthly mean temperature when the differences are greatest; moreover, there is only one outside wall to this room.

The tentative conclusions which may be suggested are that bed-sitting rooms or a bedroom next to a living room in a flat have higher mean monthly temperatures throughout the year than bedrooms which are in parts of the house away from living quarters.

ACKNOWLEDGEMENTS. I am greatly indebted to Prof. P. A. Buxton for his ready advice and help and to the occupants of the houses and rooms investigated for their co-operation. I also thank Mr T. C. Angus, who made descriptions of the structural details of the rooms, and Mr A. F. Dufton, who made thermograph records in a house and screen at Garston, Watford; these records are filed with the others dealt with in this report. Acknowledgement is also made to the Medical Research Council who financed this work, which was carried out at the London School of Hygiene and Tropical Medicine under the general direction of the Bed-bug Infestation Committee of the Medical Research Council.

EXPLANATION OF PLATES X and XI

PLATE X

Fig. 1. The house at 54 Palace Gardens Terrace, Kensington, London, W. (with figure standing in doorway).

Fig. 2. The corner of the study in 54 Palace Gardens Terrace, showing position of thermograph marked with a cross.

PLATE XI

Fig. 1. The houses at 196 (left) and 198 (centre) Wornington Road, Kensington, W.

Fig. 2. Sutton Dwellings (Block W), Dalgarno Gardens, Kensington, W. Block faces south-east.

Fig. 3. The house at 50 Oakworth Road, Kensington, W.

Fig. 4. The corner of the bedroom (top, middle window in left-hand wall, Fig. 3) at 50 Oakworth Road, Kensington, W. showing position of thermograph.

(*MS. received for publication* 16. VI. 1937.—Ed.)

Fig. 1

Fig. 2

https://doi.org/10.1017/S0022172400011050 Published online by Cambridge University Press

Fig. 1

Fig. 2

Fig. 3

Fig. 4

https://doi.org/10.1017/S0022172400011050 Published online by Cambridge University Press