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"Further investigations into the physical factors in ships' holds, with reference to the insect infestation of cargoes between West Africa and the United Kingdom".

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CONTENTS

1. INTRODUCTION.

Since the introduction of regular inspections of infestable cargoes arriving at United Kingdom ports, many theories have been put forward to account for the innumerable, unanswered problems which arise concerning the changing condition of the commodities in the ships' holds, and of the degree of insect infestation occurring on those commodities. In 1956 plans were laid at the Royal College of Science, London, for a series of expeditions to the Gold Coast Colony in West Africa, now the independant State of Ghana; in the following year the first of these was backed by the Imperial College Exploration Board, Under the direction of one of the members of the party, Mr. G. Matthews, one of the first attempts was made to carry out recordings of the physical factors affecting the cargo, and observations on the movements of insect pests, within the holds of a ship whilst at sea. A brief account of this work was later published in the "Annals of Applied Biology," Vol 46 (1958), No. 2, pp 259-263, and full reports of both this and the following work are lodged with the Imperial College Exploration Board.

In 1958 a second party visited Ghana, and Mr. C. Neville carried out further observations on the same lines as those of Matthews. The result obtained, and some of the conclusions made by Neville, did not agree with those of Matthews. Thus, after a lapse of two years, a third expedition was organised with the main object of carrying out further measurements in the holds of ships on the same United Kingdom to West Africa run, in an effort to clear up the confusion.

This was made possible to a large extent when, in March 1960, Mr. A.E. Hoffman, Managing Director of Palm Line Ltd., generously granted free return passages between England and Ghana for both members of the party.

The outward journey was on board the m.v. "VESTEROY", a Norwegian chartered vessel, sailing from Liverpool on July 11th., spending one day unloading at Freetown, Sierra Leone on July 21st., and arriving at Takoradi on July 25th.

The return voyage was made on board the m.v. "NORDKYN", a Danish chartered vessel, departing from Takoradi on September 18th., and arriving at Rotterdam on October 3rd. Both members were flown to London later on the same day, whilst all the equipment was brought to Tilbury on the m.v. "KATSINA PALM" a week later. Fig. 1 shows the routes taken and the approximate position on any date.

2. TERMS OF REFERENCE.

In December 1959 the following subjects were recommended for study by Dr. J.A. Freeman, Chief Entomologist of the Infestation Control Division, Ministry of Agriculture, Fisheries and Food, Tolworth, as being of the greatest economic importance. At the end of April 1960 a meeting was held at the Pest Infestation Laboratories, Agricultural Research Council, Slough, where the heads of sections approved this plan of work and, after a further joint meeting at Tolworth, arrangements for the loan of various items of equipment from the two departments were completed.

1. Physical Measurements (Temperature and Humidity) in the holds of ships.
2. The rate of increase of an insect population during the voyage by placing known numbers of marked insects in various places in the holds.
3. Comparison of the degree of infestation at the time of shipment from Ghana, and during unloading in the United Kingdom.
4. Observations on residual insect populations in holds during the outward voyage, with particular attention to numerical assessment.
5. Effects of chemical treatments of the holds during the outward voyage.

It was agreed, at the time, to try to carry out work on as many of these subjects as possible, but, with exception of the first, all proved impracticable, for the following reasons.

By mid February 1960, confirmation had been received that Mr. J. Rawnsley, Senior Entomologist for the Ghana Cocoa Marketing Board in Accra, would give his full support in carrying out this work. However this could not be done for two reasons. Firstly, it had been learned on the 6th September 1960, prior to leaving the interior of Ghana, that the ship would not be docking at any United Kingdom ports, but that all the cargo was destined for the Continental ports of Rotterdam, Hamburg and Bremen. Thus it would be impossible to inspect any cocoa either during unloading or afterwards during transit storage. Secondly, although it was known that some cocoa had been loaded in Accra, prior to loading logs and timber at Abidjan, it was understood that no cocoa would be loaded at Takoradi. However, on the 13th September, 24 hours before the ship's arrival, it was learned that 300 tons of cocoa beans were to be loaded after all. Arrangements were already underway for their fumigation, and by the time both members of the expedition reached the docks nearly all the bags of cocoa had been removed from the warehouse and were being hoisted into a lighter lying alongside. The fumigation, carried out by operators of the Ghana Cocoa Marketing Board, was by means of methyl bromide.

4. <u>Residual Insect Populations.</u> The m.v. "VESTEROY" was due to arrive at Liverpool on 27th/28th June, to load general cargo in time to sail on July 7th. This vessel had discharged a

cargo of West African groundnuts, palm kernels, hides and timber at Lisbon, Dunkirk and Rotterdam prior to docking at Liverpool where she was inspected by Mrs. M.T. Armstrong, Northern Area Entomologist, Infestation Control Division, M.A.F.F. Sites of residues of previous cargoes were noted by Mrs. Armstrong in the hope that it might be possible to obtain information concerning the degree of endemic insect infestation, and any fluctuations in its level during the outward voyage. However, since there were no access hatches to the holds from the main deck, it was only possible to enter them once during the voyage, when cargo was being unloaded at Freetown, Sierra Leone, ten days out from Liverpool.

5. Effects of Chemical treatments. Plans to carry out a variety of chemical treatments in the different holds of the ship were made with chemists of the Infestation Control Division, in order that the rates of insecticidal breakdown, and their comparative effects on test insects, could be measured. However these had to be cancelled due partly to the Shipping Company only being able to give about ten days notice as to which vessel the expedition members were to be sailing on, and partly to the termination of a stevedores' strike in Liverpool. This led to the immediate resumption of loading operations just when it appeared that there would be sufficient delay to enable the treatments to be carried out after all.

3. PHYSICAL RECORDS.

A. INTRODUCTION. As mentioned previously, readings of the temperature and humidity in ships' holds were made by Matthews, and then by Neville, on the previous two Imperial College expeditions to Ghana. Their major conclusions on this work are given below, and these will later be compared with the results obtained on the 1960 expedition.

a) Outward Voyage. Matthews found that the diurnal fluctuation was greatest at the top of the hold, and that solar radiation caused heating of the air in the Shelter Deck, which resulted in delayed heating of the cargo. There was a temparature increase towards the centre of the ship relative to the sides, and a certain amount of heating of cargo by the engine room, although the air space between it and the cargo acted as an insulator. The relative humidity was found to be more variable than the temperature, varying from 25 to 76 per cent. Neville, on the other hand, claimed, on the basis of rather fewer measurements, that the temperatures of different points in the hold did not fluctuate relative to one another, but maintained a relatively constant relationship, whilst varying as a whole. He found that the humidity varied from 35 to 75 per cent, and was subject to more minor fluctuations than temperature (though this may have been due to different characteristics of the measuring instruments used for continous recording of temperature and humidity).

b) Homeward Voyage. Both Matthews and Neville found that the temperature maxima in the cargo occurred in the late afternoon, and the minima shortly before sunrise. Matthews recorded heating of up to almost 107°F (42°C) in the centre of the cargo (groundnuts) and, on reaching cooler conditions, the outside of the cargo was cooled appreciably more than the centre, resulting in a temperature gradient between the two. There was also a gradual increase in temperature in the cargo towards the engine room bulkhead. These gradients remained steady except for variations in the air spaces around the cargo, the variations spreading a little way into the cargo. He also found an increase in temperature with increasing depth in the hold. Neville's series of readings taken with a thermocouple spear at various depths in groundnut cake do not confirm this gradient, however, he found a temperature minimum at 6 bags depth, both above and below this being warmer. Possibly deeper readings were needed to confirm the gradient, the surface layers being affected by diurnal fluctuations. Examination of the readings obtained by Neville from thermocouples in the hold does not show any regular gradients, due to the apparently random positioning of the thermocouples. He found an even higher peak temperature of 108 F (42.5 C), in groundnut cake.

On this expedition, therefore, it was hoped to confirm or disprove the gradients found by Matthews on both the outward and homeward voyages, and also test Neville's statement that the temperatures of points in the hold vary as a whole during the outward voyage. Similar measurements of temperature, using both thermocouples and thermohygrographs, and of humidity, as on the previous expeditions. From the figures obtained it was hoped the sources of heat influencing the holds, the degree of transmission of heat into the holds from these sources with various cargoes, and also the cooling sources affecting the cargo. A preliminary investigation was also made into the moisture content of bagged cocoa on the return voyage; an aspect not attempted by either Matthews or Neville.

B. EQUIPMENT. The items listed below were the principal ones used for physical measurements in the holds. In each case details are given of the ease of use, or otherwise, of the instrument, and also of any faults that occurred, as these may be of interest to any one considering further work of this nature.

1. Sunvic R.S.P.2. Self-balancing Potentiometer and High Speed Recorder.

This instrument was the one used by both Matthews and Neville for recording the temperatures measured by the thermocouples. It was used in conjunction with a 0°C cold reference junction, the thermocouples being connected to the instrument sequentially via a four-terminal insulated connecting block, to which the potentiometer input was permanently connected. The power supply for the potentiometer was obtained from a 220 V AC/DC rotary converter, which gave no trouble at all in use.

The potentiometer itself was capable of giving ideal results, completely unaffected by the ship's movements. Neville found that the length of thermocouple wire affected the reading obtained at any given temperature, but this did not appear to be the case in this instance: however the effect was investigated by Neville using a Doran 'Mini' Potentiometer, and, as will be mentioned later, the accuracy of this instrument on a moving ship is doubtful, and the variations observed by Neville possibly fall within its range of error.

The tubular nib of the Sunvic potentiometer pen became clogged up quite frequently: possibly the high humidity and temperature rendered the paper more liable to scratching, a point which could not have been foreseen in temperate conditions.

The instrument did give serious trouble, however, starting at 3.00 a.m. on the 19th July, while readings were being taken at hourly intervals during a 24 hour period. The pointer ceased to give definite and repeatable readings, and on standardising the battery the pointer moved to one extreme of the scale, which would normally indicate a flat battery. However replacement of the battery did not cure the fault, and, in the absence of a complete service manual, no actual fault could be found during the remainder of the expedition. At the beginning of the return voyage the trouble was still present, but it was found that a steady reading was given when both input wires, one of which had previously been earthed, were disconnected from the earth (chassis). This made the thermocouples sensitive to pick-up of any electrical disturbances in the ship, which caused the point to wobble, but this was only serious in the case of the longer wires (to No. 1 shelter deck) and this was overcome by twisting the two sets of wires together. The reasons why unearthing the input should have "cured" the fault are not clear, but as the instrument gave apparently accurate results when the calibration was repeatedly checked, its use was felt to be justified. It was used in this fashion until the 27th September, when it recommenced behaving perfectly normally, and the input could be earthed again. It is probable that the tropical conditions caused the fault, which would explain its disappearance as temperate latitudes were reached, the high humidity and temperature possibly causing a temporary insulation breakdown in some component, although this remains only an idea.

2. <u>Doran "Mini" thermocouple Potentiometer</u> -

This instrument was of the later type (Instr. No. 8256) with the scale calibrated directly in °C above or below the the reference point. Neville claimed that it was possible to use it on a moving ship by positioning the instrument relative to the axis of the ships motion, but this was found to be very difficult, due to the motion often being a complex combination of pitch and roll, with no constant resulting axis of movement.

Thus the meter needle was seldom steady at the centre zero, and the technique evolved was to Depress the switch connecting the thermocouples just as the needle reached the end of its swing, and was therefore momentarily stationary. If the circuit was not balanced, a further movement of the needle would result, and the dial was then adjusted until no such further movement occurred, indicating that the bridge circuit was balanced, and the temperature was then read off the scale. Obviously the readings taken by this method were not very accurate, and are included in the graphs mainly for completeness: it is doubtful whether they are accurate to nearer than 1°C.

On examination at the start of the homeward voyage, the galvanometer was found to be broken, although it had been intact when packed away on arrival at Takoradi, and the instrument had to be returned to the makers on arrival in the U.K. for repair.

3. Negretti and Zambra distant-reading dial thermographs.

These were used for recording the sun and shade temperatures above the holds on the return voyage, and worked extremely well. It was felt that they would be of only limited use for measurements in the holds, due to the greater inconvenience of installing, relative to thermocouples, and the limited length of cable from spear to recorder.

4. Cambridge distant-reading dial thermographs.

These were by no means new instruments, and this possibly accounted for their very erratic behaviour; they did not give any usable results, due to failure to give a complete trace. In addition, the connection between the spear and recorder was of stiff copper tubing which, while possibly suited for permanent installations, made the installation and manipulation of the instruments in confined spaces extremely difficult.

5. Thermocouple Spear Set.

This consisted of a set of 20 1 foot tubular sections with a pointed end containing a thermocuple, and which could, in theory, be pushed into bagged or bulk produce, the tip of the spear being connected to any desired recording instrument by a wire running inside the tubular sections.

However, it was found impossible in practice to push the spear manually into more than one or two bags of a stack of bagged cocoa beans; due to the high degree of compression of the stack. It was thus, unfortunately, useless on this expedition.

6. Casella Thermohygrographs.

These instruments worked satisfactorily, except for a tendency for the ink to dry up prematurely, as mentioned by

Matthews. No difficulty was experienced in calibrating the instruments before installing them in the holds; an accurate +20°C to - 20°C termometer was used for temperature calibration and, in the case of humidity, the bundle of hairs was moistened with distilled water with a paintbrush until the pointer was steady, and the adjustment then altered until the pointer indicated 95 per cent R.H.

Although they were sheltered in the holds, the exposed moving parts of these instruments suffered considerable corrosion from the salt atmosphere, and possibly this would alter the readings obtained towards the end of the voyage, by dampening the movement, when any minor fluctuations would not be recorded, or by causing the pointers to stick in one position.

7. Lovibond Comparator Set.

Although the makers state that this can be used to measure relative humidity to within 5 per cent, this was not found to be practicable due to differences of opinion between the two expedition members in matching the colours obtained with the set of standards provided. Variations of relative humidity throughout the air in the hold at any time appeared to be less than 5 per cent and thus could not be measured with this instrument.

In the light of experience gained since this trip was made, it would appear that a wet and dry thermocouple pair, used in conjunction with the Sunvic Potentiometer, would have given R.H. readings accurate to within 1 or 2 per cent, but this was not realised at the time.

8. Scott-Mec Oxley Moisture Content Meter.

This consisted of a multi-pronged probe which was thrust into the bags, and an indic ting meter. It was already calibrated for use with bagged cocoa beans, but it was found that not only the moisture content, but also the amount of compression to which a bag was subjected (i.e., whether the beans were tightly or loosely packed) affected the reading given. Another limitation was that only the outer layer of bags in any stack could be investigated.

The instrument worked well, although two people were needed for efficient operation in the holds; one to move about with the probe, and the other to remain in a sufficiently large space to operate the manually-cranked generator type of indicating meter.

9. Vickers-Armstrong Velometer.

This was of no use due to its directional characteristics, and lack of sufficient sensitivity for work in the holds. Any instrument for this purpose must be omni-directional, and very sensitive, as air currents in the holds were barely perceptible.

C. OUTWARD VOYAGE. m.v. "Vesteroy."

The expedition sailed from Liverpool at midnight on July 11th, called at Freetown, Sierra Leone, on July 21st, and arrived at Takoradi, Ghana, on the morning of July 24th.

The vessel was carrying general cargo: No. 4 hold, the one used for measurements, was almost empty. The lower hold contained only some packeted and cased goods, and light machinery; the shelter deck had only motor vehicles for discharge at Freetown, and piles of old dunnage.

The weather during the outward voyage was good, except for the day preceding our arrival at Freetown; details are given in Table 1.

21 thermocouples were installed in No. 4 hold, 15 in the lower hold, and 6 in the shelter deck. also 4 thermohygrographs were put in the lower hold. Unfortunately none of the thermohygrographs gave usable results, due to inking troubles, which were rectified before the homeward voyage. (As mentioned previously, there were no access hatches on this vessel, so the instruments could not be examined whilst at sea). The positions of the thermocouples are shown in figs. 2 and 3, and the accompanying Table 2. Readings were taken 3 times daily, using the Doran "mini" Potentiometer until noon on the 14th July, after which the Sunvic potentiometer was used until its breakdown in the early hours of July 19th, when the Doran was again used until arrival at Takoradi (except during the one day call at Freetown). In addition to these readings, measurements were made at hourly intervals for a 24 hour period, starting at 8.30 a.m. on the 18th July, to determine the daily pattern of temperature variations. These two sets of readings are given in Tables 3 and 4 respectively,

and graphed in figs. 4 to 8, and 9 to 13.

The thermocouples are arranged in groups in the graphs to show certain effects, as follows:

a) 1 - 4; the gradient from centre to port bulkhead, half-way down the hold, and close to the engine room bulkhead.

b) 5 - 8; the same gradient as above, but further off from the engine room bulkhead.

c) 9 - 13; the gradient from the centre to the starboard bulkhead at the bottom of the hold, including the effects of heating by the propellor-shaft tunnel.

d) 14, 15, 16 and 18; the vertical gradient up the metal ladder from the bottom of the hold to below the main deck.

e) 17, 19, 20 and 21; the effects of port bulkhead and main deck temperature (19 and 21) on the temperature of shelterdeck, both against and at a distance from the engine room bulkhead (17 and 20).

Each of these groups will now be considered separately, and the main implications of the readings considered.

a) <u>1 - 4</u> (figs. 4 and 9)

There was a definite gradient from the outside to the warmer centre of the hold; this gradient remained fairly constant, with point 1 some 5 to 6° C higher than point 3. Point 4, on the port bulkhead above the water line was heated strongly by the morning sun each day, and some of this heating was transferred to point 3, on the stringers, but, except on July 19th, this heating did not extend in to point 2.

b) 5 - 8 (figs. 5 and 10)

Point 5, on the engine room bulkhead gave readings very similar to point 1 further forward on the same bulkhead, However points 6 - 8 were much cooler than 2 - 4, and differed little from one another; a temperature gradient was present, but it was much smaller than between points 2 and 4. Point 8 on the bulkhead did not show the diurnal heating that point 4 did, this probably being due to it being slightly lower than 4, and lying a little below the sea level; this shows the high degree of stabilisation of the outside bulkhead temperature provided by the sea. The increase in the temperature of point 8, (and, to a lesser extent, 7), relative to point 6 on July 19th and 20th was probably due to entering a warm current.

c) 9 - 11 (figs 6 and 11)

From the start of the voyage till the 18th July there was a steady increase in temperature from the outside of the ship towards the centre. Point 9, on top of the propellor-shaft tunnel, was noticeably warmer than point 10, at the side of the tunnel, only a few feet away, and the difference was presumeably due to heating by the tunnel. Point 9 gave similar readings to point 14, although further from the engine room. Point 13, and, to a lesser extent, 12, showed a distinct increase in temperature on July 18th, and the days following, and this was thought to be due to an increase in sea temperature: the ship's position was similar to that on the return voyage when the sea temperature fell sharply (sea temperature was recorded only on the return voyage). Also the rise co-incides with that of point 8, both showing well in the 24 hour series of readings taken on 18th and 19th July.

d) 14, 15, 16 and 18. (figs. 7 and 12)

It is interesting to note that point 14 was the coolest in the vertical gradient up the access ladder, which shows how low even the highest of the lower hold temperatures was, relative to those in the shelter deck. Point 15, below the shelter deck, was constantly some 4°C above this, and suprisingly, was almost always hotter than point 16, immediately above the shelter deck. Point 18, under the main deck, showed great variation due to diurnal heating by the sun, reaching its peak temperature at about 2.00 p.m., and then falling to a lower temperature even than point 14 in the early morning. Thus, invariably in the lower hold, and frequently in the shelter deck, the temperature was higher at the top than the bottom, which conflicts with Matthews' findings. In the case of the shelter deck, solar heating of the main deck accounts for this. The difference in the lower hold was probably due to the half empty state of the hold, compared with his measurements in a full hold. In his case any heat generated by the engine room or propellor-shaft tunnel was retained locally in the cargo, whereas in this case the heat was lost into the air, and convection resulted in the hotter air lying at the top of the hold. (Heating by the sun on its own would not explain why the top of the lower hold was warmer than the bottom of the shelter deck.)

e) 17, 19, 20 and 21 (figs. 8 and 13)

Points 19, on the port side of the shelter deck, and 21, under the main deck, showed intense solar heating, 19 reaching its peak earlier, being on the east side of the southbound ship, and thus receiving the effect of the early morning sun. Points 17 and 20, actually on the shelter deck, did not show much diurnal variation despite the heating of the sides, and main deck above them. Point 17 tended to be slightly warmer than point 20; as this was especially marked when point 21 was at its hottest it was presumably due to a limited transmission of heat from the sun, rather than any effect from the engine room.

Thus, in general, the thermocouple readings on the outward voyage confirm the temperature gradients found by Matthews, except for the vertical gradient in the lower hold, where the bottom of the hold was the coolest; as mentioned this was probably due to the lack of cargo in the hold There was considerable variation between points in the hold, contrary to Neville's findings.

The 24 hour set of temperature readings show that there was little or no fluctuation over the 24 hours, except for points 4, 18, 19 and 21, all of which were on or near bulkheads heated by solar radiation.

D. HOMEWARD VOYAGE m.v. "Nordkyn."

The party sailed from Takoradi on the evening of September 18th, and docked at Rotterdam on October 3rd, with no intervening ports of call.

The cargo consisted of logs, sawn timber, cocoa and copra, and details are given later where they are relevant to the measurements taken.

The weather, details of which are given in Table 5, was variable, with generally bad conditions between September 21st and 23rd, followed by mainly showery conditions, with force 7 winds on September 29th and 30th. Fig. 14 shows the exposed sun temperature throughout the voyage, recorded on a Negretti and Zambra dial reading thermograph, with its element exposed above the hatch cover of No. 4 hold.

22 thermocouples were installed in the holds, distributed as follows: 4 in bagged cocoa in No. 1 shelter deck; 3 in bagged cocoa and 1 exposed in No. 3 shelter deck; 14 in bagged cocoa in No. 3 starboard deep tank. 3 Casella thermohygrographs were installed in the cocoa in the same deep tank, and 1 in the copra in No. 3 shelter deck. Figs. 15 - 17, show the relative positions of all these instruments, and Table 6 gives the actual sites.

i) Temperature results. Thermocouple readings were taken three or four times each day, using the Sunvic Potentiometer, with the input earthed as described previously, until September 27th, when the instrument began to function normally again.

Readings were not taken from the thermocouples in No. 1 hold until September 28th, when it was found that twisting the sets of wires together reduced the pick up of interference by the long leads involved.

No 24 hour set of readings was attempted due to the failure of the instrument during the previous such period on the outward voyage and the possibility that such prolonged use might lead to the development of another fault. With the Doran "mini" potentiometer already broken this risk could not be taken, as we weredependent on the Sunvic potentiometer for all thermocouple measurements.

The results are shownin Table 7, and graphed in figs. 18 to 23. In addition, fig. 24 shows the sea temperature throughout the voyage, as measured at regular intervals in the engine room.

As on the outward voyage, the thermocouples have been grouped in the graphs to show certain gradients, which are listed below. The temperature records from the thermohygrographs are included in the thermocouple graphs for comparison, as well as being shownin their original form in figs. 25 - 28.

a) 1 - 5, and thermohygrograph A; the gradient forward from the engine room bulkhead in No. 3 deep tank.

b) 6 - 9; the vertical gradient down an airshaft in No. 3 deep tank.

c) 11 - 13, and thermohygrograph D; the gradient inwards from the starboard side of No. 3 deep tank, measured at the surface of the cocoa.

d) 9, 10 and 15; the same gradient as above, but measured six bags below the surface of the stack.

e) 16 - 19; the gradient from the starboard side to the centre of No. 1 shelter deck, measured three bags above the bottom of the stack.

f) 14, 21 - 23, and thermohygrograph C; the gradient inwards in bagged copra from the side of No. 3 shelter deck.

(N.B. Although the thermocouples are numbered 1 - 23, no thermocouple numbered 20 was actually used, leaving only 22 sets of readings).

Each graph will now be considered separately.

a) <u>1 - 5, and thermohygrograph A</u> (fig. 18)

Initially points 4 and 3 were much hotter than 1, 2 and 5, all of which gave similar readings until September 24th. When more notherly latitudes were reached, however, a gradient was set up extending forwards from the engine room bulkhead, with point 2 at first intermediate between points 3 and 5, and then becoming as warm as 3 and 4, presumably due to heat from the engines being retained in the cargo as the temperature fell at the edge of the stack nearest to the engine room. Point A also showed this reduced cooling effect, but it was cooler than 2, probably due to being on top of the stack, whereas 2 was buried under the top layer of bags. The rise of points 3 and 4 on the 22nd to 24th September appears at first sight to be correlated with the curve of sea temperature (fig. 24), but it is doubtful whether in fact this is the true cause of the increase as an increase in sea temperature would have most effect on thermocouples on the outside bulkheads, and points 12 and 13, in such a situation, do not show any great increase on these days. It is more likely that the increase was due to lack of ventilation on these days, as the ventilation was closed from the 21st to 24th September. If this is the true explanation, it shows how the ventilation normally carries away the heat from this source, and how the temperature rises as a result, when the ventilation is cut off. This is confirmed by 1, which was cooled by the ventilation shaft, except on these dates, when it increased to the temperature of 2 and 5.

b) 6 - 9 (fig. 19)

During the first half of the voyage, till September 27th points 8 (at the bottom) and 9 (at the top) were the coolest, with 7 generally warmer than 6. Thus 9, 6 and 7 showed an increasing temperature gradient with increase in depth down the shaft, although the differences involved were relatively small. After 24th September, point 8 became much cooler than the others, due presumably to the cooling effect of the sea, and the other three points gave very similar readings from September 27th until October 1st, when a reverse temperature gradient seemed to be forming, with point 9, almost at the top of the shaft, the warmest, and then 6, 7 and 8 in decreasing temperature order. The reversal of gradient may have been due to the cooling effect of the sea gradually affecting the higher parts of the air shaft: whether similar gradient would occur actually among the bags is not certain. In addition, point 9 was probably more stable than the others, it alone being embedded between the bags, the other points being almost exposed to the air in the shaft.

c) <u>11 - 13, and thermohygrograph D</u>. (fig. 20)

There was a distinct increasing temperature gradient towards the inside of the hold, as shown by points 11, 12, and 13. Point 13, on the starboard (eastern) bulkhead, showed heating by the sea on the same days as point 23, at shelter deck level on the same side, except on September 25th and 30th, when 13 was not heated. The peaks of 13 appeared to be earlier than those of 23, the temperature falling again by 2.00 p.m., and thus the heating was probably due to the early morning sun, which on the two dates mentioned was probably behind cloud until it had risen higher, and then only heated point 23, mainly by conduction from the horizontal decksurface above. The weather records show this to be likely on both the days concerned. The degree to which the fluctuations of point 13 affected the inner points varied; on September 22nd and 24th, for example, all the points rose, but these dates were overcast, with the ventilation closed, which resulted in the general rise in temperature, whereas when 13 was heated by the sun alone, with the ventilation open, as on September 28th, and October 1st, the inner points were not affected. The thermohygrograph D recorded a cooler temperature than the thermocouples although it was nearer the centre of the ship. This was probably because it was beneath the deep tank cover, where there was more ventilation. It showed fluctuations similar to those of point 11, but was always some 2°C cooler.

d) 9, 10 and 15 (fig. 21)

These gave very similar readings until near the end of the voyage, when point 10 cooled down the most, and point 15 the least, for no obvious reason, there being no clear gradient between the three. Point 15 was considerably warmer than point 11, and also fluctuated less, indicating that conditions were both warmer and more stable six bags below the surface of the stack than at the top. By the end of the voyage the temperatures were cooler than in the equivalent positions in No. 1 shelter deck: possibly the hold was more sheltered from the sun. This does show that any effects of heating by the engine room did not affect the bulk of the cargo in the adjacent hold.

-) 16 - 19 (fig. 22)

There was a distinct gradient in towards the warmer centre of the hold. The fluctuations of point 19 on the starboard bulkhead had little effect on the points in the cocoa (as found also by Matthews). The temperature at the centre did not appear to be falling fast at the end of the voyage. It is unfortunate that no earlier readings were taken to see if the temperature gradient was present at the start of the voyage, as it was increasing towards the end.

f) 14, 21 - 23 and thermohygrograph C (fig. 23)

Point 23 showed variation due to diurnal heating by the sun, although it was somewhat cooler than point 19 in No. 1 shelter deck. The cargo in No. 3 shelter deck (Copra) was initially considerably hotter than any of the cocoa in which readings were taken, but by the end of the voyage it had cooled down to a similar level. In the copra point 22 was often hotter than 21, which was further in. This could not have been due to heating of the outside bulkhead by the sun because several of the days in question were overcast, and the reasons are therefore uncertain. When cooling occurred, however, a more normal gradient was set up, with point 21, the innermost in the copra, being the hottest.

Point 14 was on the centre of the shelter deck, in an exposed poisition. It was as a result cooler, and its peaks occurred later in the day,than those on the starboard side, due to heating of the deck above, rather than of the side of the ship. During the days with some solar heating but no ventilation (e.g. September 22nd and 24th) the temperature of 14 increased more than on days when there was strong solar heating with the ventilation system opened (e.g. September 26th to 28th). As in the case of points 3 and 4 previously mentioned this shows that lack of ventilation can cause a general diurnal temperature increase in the holds. This corresponds with Neville's findings of a drop in temperature of up to 4°C when the ventilation is opened,

The thermohygrograph C gave much lower readings than those obtained in the copra on which it was standing, indicating possibly that the air temperature in the hold was dependant more on the solar heating of the ship than the warmth of the cargo. It did record a gradual increase relative to point 14, which was also exposed to the air, throughout the voyage, indicating that the cooling of the air over the copra was somewhat retarded.

Humidity results.

The positions of the four thermohygrographs are shown in figs. 15 and 17, and their traces are shown in figs. 25 - 28.

Instruments A, B and D, all in No. 3 starboard deep tank, showed a high humidity falling gradually throughout the voyage, from 80 - 90 per cent at the start to 70 - 80 per cent at the end. A showed sudden variation on the 28th to 30th September, and both B and D showed a sudden fall and subsequent rise on 30th September; The reasons for these changes are not obvious, although they appear to be correlated with falls in the general temperature level in the hold.

Instrument C was in the copra in No. 3 shelter deck, where the humidity was initially slightly lower (80 per cent), but generally remained higher than in the deep tank, being between 80 and 90 per cent at the end of the voyage. There were considerable fluctuations in humidity, without any apparent corresponding changes in temperature, and little sign of any regular daily fluctuations. The high humidity and small fluctuations were probably correlated with the large amount of condensation above the copra on the underside of the main deck. Dripping from this deck may have caused the minor fluctuations.

In addition to the thermohygrograph measurements, an attempt was made to measure the humidity at different levels in a ventilation shaft, using the Lovibond Comparator set. However no differences could be distinguished between any of the results, and the method was not tried again.

i) Moisture Content results.

Using the Scott-Mec Oxley moisture content meter, readings were taken on September 27th of the moisture content in bagged cocoa in No. 1 shelter deck, and No. 3 starboard deep tank. Where possible readings were taken at both ends of bags, in the hope that this would show up gradients in the holds, independent of variations between bags due to different degrees of compression. The results are shown on diagrammatic plans of the cargo in figs. 29 - 31. It is possible that more detailed statistical analyses would show up significant gradients in the stacks, but in this case, as no previous work of this type appears to have been done, it has been thought sufficient just to give the figures obtained, and to average them wherever possible into mean figures for rows of bags, or areas in the hold, etc.

In No. 1 shelter deck, readings were taken on the upper layer and the aft face of the stack of bags on the starboard side of the hold. The upper layer (fig. 29) showed a gradient of decreasing moisture content from 7.4 - 7.5 per cent at the centre of the hold, to 6.9 - 7.0 per cent at the outside, except for a high value (7.7 per cent) from the row of bags directly under the starboard side of the deck hatch, which was usually opened for ventilation purposes. No definite gradient was found from the forward to aft bags varying from 6.9 - 7.9 per cent. The mean value for the whole top layer of bags was 7.3 per cent. The aft face of the stack (fig. 30) showed an increase in moisture content with depth down the stack down to a depth of nine bags, after which it remained constant at about 8.1 per cent. It is possible, however, that part or all of any apparent increase in moisture content with depth is due to the greater compression of the bags towards the bottom of the stack: further work would be needed to determine this. There were no large differences between the columns of bags at the centre of the ship and nearer the starboard side, the latter being only 0.2 per cent greater.

In No. 3 starboard deep tank (fig. 31) readings were taken from various bags on the top of the stack, from the engine room bulkhead to the forward limit of the deep tank. Readings were also taken at various depths on the four sides of three air shafts (shown as A, B, C in fig. 31). The upper layer of bags could not be divided into rows and columns as in No. 1 shelder deck, and instead the readings have been divided into three main groups according to position, and the average calculated for each. The bags near the engine room bulkhead had a low moisture content, averaging 6.5 per cent. Those intermediate between the engine room and the deep tank hatch cover had an average value of 7.4 per cent, similar to the overall value of the top of the stack in No. 1 shelter deck. The third group, consisting of the bags under the deep tank hatch cover, had a high moisture content, the average being 8.6 per cent. Whether this was due purely to a lack of drying by the engine room, or being dampened by cooling and condensation from the air in the shelter deck above is not certain, and readings would have to be taken throughout the voyage, instead of on a single occasion, to determine this.

The readings taken in the air shafts are given in Table 8. Direct comparisons between the shafts are complicated by the fact that the top of the stack in the square of the hatch was three bags above the level of the rest of the stack, and thus the tops of shafts A and B were at the same level as the 3rd bag down in shaft C. Each shaft showed some increase in moisture content with depth, this being most marked in shaft

4, where possibly only the upper bags were dried out by the engine room heat. Averaging the readings from each side of the hafts did not show any significant trends.

As on the two previous expeditions, the physical conditions in the holds were found to be suitable for the growth of insect populations. The temperature in the cocoa was generally between 25 and 30°C. External changes in temperature appeared to have little effect on the main bulk of the cargo, except near air channels, and towards the top, bottom and sides of the stack. Elsewhere the variations were gradual: on the outward voyage the temperature near the engine room bulkhead rose from 27°C to 34°C, whilst that in the hold rose from 19°C to 27.5°C. On the homeward voyage temperatures in the bulk cocoa, starting at 28°C, fell to 26°C (e.g. points 2 and 9, towards the centre of the stack) or to 22°C (e.g. point 11, nearer the edge of the stack).

These temperatures are well within the range at which the insects commonly found in West African produce can breed and be active. In addition, the high relative humidities (70 - 90 per cent) in the free space would also be favourable.

Various aspects of the results will now be considered in more detail, and compared with the results of the previous expeditions where relevant.

CONCLUSIONS

Most of the temperature gradients found by Matthews were confirmed, except for the vertical ones. Thus the temperature in the holds increased towards the centre of the ship, and towards the engine room bulkheads. However the increase in temperature with depth was not confirmed: on the outward voyage, probably due to the empty condition of the hold, the tops of both lower hold and shelter deck were hottest, and on the return voyage, when the gradient was measured in an air shaft in bagged cocoa, an increase occurred only down to the middle of the shaft, below which the temperature dropped, probably due to the cooling effect of the sea. This decrease in temperature gradually spread upwards until the end of the voyage the top of the shaft was the warmest point. However it is possible that this condition only occurs where an air shaft allows easy heat transmission, and that in the cargo itself there is in fact an increasein temperature with depth, the sea only cooling the extreme lower layers of the stack. Alternatively, the rise in temperature in Matthews' case may have been due to his taking readings in a hold aft of the engine room, with the propellor-shaft tunnel at the base of the hold warming the cargo.

2. The temperature maxima in the cargo on the homeward voyage were lower than those recorded by Matthews and Neville. The highest temperature recorded in the cocoa was 37°C (99°F), and in the copra 34°C (93°F). The difference was probably due to the different nature of the cargoes on the different expeditions.

3 On the shelter deck in particular, diurnal solar heating resulted in very high bulkhead temperatures, but these did not greatly affect the temperature in the cargo.

There did not appear to be much heat generated by the propeller-shaft tunnel on the outward voyage. However, if it had been covered by an insulating cargo, there might have been a significant increase in temperature due to the heat not being carried away, and it was unfortunate that no readings could be taken in this region on the homeward voyage.

5. Contrary to Neville's findings, the temperatures of points throughout the hold did not always increase or decrease together.

6. Any sudden fall in temperature in the holds on the 24th and 25th September could partly be due to the sharp decrease in sea temperature on these dates (from 26°C to 22°C), in addition to the ventilation changes already discussed. This decrease correlates with the position of the cold southbound Canary current. Thus the possibility of ocean currents affecting the physical conditions in the holds must not be overruled.

7. The variations in humidity recorded were less than those found by both Matthews and Neville. However, their thermohygrographs, with one exception, were located in the open spaces in the holds, and thus the results obtained on this voayge show that the relative humidity immediately above, and just within the cargo is more constant than in the air spaces away from the cargo, and remains high even at the end of the homeward voyage.

8. The moisture content of bagged cocoa varied from 5.8 per cent to 9.8 per cent, being least near the engine room

bulkhead, and greatest under the hatch covers. It tended to increase with depth down the stack, but this apparent increase have been due to greater compression of the lower bags.

TRANSIT STORAGE AT TAKORADI DOCKS.

Certain modifications, both in the actual structure of the warehouses, and of the treatments carried out in them, have taken place since Matthews reported on them in 1957.

In the summer of 1960, seven of the privately owned dock warehouses had recently been taken over by the Ghana Cocoa Marketing Board. Work was in progress on opening up these warehouses into one large store by knocking down the intervening walls. Eventually all the dock warehouses will become G.C.M.B. property, and all cocoa leaving the port will be overstamped with their mark. It is hoped that this will speed up the loading of cocoa, as ships will be able to take on their complete consignment of cocoa at one berth instead of having to load small parcels of different marks from separate privately owned sheds.

At the time the warehouses were visited only a relatively small quantity of new season's cocoa was in store. Small stacks of old cocoa were still present in some sheds, and these supported few to moderate numbers of _Lasioderma serricorne_ F., very few to few _Araecerus fasciculatus_ Deg., and very few _Cadra cautella_ (Walker). All cocoa was stacked on wooden dunnage, and the amounts of old spillage residues seen were light.

With the opening up of the warehouses and the more systematic movement of bagged cocoa, the removal of the sectional dunnage for cleaning of spillage should be greatly facilitated.

Pybuthrin fogging is now a daily operation compared with the twice-weekly tre tments used in 1957. Before the warehouses were knocked into one, 15 pints were required to treat each one, using a Dynafog machine. At the time of his inspection of these warehouses, Matthews reported that during misting operations the doors were not completely closed. On this occasion, however, small holes were seen to have been cut in the doors through which the barrels of the Dynafog machines could be inserted for use. However leakage still occurred from the ridge ventilators of the warehouses. Similar fogging is carried out in transit warehouses in the Ashanti region. As a result, the number of adult C. cautella seen in the dock transit sheds was very small. One newly-arrived closed railway wagon of cocoa from Ashanti was opened, and this revealed moderate numbers of C. cautella adults flying above the bags.

One bag in every hundred removed from the warehouses for export is opened by the Produce Inspection Office, sieved and the numbers of insects present noted. C. cautella larvae and adults are listed separately, but all stages of Coleoptera are added together. However the inspectors were seen to be quite familiar with the larvae stages of Tribolium castaneum Herbst., and L. serricorne, and experienced no difficulty in identifying them. Sample insect count forms as used are reproduced in Table 9. Provided that there are less than 40 insects per bag the consignment is passed, although cocoa destined for the United States must have an average of less than 10 insects per bag. However, in practice all cocoa for export to the United States is automatically fumigated before shipment.

All fumigations taking place in the port of Takoradi are carried out in lighters (dumb barges) of known cubic capacity. The bags are covered with a double layer of gas-proof sheeting, sealed down with sections of fire hose tightly packed with sand. Methyl bromide is piped in through four jets, without the use of a vaporizer, at the rate of 32 ozs. per 1,000 cu-ft for four hours exposure, and allowed to air off overnight. A Coventry Motor compressor driving a contra-rotating aerofoil fan has recently been mounted on the back of a lorry to act as a mobile gas extractor. A series of 25ft lengths of flexible hose, 1½ inches in diameter, could be attatched to the fan, and it was hoped to be able to clear the methyl bromide from a sheeted stack of cocoa in about 30 minutes.

5. DISCUSSION.

Whenever large quantities of foodstuffs are stored in other than insect proof containers, they are liable to insect infestation. This is true both of long term storage in warehouses and whilst in transit, such as in railway wagons and the holds of ships. It is in this transient storage that greatest difficulties arise in the prevention of infestation.

Ideally if all commodities were fumigated such difficulties could virtually be eliminated, but if a fumigated consignment such as cocoa is stored adjacent to a non-fumigated and infested consignment, the former will itself become infested with insects from the infested consignment; the phenomenon of cross infestation.

Matthews investigated the conditions of storage both in warehouses in West Africa, and in the ships carrying produce from there to the U.K., and found that the physical conditions in the ships' holds were suitable for increases in insect populations, and that the conditions both there and in transit storage in Ghana and Nigeria were such that cross infestation could and did occur. This expedition has confirmed the suitability of ships' holds for the increase of insect populations and has provided more detailed data on the actual sources of heat in the holds. The arrangements in the transit storage sheds visited in Ghana had changed since they were visited by Matthews, but those in Nigeria were not seen on this occasion. In Ghana all exported infestible commodities are now under the one authority, and this should enable a universal standard to be maintained throughout the country. However since ships loading in Ghana have usually already loaded in other West African countries, such as Nigeria the treatment given to the Ghanaian produce is only of use if all cargo previously or subsequently loaded in the same hold is free of infestation. In fact it was observed that cargo loaded previous to Takoradi was infested with species of insects capable of infesting the Ghanaian cocoa, and was stored in close proximity to it.

The remainder of the work planned for this expedition, and listed in the terms of reference at the beginning of this report, was concerned with obtaining quantitative data on the degree of cross infestation either occurring or potentially capable of occurring in the ships, and the efficiency of existing methods of chemical control of combating it. As mentioned, non of these plans were actually carried out, and it is worth noting that in every case the reason was that executing the plans would have conflicted with the efficient or economic running of the ship or port concerned.

In a normal plan of research work this consideration does not arise, but in all work of this nature, where the subject matter and its disposal are already determined by economic considerations, scientific work takes second place to economic needs and business efficiency. Thus no detailed plans can be made in advance about the programme of work. There is often little advance notice of the cargo or destination of some ships (especially those on charter), and arrangements for scientific work must often be made at the last minute, which excludes some types of research altogether from this field.

In this case the work was further hampered by the fact that the members of the expedition were both undergraduate students, and their time for the work was therefore limited to the long vacation (i.e. July to September inclusive). The first consequence of this was that the work had to be done before the main cocoa season, so that there was relatively little cocoa being loaded at Takoradi when the party returned. The limited time available also meant that the return to the U.K. had to be made by October 3rd, and thus a ship had to be used which did not in fact dock in the U.K., but which unloaded on the Continent, making the intended co-operation with the Ministry of Agriculture inspectors impossible. This does not in any way reflect on Palm Lines Ltd., who very generously provided and arranged the passages for the expedition: however had the expedition been able to choose its time, it would have been able to make better scientific use of the facilities provided.

Ideally, any work of this nature required close and continued co-operation between scientific organisations, both in West Africa and the U.K., and the companies concerned with marketing and shipping the produce in question. It follows that part-time workers such as university students can do little even when helped by research organisations, and in fact the work would be done best by the research organisations in question who can choose the best time of year for the work, and would not have to keep to such a restricted timetable. Matthews states that trained personnel in West Africa would be needed for this, but it would seem more desirable from the point of view of the importing country for the investigating personnel to travel back with the cargo, and then examine it on unloading and during subsequent storage. Matthews also considers that the ideal is to have un-infested produce, protected from re-infestation, and in transit for as short a time as possible. However the transit time cannot be made less than the duration of the voyage from West Africa to the U.K., and the loading requirements of ships often neccesitate stowing cargo from different countries in the same holds. As recommended above, work can be done to investigate cross infestation during this period, but the ultimate aim should be for all West African produce exporting countries to use similar methods to reduce infestation as those now being carried out under the Ghana Cocoa Marketing Board, and thus render the problem of cross infestation insignificant.

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Mr. P. Taylor, Secretary, Imperial College Exploration Board.

Also they are very grateful to Dr. J.A. Freeman, for his criticisms and useful advice in the preparation of this report.

7. List of Figures and Tables.

le 7 Daily thermocouple readings.

.13 " " " , thermocouples 1 - 5.

.19 " " " , " 6 - 9.

20 " " " , " 11 - 13.

21 " " " , " 9, 10 & 15.

22 " " " , " 16 - 19.

23 " " " , " 14, 21 - 23.

24 Sea temperature.

25 Chart of thermohygrograph A.

26 " " " B.

27 " " " C.

28 " " " D.

29 Moisture content of bagged cocoa in No. 1 shelter deck:
a) top of stack.

30 ditto b) aft face of stack.

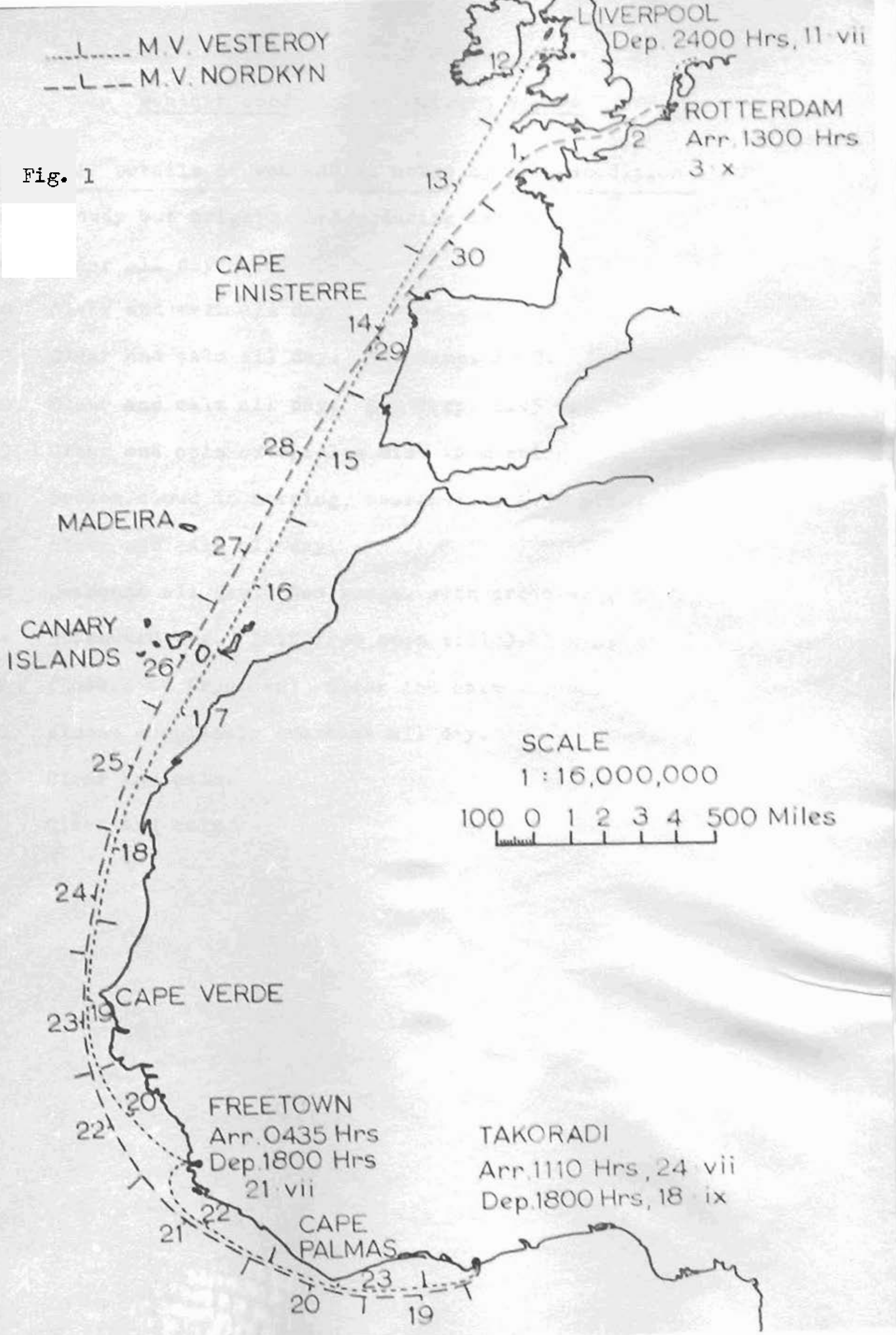
31 Moisture content of bagged cocoa in No. 3 starboard deep tank.

e 8 Moisture content in air shafts.

Takoradi Docks.

e 9 Sample insect count forms.

Fig. 1


M.V. VESTEROY
M.V. NORDKYN
LIVERPOOL
Dep. 2400 Hrs, 11 vii
ROTTERDAM
Arr. 1300 Hrs
3 x
CAPE
FINISTERRE
MADEIRA
CANARY
ISLANDS
SCALE
1 : 16,000,000
100 0 1 2 3 4 500 Miles
CAPE VERDE
FREETOWN
Arr. 0435 Hrs
Dep. 1800 Hrs
21 vii
TAKORADI
Arr. 1110 Hrs, 24 vii
Dep. 1800 Hrs, 18 ix
CAPE
PALMAS

Positions of thermocouples: Outward Voyage

No	Position
	. 4 LOWER HOLD
1	Attached to engine room bulkhead
2	" " " " "
3	" " " " " on stringers
4	" " " " " at port bulkhead
5	Attached to engine room bulkhead
6	On surface of boxed goods
7	" " " " " on stringers
8	On port bulkhead.
9	On top of propellor-shaft tunnel.
10	At side of " " "
11	On surface of boxed goods
12	" " " " " on stringers
13	On starboard bulkhead.
14	At foot of access ladder.
15	In box beam under shelter deck at top of access ladder.
	NO. 4 SHELTER DECK
16	At foot of access ladder on shelter deck.
17	On shelter deck behind cased goods.
18	At top of access ladder on underside of main deck.
19	On port bulkhead
20	On shelter deck, at side of lower hold hatch.
21	On underside of main deck.

Fig. 2

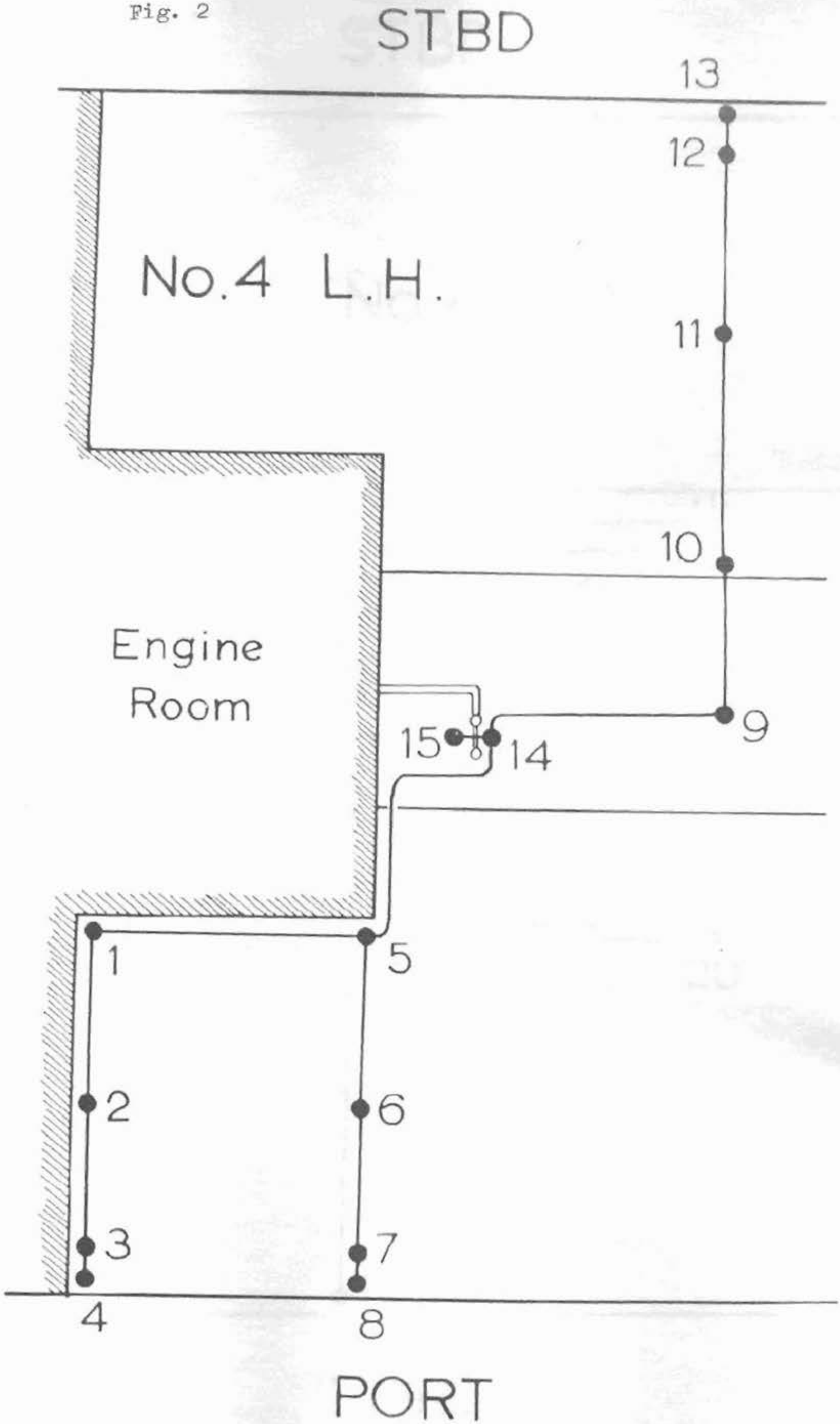
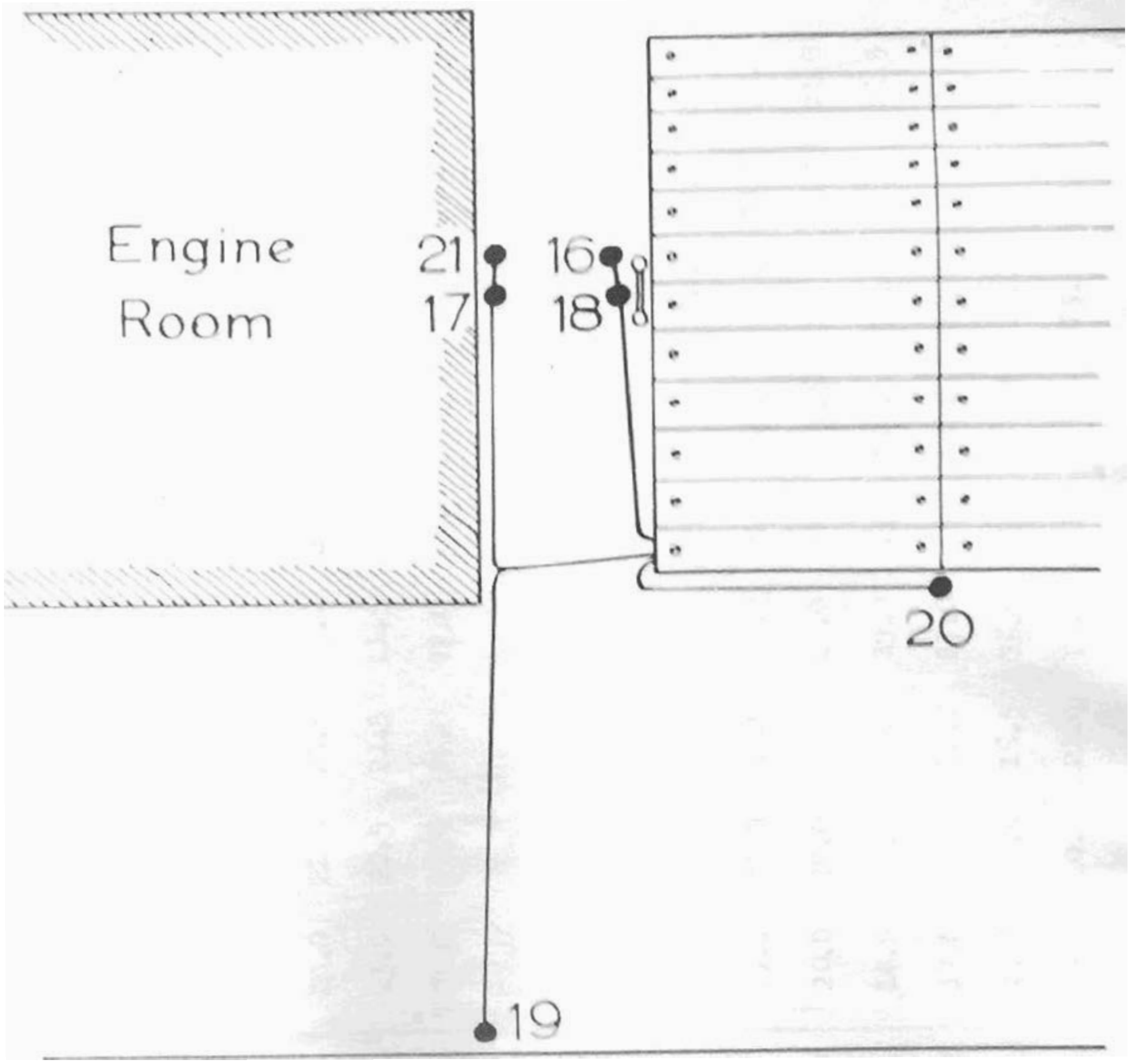


Fig. 3

STBD

No.4 S.D.



PORT

TABLE 3 — Daily thermocouple readings :

DATE	12.7.60	13.7.60			14.7.60			15.7.60			16.7.60			17.
TIME	4.15 p.m.	8.35 a.m.	12.35 a.m.	6.10 p.m.	8.30 a.m.	1.10 p.m.	7.50 p.m.	8.55 a.m.	1.00 p.m.	7.10 p.m.	8.35 a.m.	12.55 p.m.	6.10 p.m.	9.0 a.m.
	← DORAN →					← SUNVIC								
1	27.0	22.0	26.5	25.0	28.5	29.2	29.6	30.5	30.9	30.6	30.7	31.8	31.1	31.4
2	23.0	22.0	23.5	23.0	25.0	24.8	25.2	27.0	27.2	27.5	27.4	27.9	28.3	28.6
3	23.0	20.5	21.5	21.5	23.5	24.3	24.1	27.5	26.6	25.7	26.1	26.0	26.1	28.7
4	20.0	20.5	19.0	19.0	23.5	23.6	21.7	33.8	25.3	22.8	25.1	23.0	23.0	29.5
5	27.0	25.5	26.0	26.0	26.5	29.2	29.1	30.1	30.7	30.8	30.7	31.6	31.5	32.9
6	20.0	19.0	19.5	20.5	20.0	21.2	21.7	23.1	23.6	23.8	24.0	24.3	24.5	24.7
7	20.0	19.0	18.5	19.5	19.5	21.1	21.3	22.9	23.3	23.4	23.5	23.6	23.8	24.4
8	17.5	18.5	17.5	18.5	18.5	20.9	20.8	22.4	22.5	23.0	22.9	22.5	23.3	23.8
9	19.0	21.0	19.5	21.0	21.5	22.7	23.1	23.3	23.6	24.3	24.2	24.3	24.8	25.2
10	20.0	19.0	20.0	20.0	20.5	21.6	21.5	22.3	21.8	22.4	23.4	23.2	23.3	24.0
11	18.0	17.5	18.0	19.0	19.5	20.3	20.6	21.1	21.5	22.1	22.0	22.2	22.7	23.4
12	17.0	17.0	17.0	17.0	18.0	19.4	19.5	20.1	20.3	20.8	21.0	21.1	21.3	21.9
13	16.0	15.5	16.5	16.5	17.0	20.3	20.0	20.4	20.6	20.8	21.0	20.7	21.1	21.8
14	18.5	20.0	21.0	21.0	21.0	22.8	23.1	22.6	23.2	23.5	24.2	24.1	24.5	25.0
15	21.5	21.5	22.5	22.0	23.0	24.5	24.6	27.3	27.7	27.6	27.2	28.1	30.0	28.6

outward voyage.

Table 3 (cont'd 2)

7.60.		18.7.60			19.7.60			20.7.60			22.7.60		23.7.60	
1.40 p.m.	7.00 p.m.	8.55 a.m.	1.45 p.m.	8.10 p.m.	8.30 a.m.	12.45 p.m.	7.30 p.m.	8.30 a.m.	6.45 p.m.		8.45 a.m.	6.15 p.m.	8.30 a.m.	6.00 p.m.
———	———	———	———	——→	←——	———	———	D O R A N	———	———	———	———	———	——→
31.6	31.9	31.3	31.2	32.8	32.5	35.0	34.5	34.0	34.0		34.0	34.0	33.5	34.5
28.0	28.5	27.4	29.6	29.8	29.0	32.0	30.5	29.0	33.0		30.0	32.0	31.0	31.0
27.0	27.1	26.6	28.4	28.3	29.0	31.5	29.0	28.5	30.0		28.0	30.0	29.5	29.5
25.0	23.9	27.8	27.2	26.9	33.5	33.0	28.0	28.0	26.0		28.5	26.5	28.5	28.5
32.8	31.7	29.7	31.3	33.3	31.0	33.5	34.0	34.0	32.0		34.0	33.5	33.5	34.5
25.3	25.1	24.5	25.7	26.1	25.0	26.0	27.0	27.5	28.0		28.0	27.5	28.0	28.5
24.1	23.8	23.7	25.3	25.7	25.5	27.5	27.0	26.5	28.0		27.5	26.5	26.5	28.0
23.6	23.4	22.8	24.2	25.1	26.0	28.0	28.0	26.5	27.0		26.5	26.5	26.0	27.5
25.5	25.3	24.5	24.4	26.1	25.0	27.0	27.0	27.5	26.0		28.0	28.5	27.0	28.0
23.5	23.6	22.8	23.9	24.4	24.5	25.0	25.0	25.5	25.0		26.5	27.5	27.5	27.0
22.7	22.5	21.5	22.5	24.1	23.5	25.0	25.0	24.5	25.5		27.0	26.5	27.5	25.5
21.8	21.4	20.9	21.6	23.5	24.0	25.0	25.5	23.5	25.5		26.0	25.5	25.5	27.0
21.0	20.6	20.7	22.4	24.1	26.0	24.5	27.5	25.5	26.0		26.5	27.0	26.0	26.0
24.9	24.7	24.9	24.5	25.3	25.0	24.5	27.0	29.5	27.0		27.5	27.5	27.5	27.5
29.5	28.4	27.7	29.9	29.6	29.5	31.5	31.0	26.5	28.5		30.0	28.0	31.0	32.0

DATE	12.7.60	13.7.60			14.7.60			15.7.60			16.7.60			17
TIME	4.15 p.m.	8.35 a.m.	12.35 a.m.	6.10 p.m.	8.30 a.m.	1.10 p.m.	7.50 p.m.	8.55 a.m.	1.00 p.m.	7.10 p.m.	8.35 a.m.	12.55 p.m.	6.10 p.m.	9.0 a.m.
	← DORAN →					← SUNVIC →								
16	21.0	21.0	22.0	21.5	21.5	24.0	24.1	24.8	26.1	26.8	26.1	26.7	27.3	27.1
17	21.0	20.0	19.5	20.5	20.5	23.0	22.6	23.9	24.9	24.7	24.7	25.5	25.5	25.7
18	19.0	21.0	20.0	20.0	24.0	23.9	22.4	30.8	30.9	26.7	29.0	30.7	28.1	31.5
19	17.0	19.5	17.5	17.0	25.5	23.9	21.1	36.1	28.9	23.4	36.2	29.1	25.0	36.0
20	18.0	18.5	18.0	19.5	20.0	23.3	22.8	23.9	24.6	25.0	24.5	24.8	25.1	25.1
21	19.0	21.0	18.0	20.5	23.5	23.6	23.2	25.9	29.1	25.9	30.9	28.9	27.3	35.8

7.60		18.7.60			19.7.60			20.7.60			22.7.60		23.7.60	
1.40 p.m.	7.00 p.m.	8.55 a.m.	1.45 p.m.	8.10 p.m.	8.30 a.m.	12.45 p.m.	7.30 p.m.	8.30 a.m.	6.45 p.m.		8.45 a.m.	6.15 p.m.	8.30 a.m.	6.00 p.m.
→					← DORAN →									
28.1	28.2	26.7	28.9	28.9	28.0	30.0	26.5	28.0	28.0		29.0	29.0	27.5	29.5
27.2	26.1	22.6	26.8	26.8	26.5	28.5	29.5	27.5	27.5		29.5	29.5	28.5	29.5
34.1	28.3	27.5	33.5	27.7	29.0	40.0	30.5	26.0	26.0		28.5	28.5	26.5	29.0
30.0	24.8	33.4	31.3	26.3	35.0	39.5	27.5	26.0	25.5		28.5	25.5	26.0	27.5
26.2	26.2	25.5	26.4	26.6	26.5	27.5	27.5	26.5	25.5		28.0	28.5	26.5	29.0
34.3	27.7	23.9	34.4	27.0	33.5	40.5	30.5	27.0	26.5		27.0	28.5	26.5	31.0

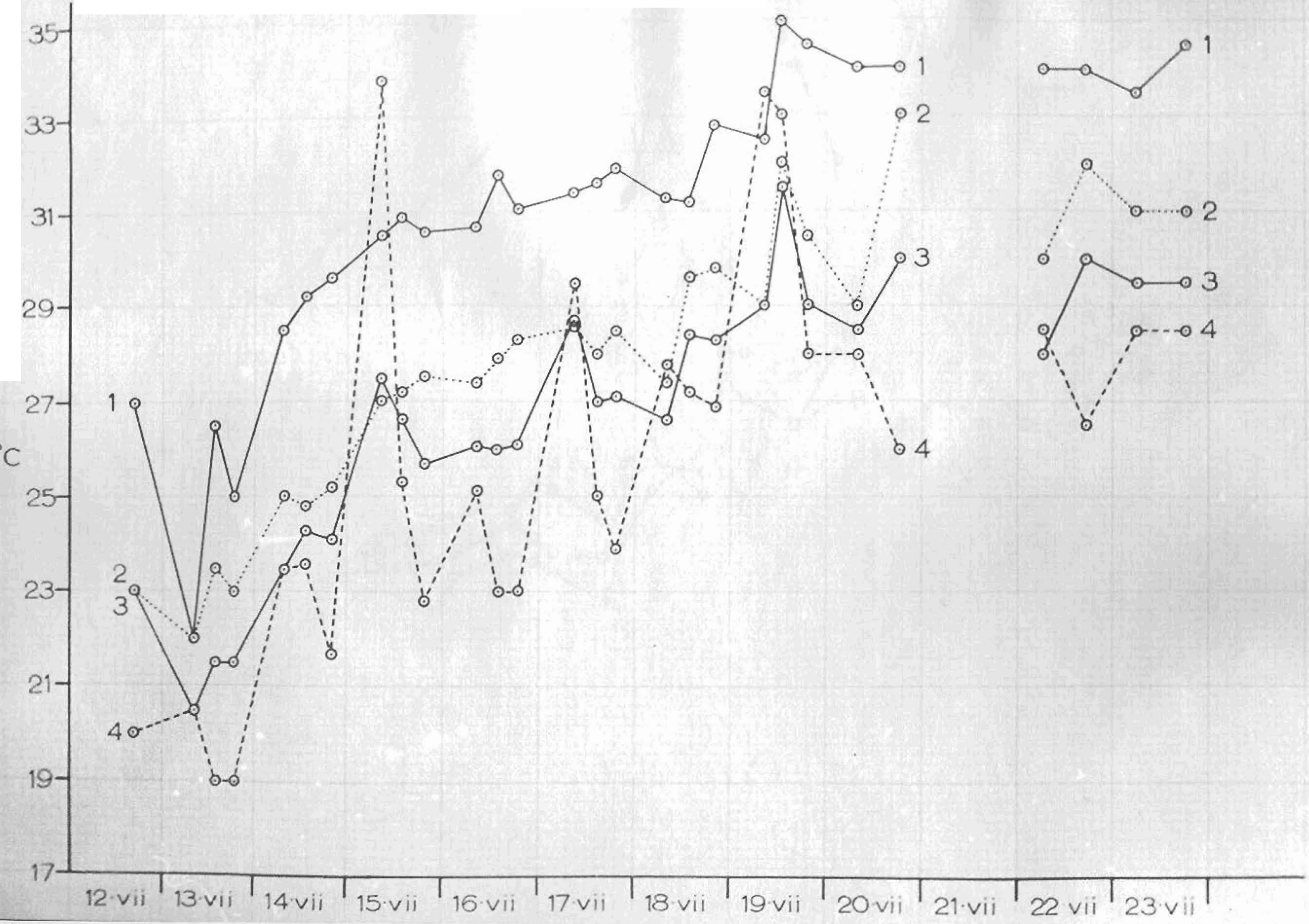

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Fig. 4

Positions of thermocouples: Outward Voyage

No	Position
	NO. 4 LOWER HOLD
1	Attached to engine room bulkhead
-	" " " " "
3	" " " " " on stringers
4	" " " " " at port bulkhead
5	Attached to engine room bulkhead
6	On surface of boxed goods
7	" " " " " on stringers
8	On port bulkhead.
9	On top of propellor-shaft tunnel.
10	At side of " " "
11	On surface of boxed goods
12	" " " " " on stringers
13	On starboard bulkhead.
14	At foot of access ladder.
15	In box beam under shelter deck at top of access ladder.
	NO. 4 SHELTER DECK
16	At foot of access ladder on shelter deck.
17	On shelter deck behind cased goods.
	At top of access ladder on underside of main deck.
19	On port bulkhead
20	On shelter deck, at side of lower hold hatch.
21	On underside of main deck.

Fig. 2

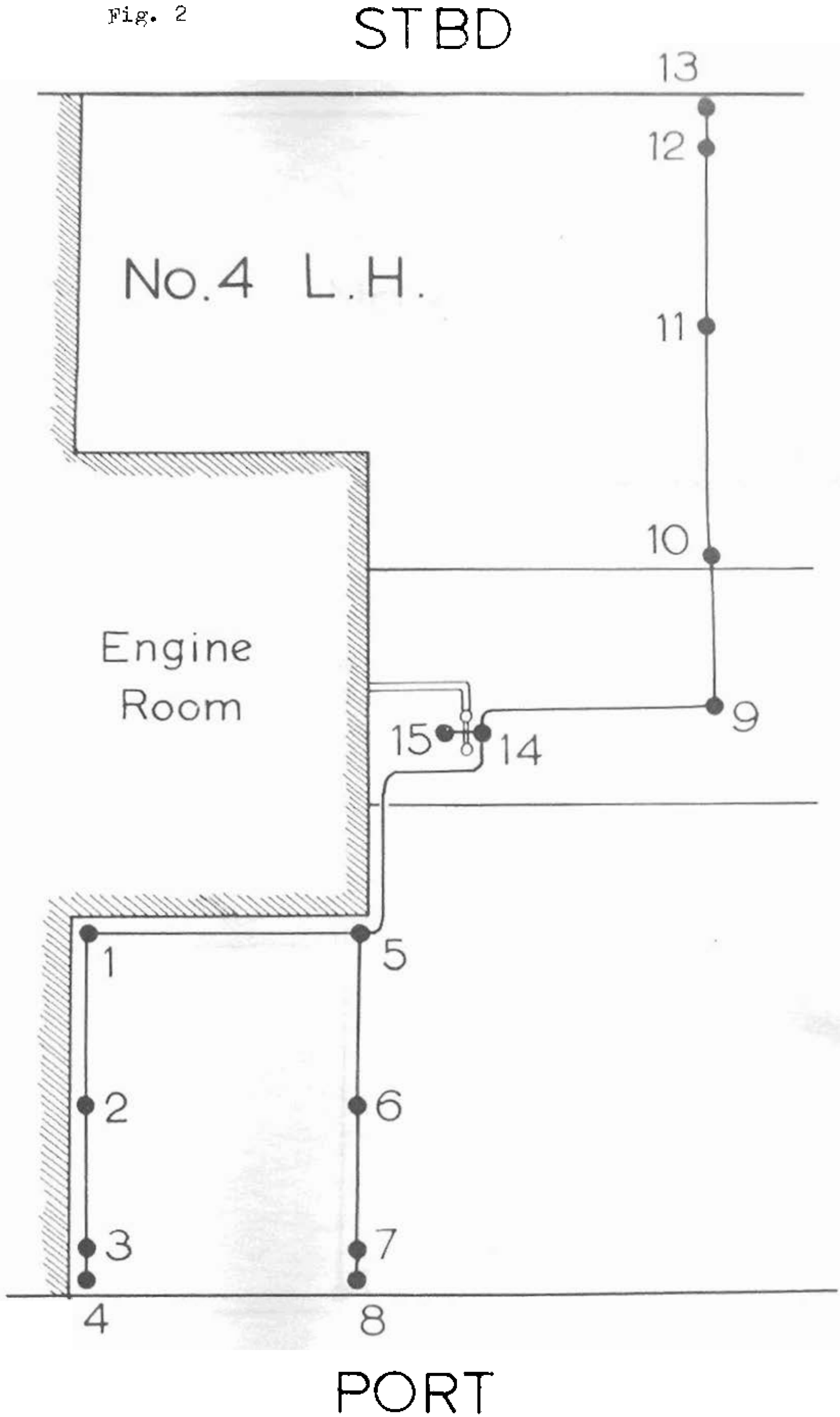

Fig. 3

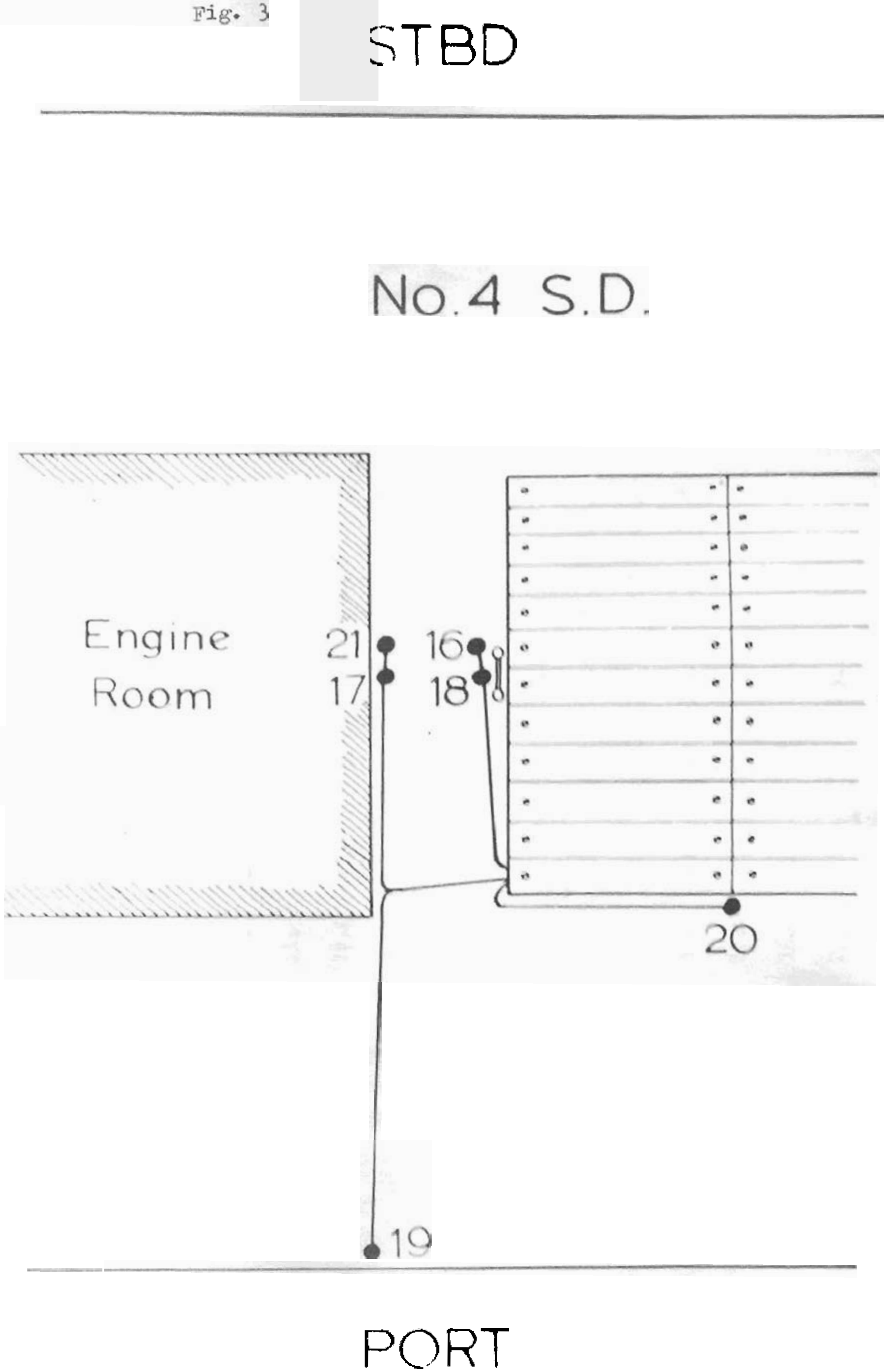

TABLE 3 Daily thermocouple readings :

DATE	12.7.60	13.7.60			14.7.60			15.7.60			16.7.60			17.
TIME	4.15 p.m.	8.35 a.m.	12.35 a.m.	6.10 p.m.	8.30 a.m.	1.10 p.m.	7.50 p.m.	8.55 a.m.	1.00 p.m.	7.10 p.m.	8.35 a.m.	12.55 p.m.	6.10 p.m.	9.0 a.m.
	←DORAN→					←SUNVIC→								
1	27.0	22.0	26.5	25.0	28.5	29.2	29.6	30.5	30.9	30.6	30.7	31.8	31.1	31.4
2	23.0	22.0	23.5	23.0	25.0	24.8	25.2	27.0	27.2	27.5	27.4	27.9	28.3	28.6
3	23.0	20.5	21.5	21.5	23.5	24.3	24.1	27.5	26.6	25.7	26.1	26.0	26.1	28.7
4	20.0	20.5	19.0	19.0	23.5	23.6	21.7	33.8	25.3	22.8	25.1	23.0	23.0	29.5
5	27.0	25.5	26.0	26.0	26.5	29.2	29.1	30.1	30.7	30.8	30.7	31.6	31.5	32.9
6	20.0	19.0	19.5	20.5	20.0	21.2	21.7	23.1	23.6	23.8	24.0	24.3	24.5	24.7
7	20.0	19.0	18.5	19.5	19.5	21.1	21.3	22.9	23.3	23.4	23.5	23.6	23.8	24.4
8	17.5	18.5	17.5	18.5	18.5	20.9	20.8	22.4	22.5	23.0	22.9	22.5	23.3	23.8
9	19.0	21.0	19.5	21.0	21.5	22.7	23.1	23.3	23.6	24.3	24.2	24.3	24.8	25.2
10	20.0	19.0	20.0	20.0	20.5	21.6	21.5	22.3	21.8	22.4	23.4	23.2	23.3	24.0
11	18.0	17.5	18.0	19.0	19.5	20.3	20.6	21.1	21.5	22.1	22.0	22.2	22.7	23.4
12	17.0	17.0	17.0	17.0	18.0	19.4	19.5	20.1	20.3	20.8	21.0	21.1	21.3	21.9
13	16.0	15.5	16.5	16.5	17.0	20.3	20.0	20.4	20.6	20.8	21.0	20.7	21.1	21.8
14	18.5	20.0	21.0	21.0	21.0	22.8	23.1	22.6	23.2	23.5	24.2	24.1	24.5	25.0
15	21.5	21.5	22.5	22.0	23.0	24.5	24.6	27.3	27.7	27.6	27.2	28.1	30.0	28.6

outward voyage.

Table 3 (cont'd 2)

7.60.		18.7.60			19.7.60			20.7.60			22.7.60		23.7.60	
1.40 p.m.	7.00 p.m.	8.55 a.m.	1.45 p.m.	8.10 p.m.	8.30 a.m.	12.45 p.m.	7.30 p.m.	8.30 a.m.	6.45 p.m.		8.45 a.m.	6.15 p.m.	8.30 a.m.	6.00 p.m.
———	———	———	———	——>	<———	———	———	D O R A N	———	———	———	———	———	——>
31.6	31.9	31.3	31.2	32.8	32.5	35.0	34.5	34.0	34.0		34.0	34.0	33.5	34.5
28.0	28.5	27.4	29.6	29.8	29.0	32.0	30.5	29.0	33.0		30.0	32.0	31.0	31.0
27.0	27.1	26.6	28.4	28.3	29.0	31.5	29.0	28.5	30.0		28.0	30.0	29.5	29.5
25.0	23.9	27.8	27.2	26.9	33.5	33.0	28.0	28.0	26.0		28.5	26.5	28.5	28.5
32.8	31.7	29.7	31.3	33.3	31.0	33.5	34.0	34.0	32.0		34.0	33.5	33.5	34.5
25.3	25.1	24.5	25.7	26.1	25.0	26.0	27.0	27.5	28.0		28.0	27.5	28.0	28.5
24.1	23.8	23.7	25.3	25.7	25.5	27.5	27.0	26.5	28.0		27.5	26.5	26.5	28.0
23.6	23.4	22.8	24.2	25.1	26.0	28.0	28.0	26.5	27.0		26.5	26.5	26.0	27.5
25.5	25.3	24.5	24.4	26.1	25.0	27.0	27.0	27.5	26.0		28.0	28.5	27.0	28.0
23.5	23.6	22.8	23.9	24.4	24.5	25.0	25.0	25.5	25.0		26.5	27.5	27.5	27.0
22.7	22.5	21.5	22.5	24.1	23.5	25.0	25.0	24.5	25.5		27.0	26.5	27.5	25.5
21.8	21.4	20.9	21.6	23.5	24.0	25.0	25.5	23.5	25.5		26.0	25.5	25.5	27.0
21.0	20.6	20.7	22.4	24.1	26.0	24.5	27.5	25.5	26.0		26.5	27.0	26.0	26.0
24.9	24.7	24.9	24.5	25.3	25.0	24.5	27.0	29.5	27.0		27.5	27.5	27.5	27.5
29.5	28.4	27.7	29.9	29.6	29.5	31.5	31.0	26.5	28.5		30.0	28.0	31.0	32.0

Table 3 ([illegible])

DATE	12.7.60	13.7.60			14.7.60			15.7.60			16.7.60			17
TIME	4.15 p.m.	8.35 a.m.	12.35 a.m.	6.10 p.m.	8.30 a.m.	1.10 p.m.	7.50 p.m.	8.55 a.m.	1.00 p.m.	7.10 p.m.	8.35 a.m.	12.55 p.m.	6.10 p.m.	9.0 a.m.
	← DORAN →					← SUNVIC —								
16	21.0	21.0	22.0	21.5	21.5	24.0	24.1	24.8	26.1	26.8	26.1	26.7	27.3	27.1
17	21.0	20.0	19.5	20.5	20.5	23.0	22.6	23.9	24.9	24.7	24.7	25.5	25.5	25.7
18	19.0	21.0	20.0	20.0	24.0	23.9	22.4	30.8	30.9	26.7	29.0	30.7	28.1	31.5
19	17.0	19.5	17.5	17.0	25.5	23.9	21.1	36.1	28.9	23.4	36.2	29.1	25.0	36.0
20	18.0	18.5	18.0	19.5	20.0	23.3	22.8	23.9	24.6	25.0	24.5	24.8	25.1	25.1
21	19.0	21.0	18.0	20.5	23.5	23.6	23.2	25.9	29.1	25.9	30.9	28.9	27.3	35.8

TABLE 3 (Cont'd)

7.60		18.7.60			19.7.60			20.7.60			22.7.60		23.7.60	
1.40 p.m.	7.00 p.m.	8.55 a.m.	1.45 p.m.	8.10 p.m.	8.30 a.m.	12.45 p.m.	7.30 p.m.	8.30 a.m.	6.45 p.m.		8.45 a.m.	6.15 p.m.	8.30 a.m.	6.00 p.m.
⟶				⟶	⟵			D O R A N						⟶
28.1	28.2	26.7	28.9	28.9	28.0	30.0	26.5	28.0	28.0		29.0	29.0	27.5	29.5
27.2	26.1	22.6	26.8	26.8	26.5	28.5	29.5	27.5	27.5		29.5	29.5	28.5	29.5
34.1	28.3	27.5	33.5	27.7	29.0	40.0	30.5	26.0	26.0		28.5	28.5	26.5	29.0
30.0	24.8	33.4	31.3	26.3	35.0	39.5	27.5	26.0	25.5		28.5	25.5	26.0	27.5
26.2	26.2	25.5	26.4	26.6	26.5	27.5	27.5	26.5	25.5		28.0	28.5	26.5	29.0
34.3	27.7	23.9	34.4	27.0	33.5	40.5	30.5	27.0	26.5		27.0	28.5	26.5	31.0

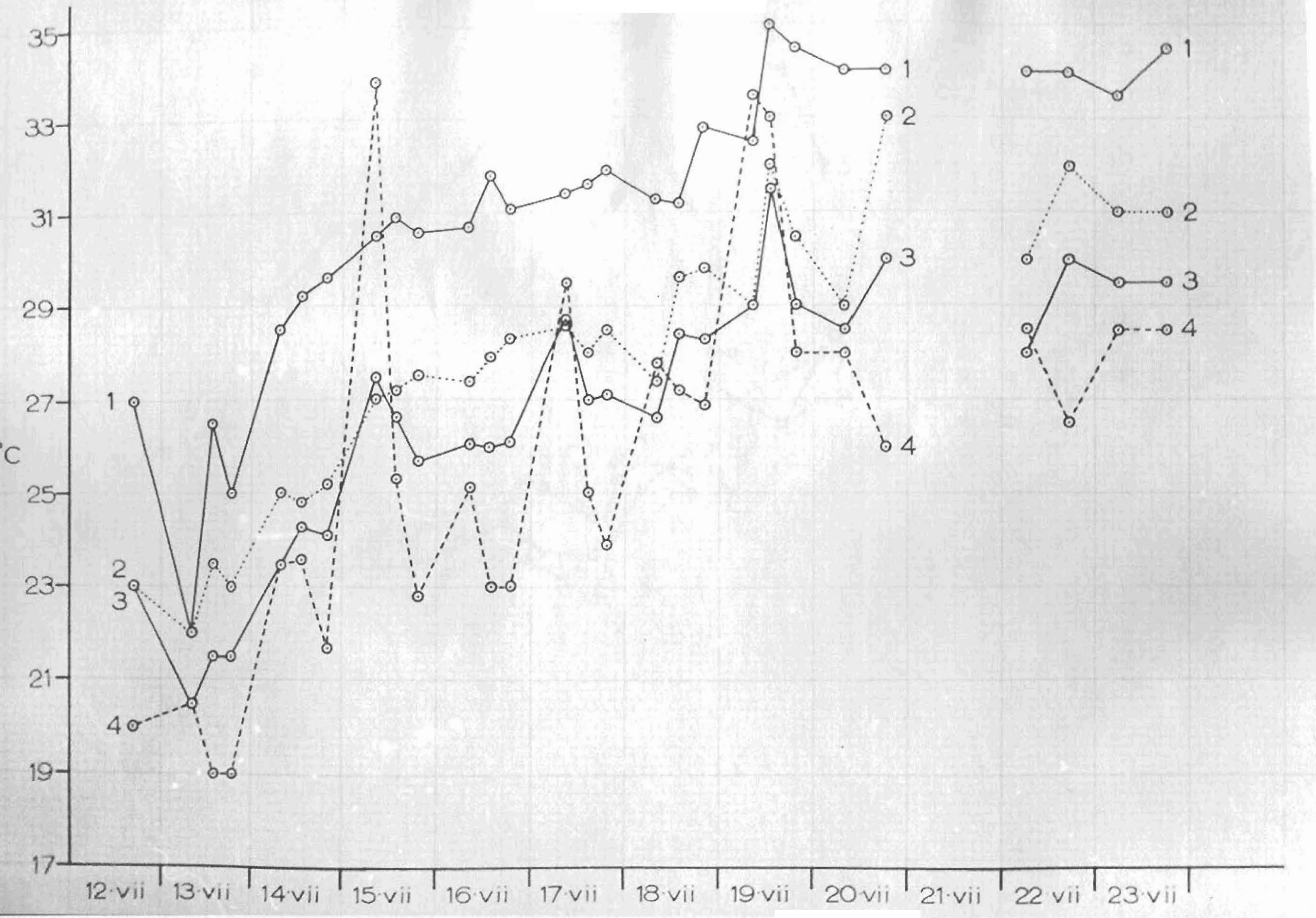

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Fig. 4

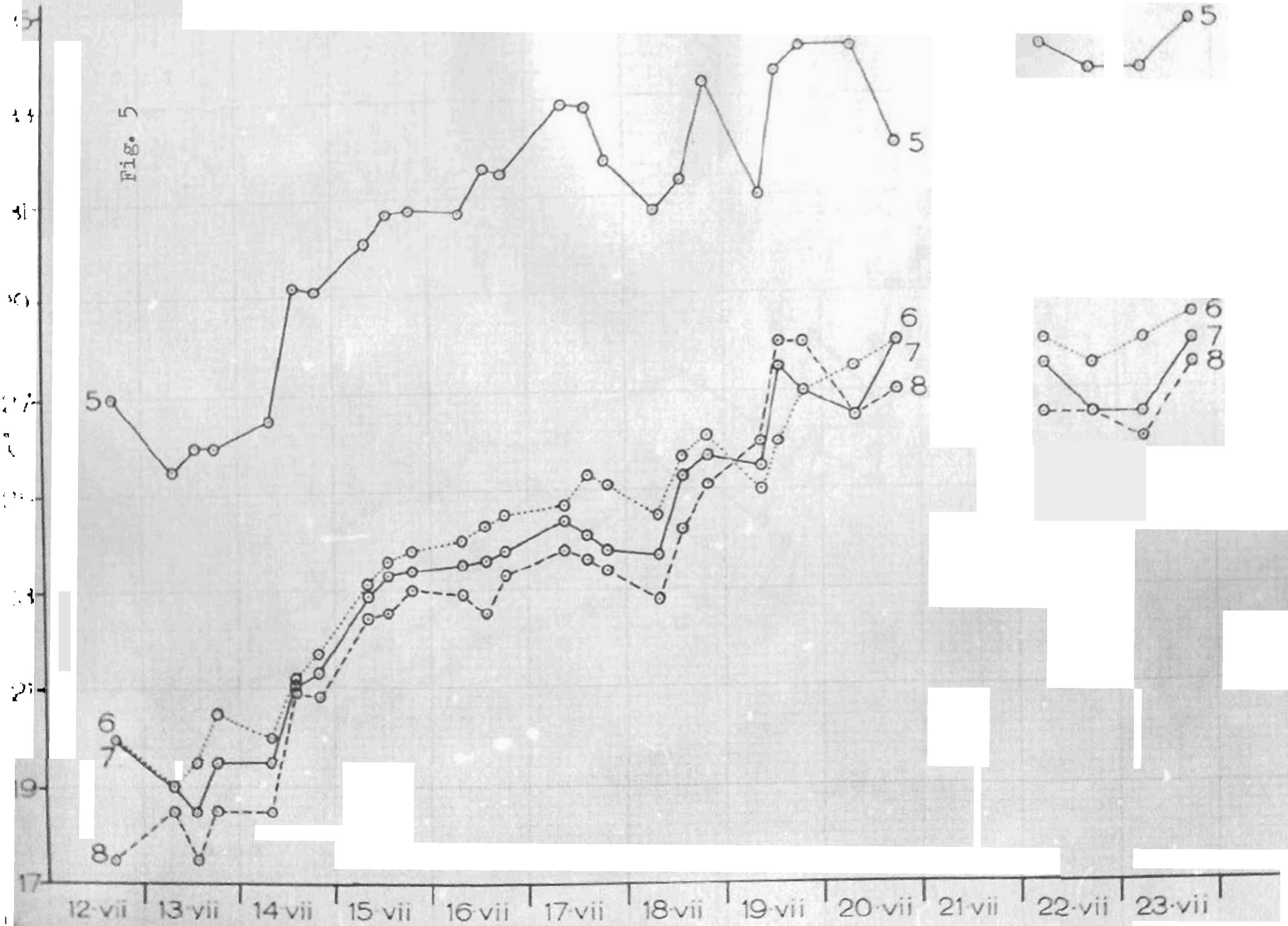
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Fig. 5

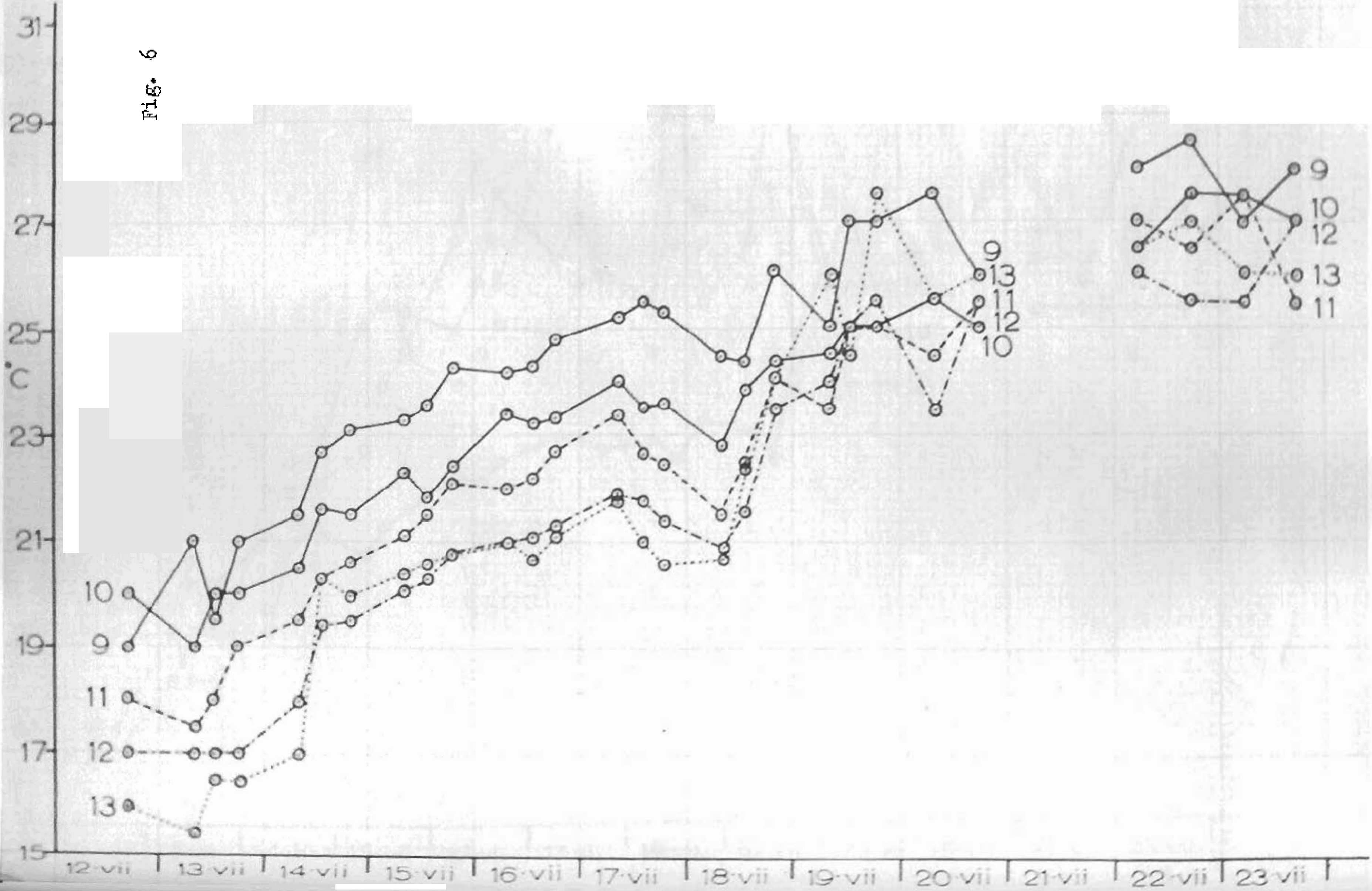
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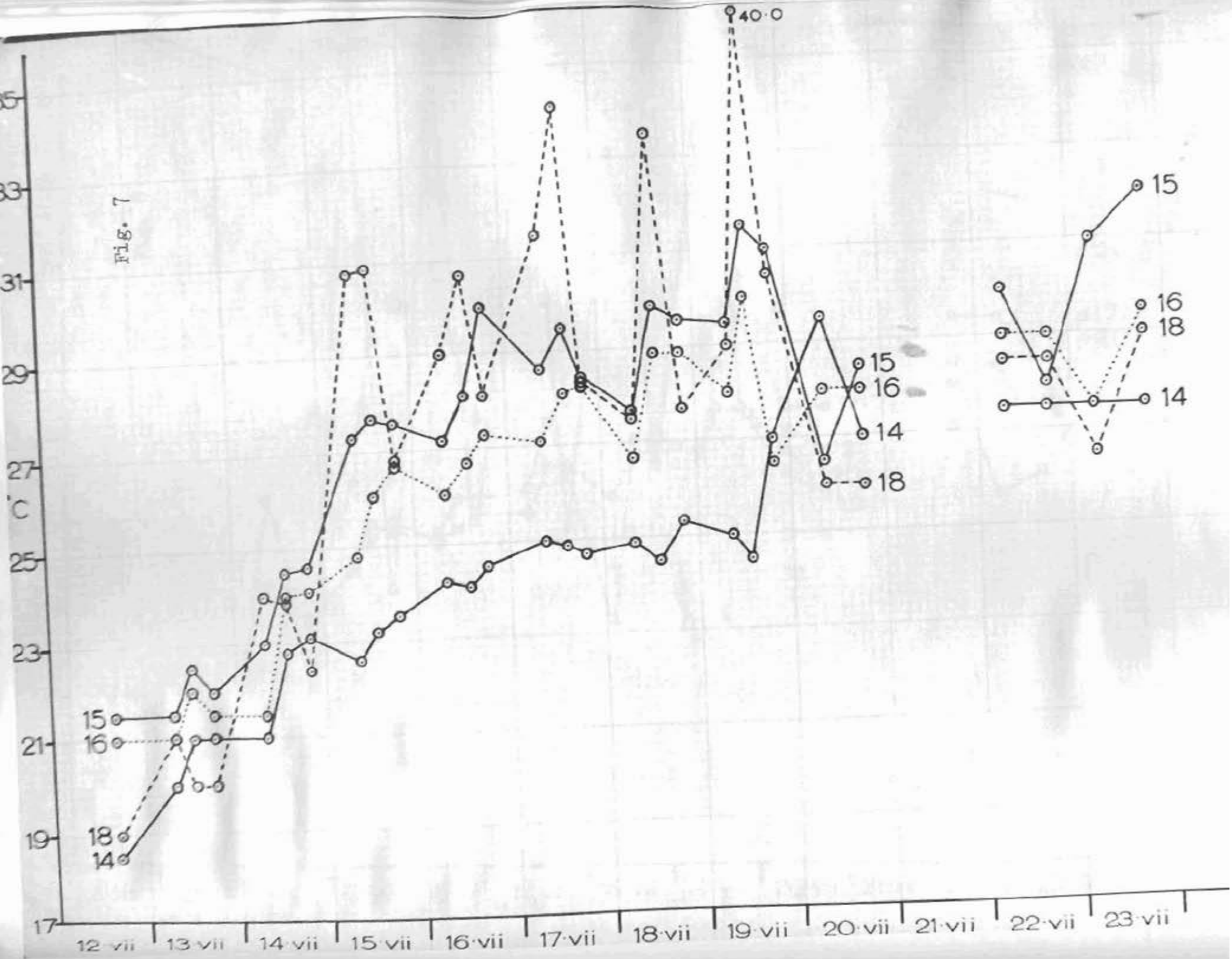
Fig. 6

Fig. 7



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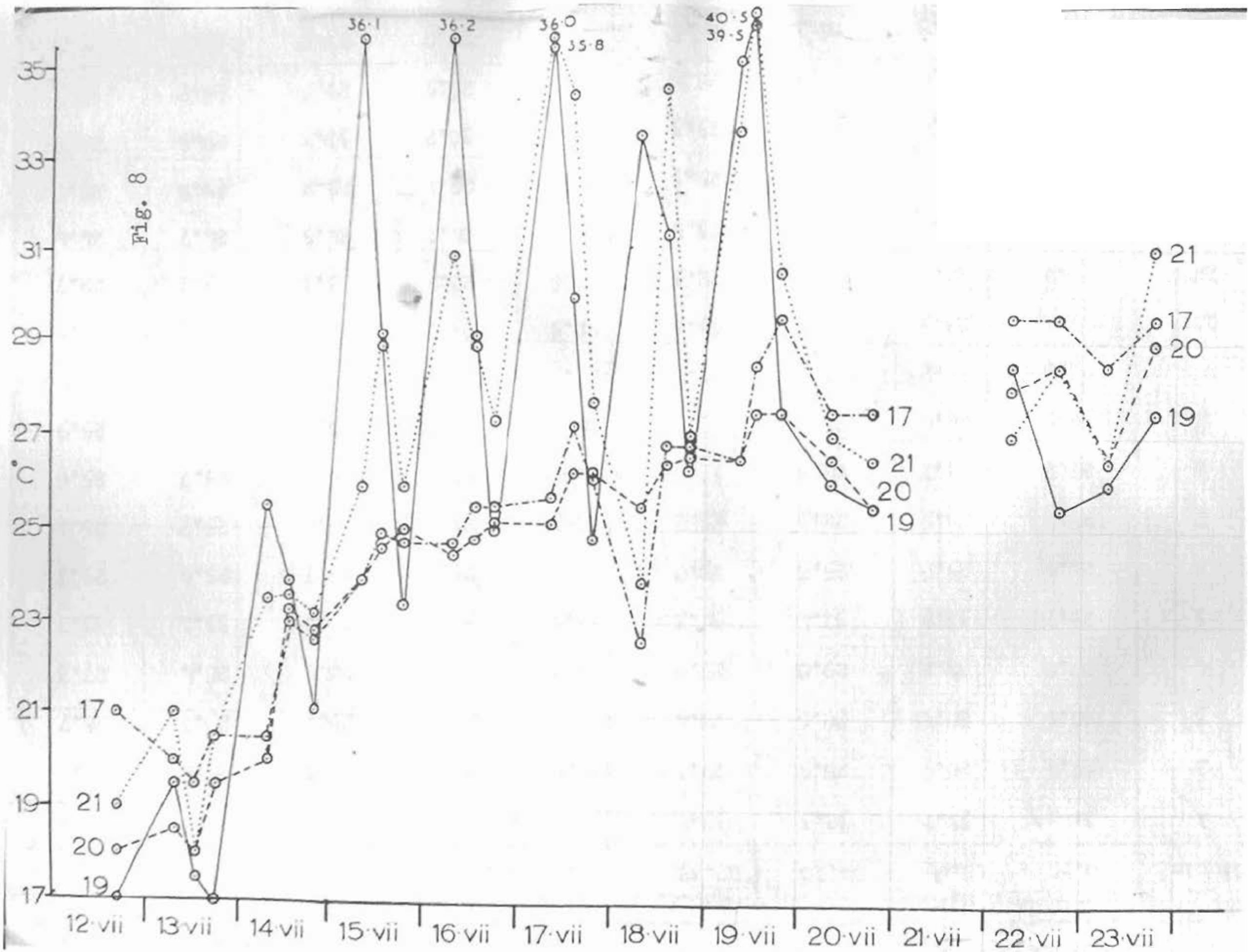

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Fig. 8

TABLE 4 — 24 hour thermocouple readings :

Couple	A.M. 8.55	10.05	11.10	18. 7. 60. 12.35	1.45	P.M. 2.37	3.45	4.45	6.05
1	31.3	31.9	32.3	32.8	31.2	32.0	32.6	32.6	32.9
2	27.4	28.4	28.9	29.3	29.6	29.3	29.7	29.6	29.7
3	26.6	28.5	28.6	28.4	28.4	29.0	29.1	29.1	28.7
4	27.8	32.2	29.8	27.8	27.2	27.8	28.4	28.4	27.3
5	29.7	31.5	31.4	32.3	31.3	33.1	33.0	33.1	33.1
6	24.5	25.0	25.3	25.8	25.7	25.8	25.7	25.9	25.7
7	23.7	24.5	24.3	25.2	25.3	25.7	26.0	25.7	26.1
8	22.8	23.7	24.3	25.0	24.2	25.8	26.1	25.7	25.6
9	24.5	24.8	25.8	25.0	24.4	25.5	25.7	25.9	25.9
10	22.8	24.2	23.9	24.2	23.9	24.3	24.0	24.0	24.2
11	21.5	23.3	22.3	23.6	22.5	23.8	24.3	24.0	23.6
12	20.9	22.5	21.3	22.3	21.6	22.9	23.1	23.2	22.7
13	20.7	22.0	22.0	23.4	22.4	24.2	24.9	24.7	24.4
14.	24.9	25.4	24.9	25.3	24.5	25.4	25.2	25.2	25.4
15	27.7	29.0	28.7	29.3	29.9	30.2	30.3	29.9	29.7
16	26.7	27.4	27.8	28.4	28.9	28.9	29.0	28.9	28.9
17	22.6	25.5	26.1	26.5	26.8	27.0	27.0	26.6	26.8

outward voyage.

Table 4 (cont'd 1)

						19.7.60		A.M.		
7.05	8.10	9.07	10.00	11.00	00.02	1.02	2.10	3.05	4.02	8.30.
33.1	32.8	33.4	33.4	33.4	33.3	33.1	33.1	31.7	31.7	32.5
29.7	29.8	29.6	29.9	30.0	30.5	29.1	29.1	28.7	27.8	29.0
28.6	28.3	27.8	28.3	28.2	28.2	27.8	27.4	27.4	25.7	29.0
27.0	26.9	26.0	26.1	26.0	25.6	25.5	25.8	24.8	23.4	33.5
33.3	33.3	33.3	33.0	33.3	33.3	32.8	33.4	32.7	31.0	31.0
26.1	26.1	26.2	26.2	26.1	26.1	26.6	26.0	25.9	24.5	25.0
25.7	25.7	25.3	25.6	25.2	25.3	25.5	25.5	25.2	24.5	25.5
25.3	25.1	24.8	25.5	25.0	25.0	25.1	25.1	25.7	24.0	26.0
25.8	26.1	26.1	26.5	26.4	26.3	26.4	26.3	27.0	24.5	25.0
24.2	24.4	24.2	24.6	24.9	24.5	24.5	25.3	24.8	23.2	24.5
24.0	24.1	23.9	24.1	24.1	24.2	24.1	25.2	23.2	22.2	23.5
23.2	23.5	23.1	23.2	23.2	23.5	23.6	24.1	22.8	22.7	24.0
24.0	24.1	23.8	23.9	24.1	24.3	24.5	25.7	24.4	24.5	26.0
25.4	25.3	25.3	25.4	25.6	25.6	25.5	25.4	26.1	25.0	25.0
29.7	29.6	30.0	30.1	29.7	29.4	28.7	28.5	28.3	27.5	29.5
28.9	28.9	27.6	28.8	28.5	28.7	28.6	27.9	27.5	26.0	28.0
26.7	26.8	27.0	27.0	27.0	27.0	26.9	27.0	26.6	26.0	26.5

Table 4 (cont'd 2)

Couple	A.M.			18. 7. 60.		P.M.			
	8.55	10.05	11.10	12.35	1.45	2.37	3.45	4.45	6.05
18	27.5	30.2	31.4	32.8	33.5	33.3	32.3	30.7	29.2
19	33.4	34.8	34.1	32.4	31.3	31.4	30.7	29.7	28.1
20	25.5	26.3	25.7	25.5	26.4	26.5	26.6	26.6	26.6
21	23.9	30.1	31.0	32.9	34.4	34.2	32.9	31.5	28.8

TABLE 4 (Cont'd 3)

					19. 7. 60. A.M.					
7.05	8.10	9.07	10.00	11.00	00.02	1.02	2.10	3.05	4.02	8.30
28.4	27.7	27.3	27.1	26.3	26.1	25.5	25.2	25.3	24.5	29.0
27.2	26.3	25.9	26.1	25.3	24.7	24.6	24.0	24.0	23.0	35.0
26.6	26.6	26.6	26.6	26.6	26.5	26.3	26.1	26.1	24.5	26.5
27.8	27.0	26.7	26.5	26.1	25.8	25.7	25.5	25.1	24.0	33.5

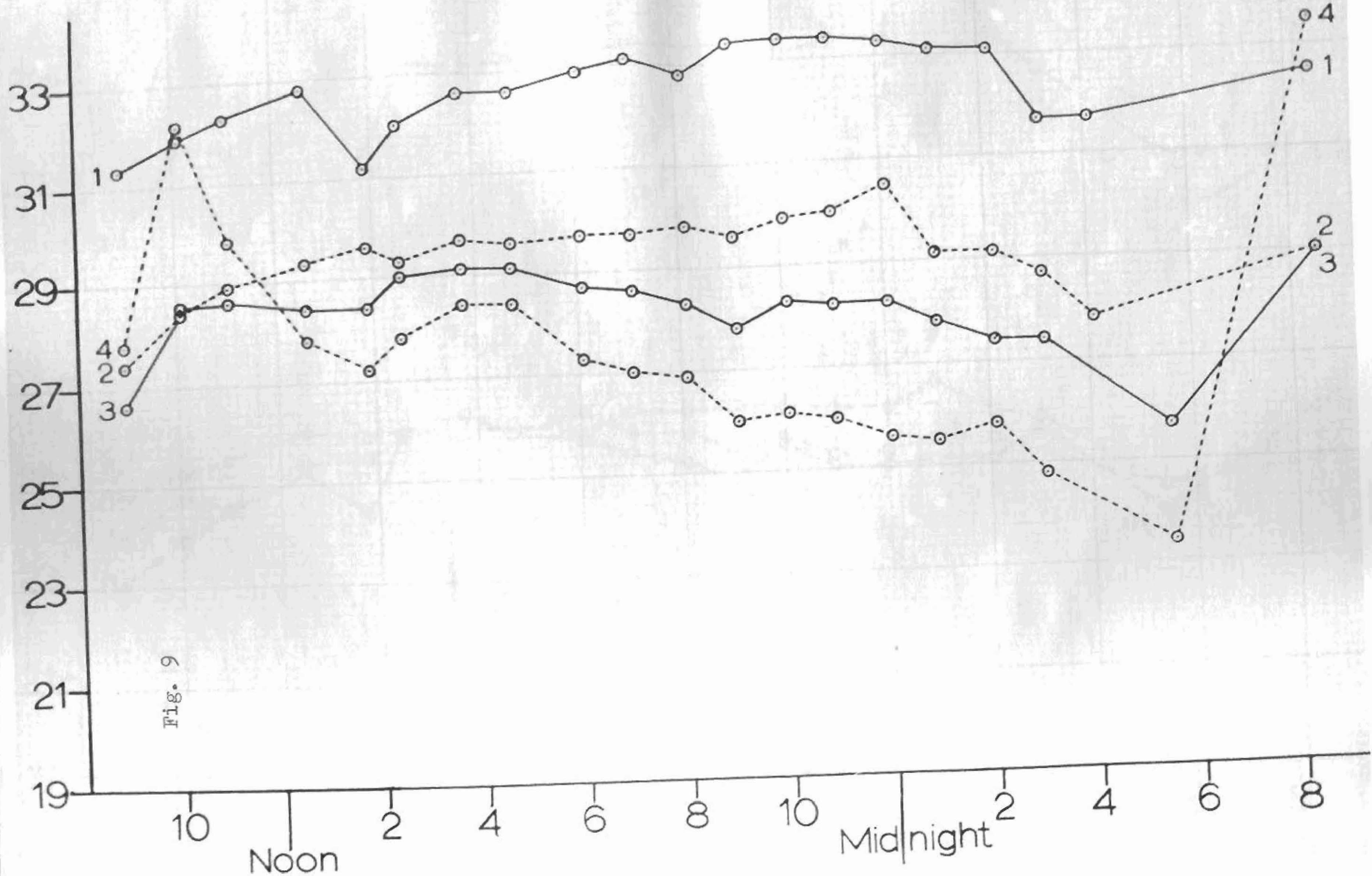


Fig. 9

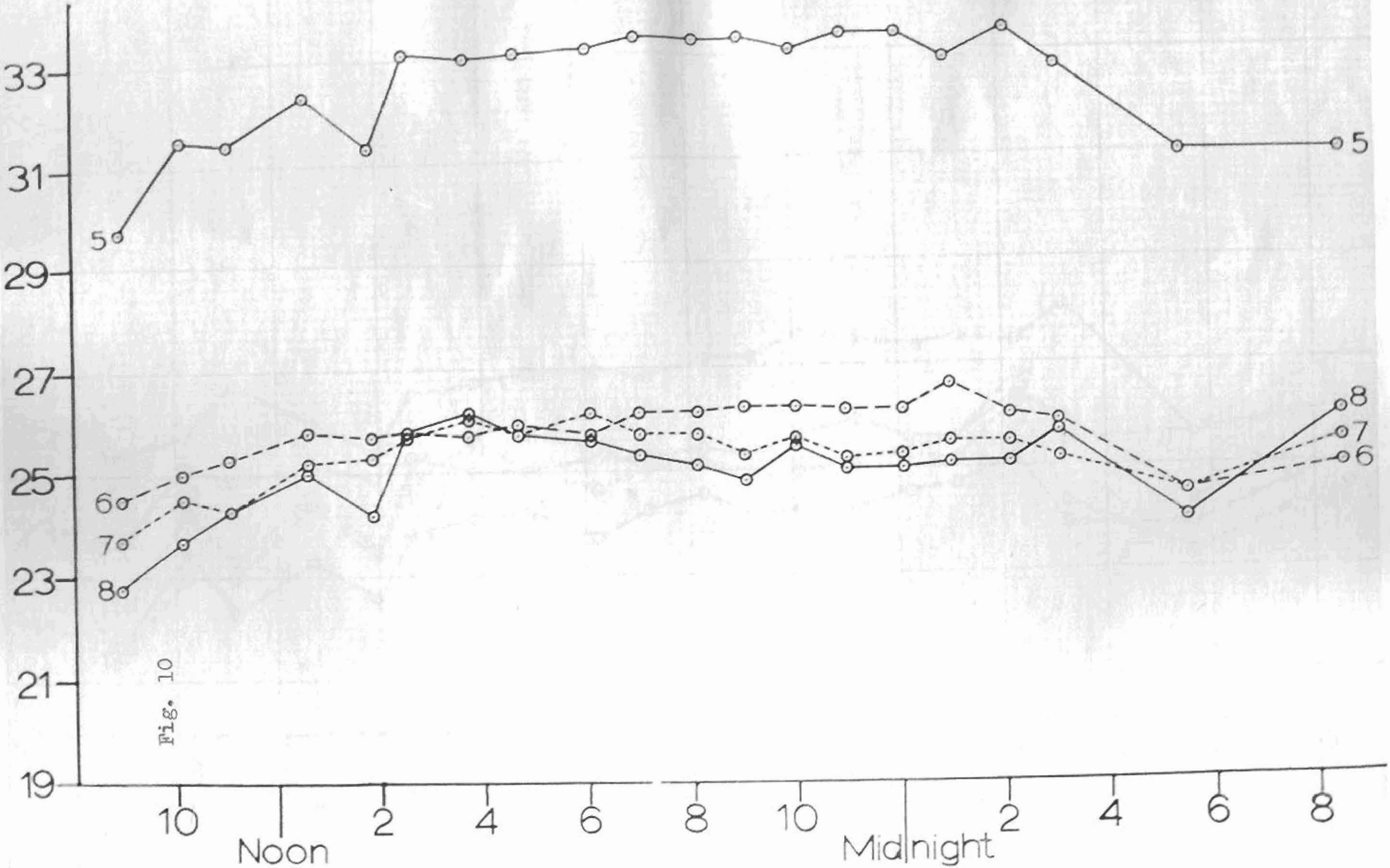


Fig. 10

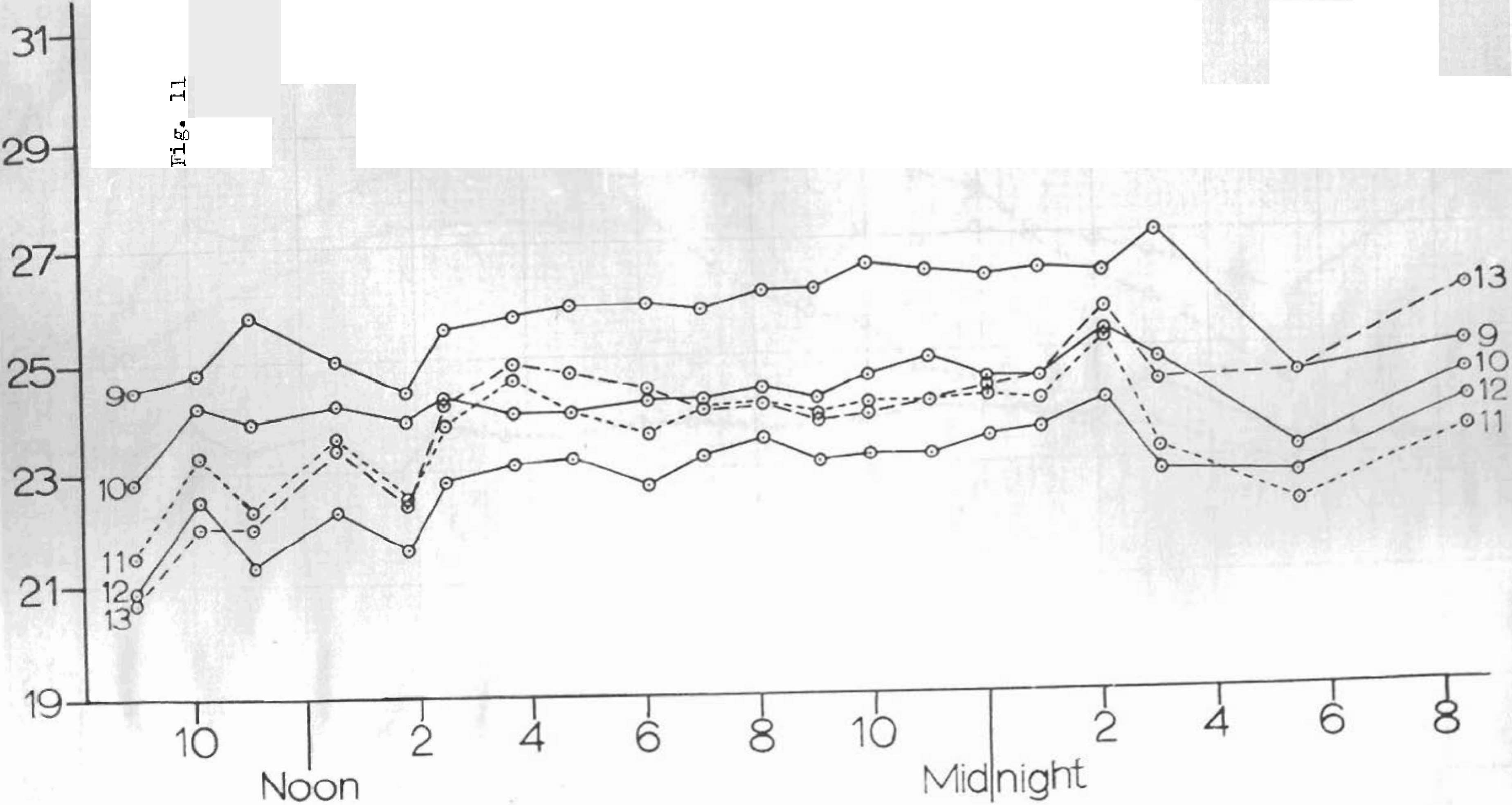
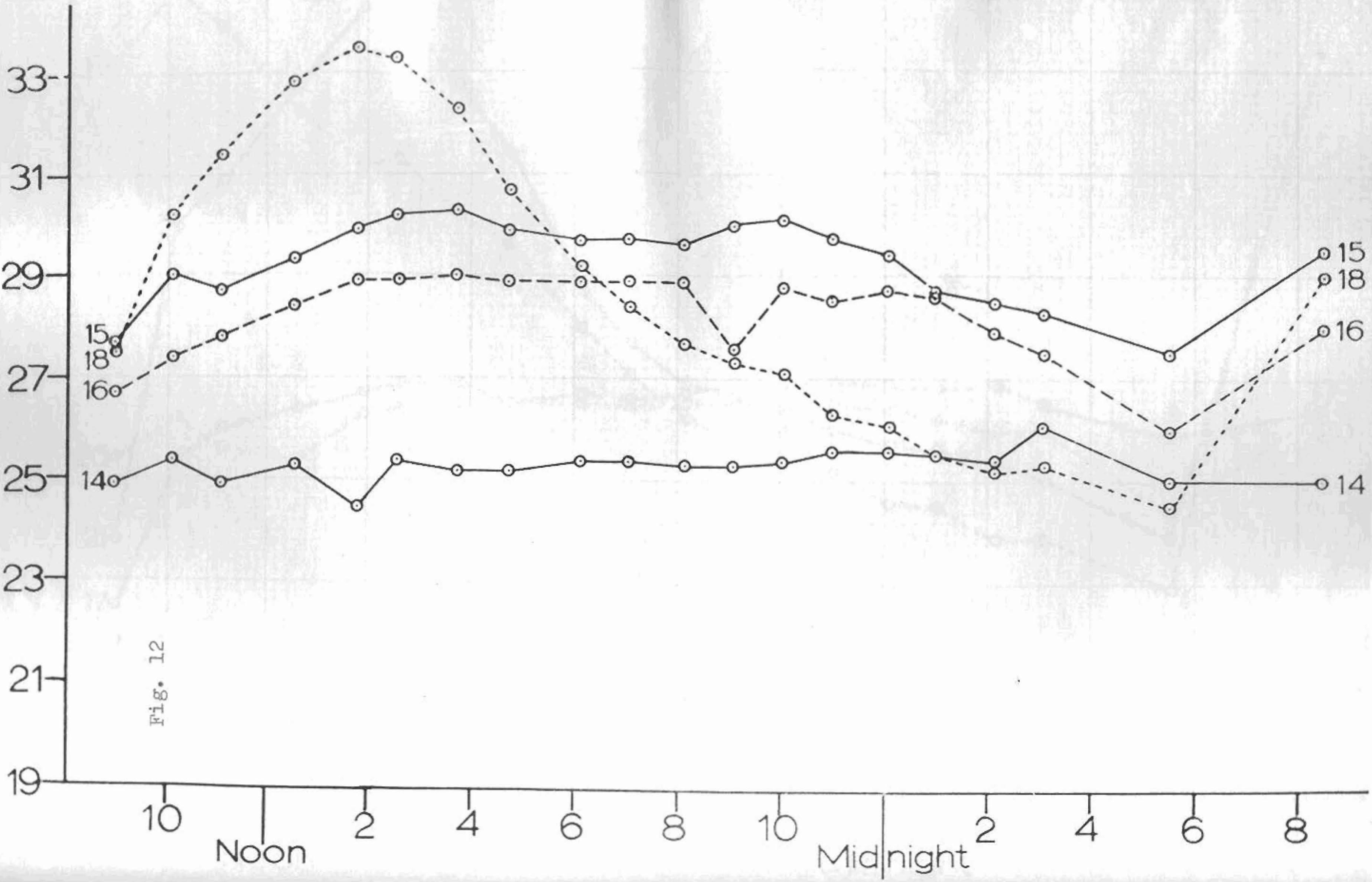


Fig. 11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Midnight
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Fig. 12

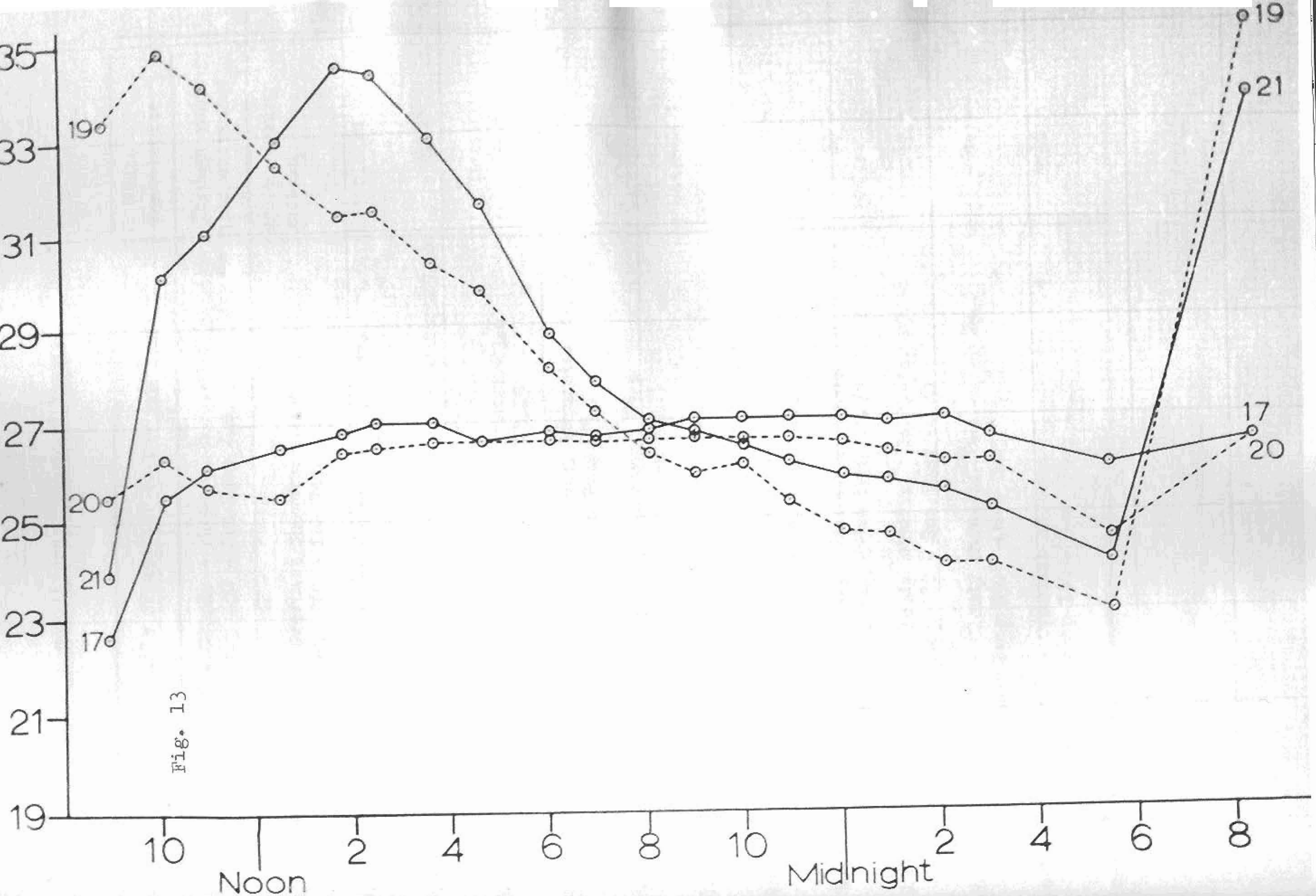
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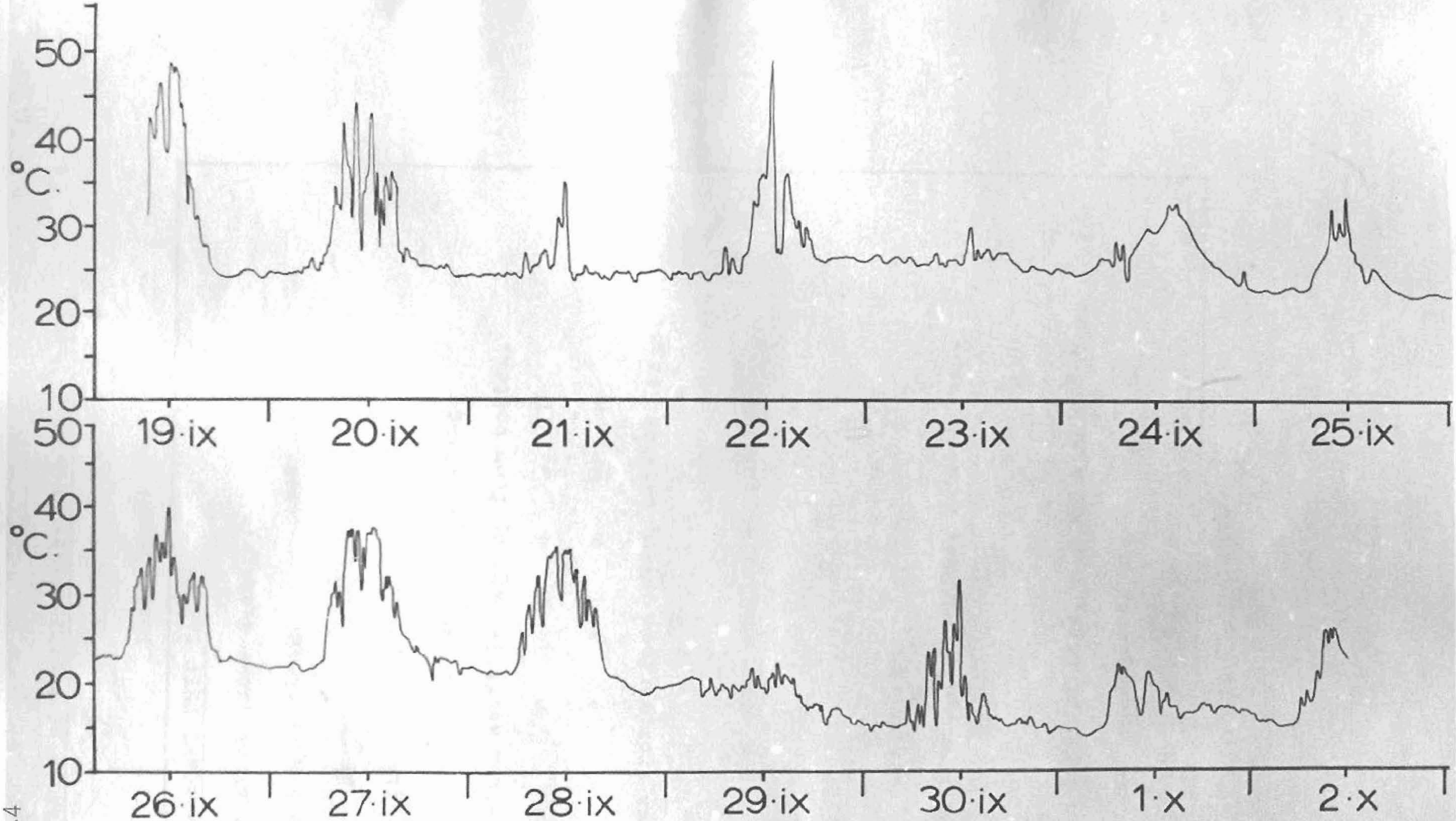
Fig. 13

BLE 5

Weather conditions: Homeward Voyage

Date	Wind Force	Details of weather as per Log Book	State of Ventilation
9.9.60	W 2	Sea 2 - Cloudy - showers. Barometer 29.76 Air Temp 26C - Sea Temp 24C	Through vents hold entrances & hatch Nos. 1,3 except during showers
0.9.60	Variable 3	Sea 3 - Overcast Showers. Barometer 29.76 Temp 26C - Sea Temp 26	
1.9.62	SW 4	Sea 4 - Overcast Heavy Rain. Barometer 29.64 Air Temp 26C - Sea Temp 24.75	closed
2.9.60	SW 5	Sea 5 - Overcast Heavy Rain. Barometer 29.58 Air Temp 28C - Sea Temp 27.75	- do -
3.9.60	SW 7	Sea 6 - Overcast Rain. Barometer 29.6 Air Temp 24C - Sea Temp 28.25	- do -
4.9.60	SE 6	Sea 5 - Overcast showers. Barometer 29.67 Air Temp 27C - Sea Temp 28.5	- do -
25.9.60	N 5	Sea 4 - Overcast. Barometer 29.8 Sea Temp 22C - Air Temp 24.75	Through vents hold entrances & hatches 1,3 except during showers
26.9.60	NNE 5	Sea 5 - Overcast showers. Barometer 29.98 Air Temp 24C - Sea Temp 22.25	
27.9.60	NNE 4	Sea 4 - Cloudy. Barometer 29.86 Air Temp 23C - Sea Temp 22.5	- do -
28.9.60	NW 2	Sea 2 - Cloudy. Barometer 29.86 Air Temp 22C - Sea Temp 23.75	- do -
.9.60	SW 7	Sea 7 - Cloudy showers. Barometer 29.38 Air Temp 18C - Sea Temp 22.25	- do -
.9.60	WSW 7	Sea 7 - Cloudy showers. Barometer 29.2 Air Temp 29.2 - Sea Temp 20.25	- do -
.10.60	W 4	Sea 4 - Overcast showers. Barometer 29.4 Air Temp 15C - Sea Temp 16.5	- do -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30
20
10
26·ix
27·ix
28·ix
29·ix
30·ix
1·x
2·x

Fig. 14

TABLE 6

Positions of thermocouples: Homeward Voyage

No.	Position
	NO. 3 STARBOARD DEEP TANK
1	On top of stack under dunnage.
2	Under top bag of stack.
3	Under dunnage on edge of stack.
4	Against engine room bulkhead.
5	On top of stack below water pipe casing.
6	In ventilation shaft 19 bags up from bottom.
7	" " " 12 " " " "
8	" " " 3 " " " "
9	6 bags down from surface layer, between bags.
10	" " " " " " " "
11	On top of stack under shelter deck.
12	At edge of stack.
13	Against starboard bulkhead.
14	On shelter deck.
15	6 bags down from surface layer, between bags.
...mohygro-...aphs	
A	Between top layer of bags, covered with dunnage.
B	In space under top layer of bags.
D	On top of stack, covered with dunnage.

TABLE 6 (cont'd 2)

No.	Position
	NO. 1 SHELTER DECK
16	3 bags above lower hold hatch boards.
17	3 bags above shelter deck.
18	" " " " "
19	Against starboard bulkhead.
	NO. 3 SHELTER DECK
21	2 bags down from top of stack
22	Under top bag on edge of stack
23	Against starboard bulkhead.
mohygro-graph	
C	On top of stack, covered with dunnage.

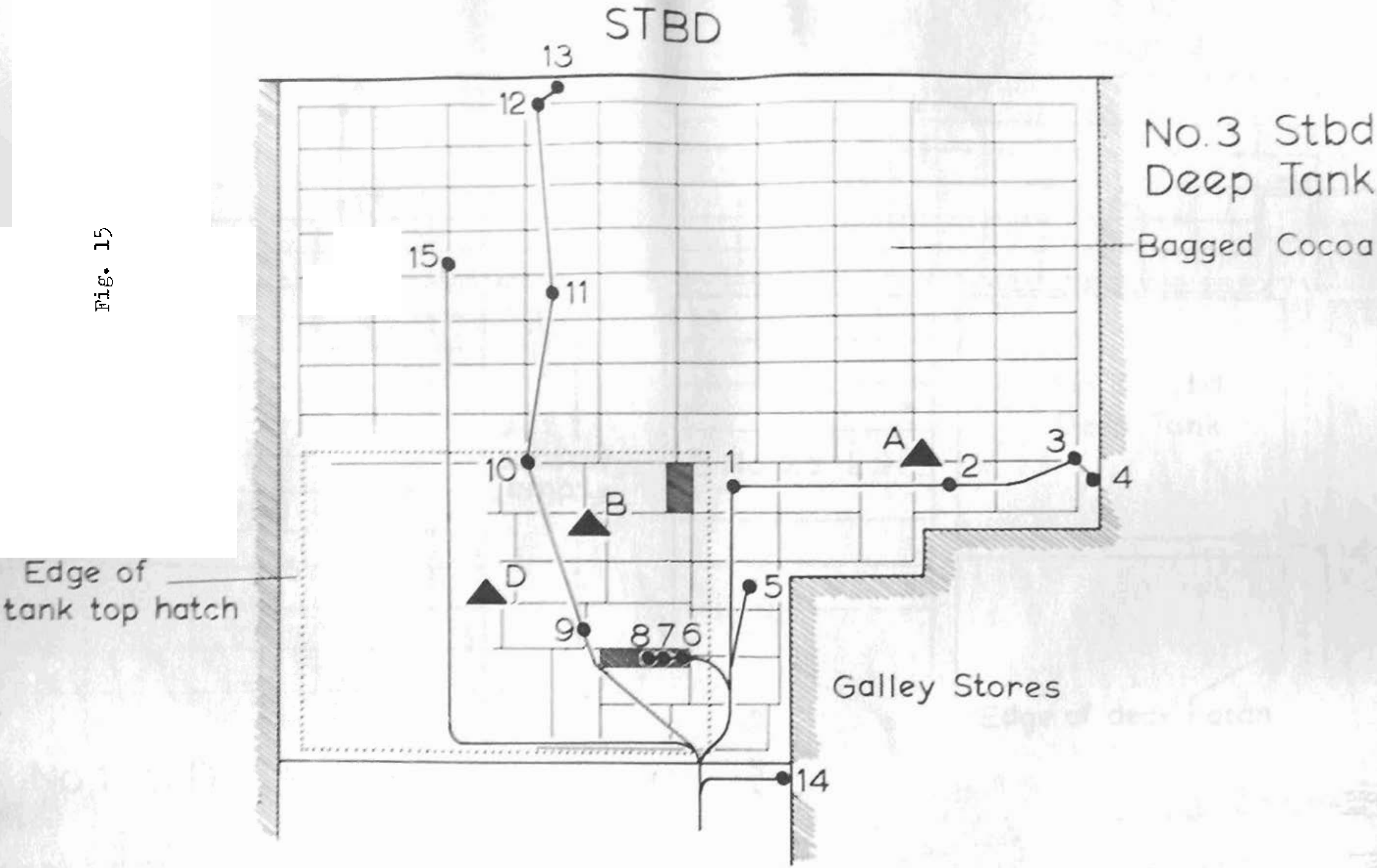
STBD
No.3 Stbd.
Deep Tank
Bagged Cocoa
Edge of
tank top hatch
Galley Stores
A
B
D
1
2
3
4
5
8 7 6
9
10
11
12
13
14
15

Fig. 15

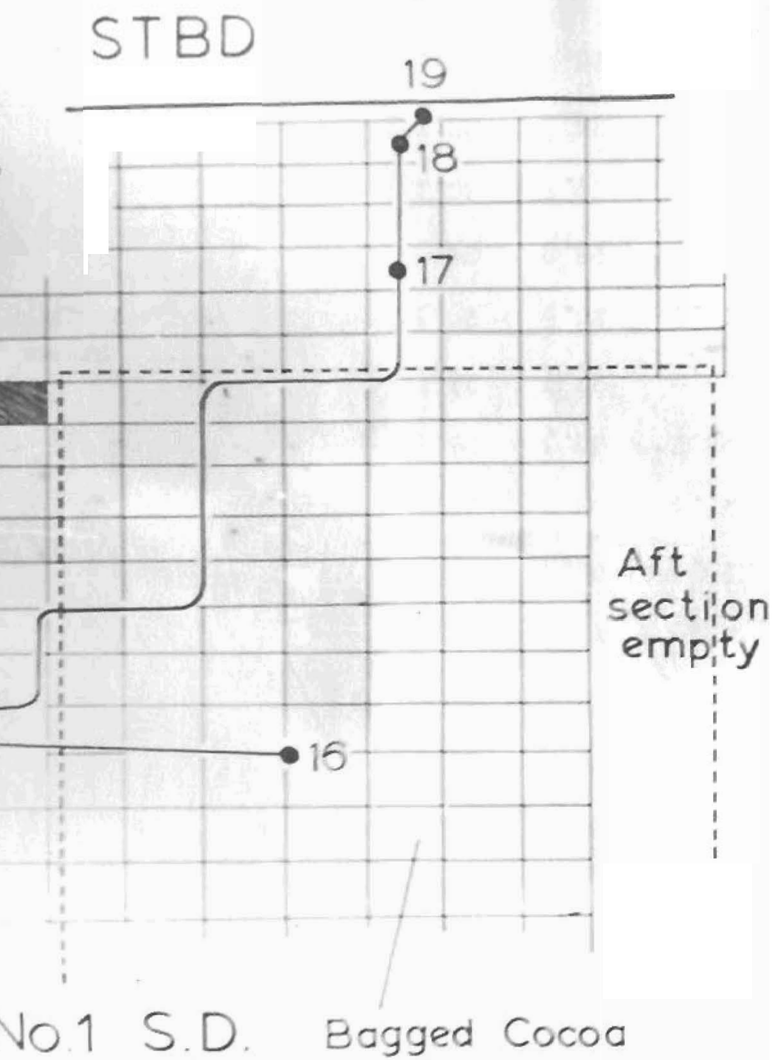
STBD
19
18
17
16
Aft section empty
No.1 S.D.
Bagged Cocoa

Fig. 17

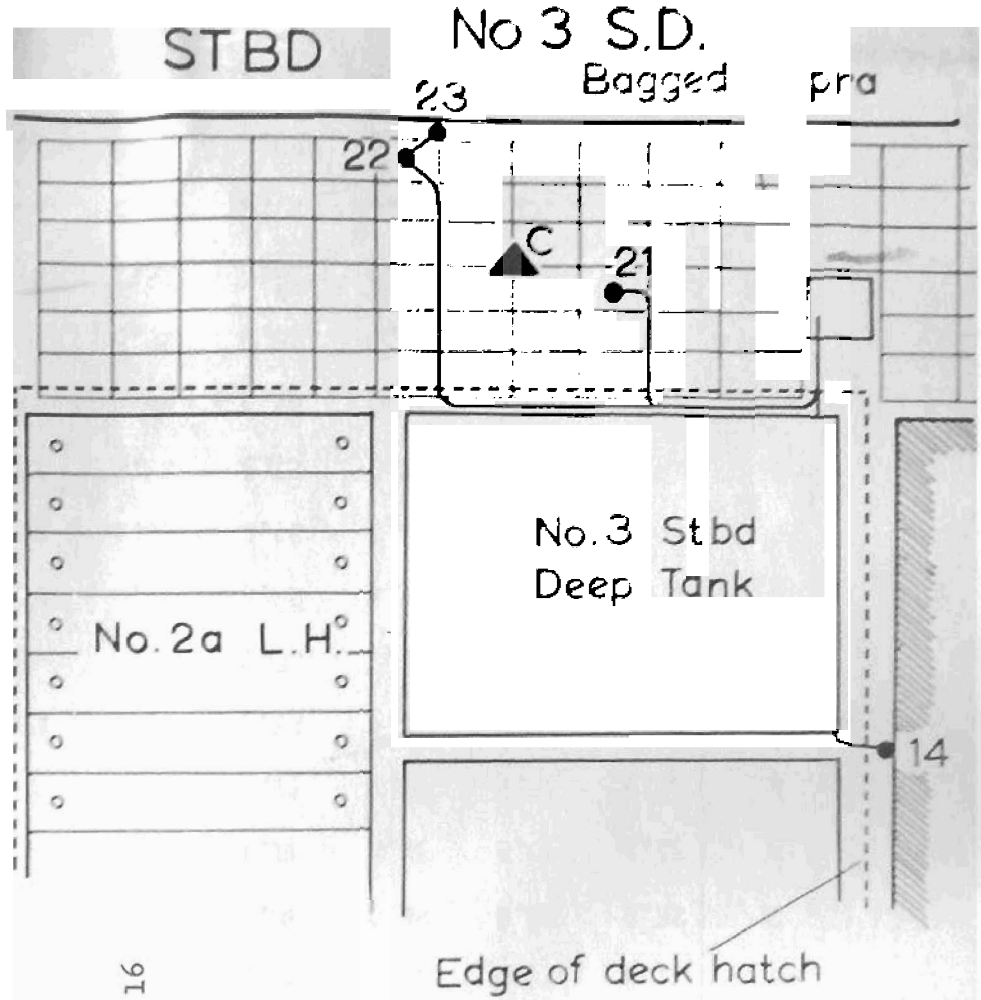
STBD
No 3 S.D.
Bagged
pra
23
22
C
21
No.2a L.H.
No. 3 Stbd Deep Tank
14
Edge of deck hatch

Fig. 16

TABLE 7 Daily thermocouple readings: Homeward voyage.

°C recorded from Sunvic. M.S. NORDKYN Ships Time

Thermo-couple No.	19.9.60	20.9.60			21.9.60			22.9.60	
	7.10 p.m.	8.50 a.m.	1.20 p.m.	6.30 p.m.	8.40 a.m.	2.00 p.m.	7.15 p.m.	8.30 a.m.	12.50 p.m.
1	27.8	27.8	28.5	27.5	27.7	27.8	28.3	28.3	29.5
2	28.4	28.8	28.7	28.2	28.8	28.5	29.1	28.8	29.8
3	31.1	30.8	31.4	31.1	31.9	32.8	33.4	33.1	34.3
4	31.5	32.2	31.6	31.8	33.2	33.4	33.9	35.4	35.3
5	28.5	28.3	28.3	28.3	28.4	28.5	28.8	28.7	29.4
6	28.0	28.8	28.7	28.7	28.8	28.7	28.9	28.8	29.4
7	27.8	28.3	28.2	28.4	29.0	28.7	29.2	29.0	30.0
8	26.0	26.8	26.7	27.4	28.1	28.0	28.3	28.2	29.1
9	28.0	28.0	28.0	27.5	28.2	27.5	28.2	28.3	28.5
10	27.8	27.8	28.0	27.5	28.0	27.4	28.2	27.7	28.3
11	28.7	28.5	28.7	28.6	28.5	28.3	28.5	28.5	29.3
12	28.5	29.0	28.9	28.5	28.1	27.7	27.6	28.0	29.3
13	26.7	29.7	29.4	27.6	26.5	26.9	26.8	27.2	30.1
14	27.2	27.0	27.5	27.4	26.8	26.7	26.8	26.7	28.3
15	29.3	27.7	29.1	29.1	27.9	27.7	27.8	28.2	28.6

TABLE 7
(cont'd 2)

Thermo-couple No.	19.9.60	20.9.60			21.9.60			22.9.60	
	7.10 p.m.	8.50 a.m.	1.20 p.m.	6.30 p.m.	8.40 a.m.	2.00 p.m.	7.15 p.m.	8.30 a.m.	12.50 p.m.
21	32.3	32.3	32.5	32.2	32.9	32.1	31.9	32.0	32.7
22	33.5	33.1	33.5	33.0	32.1	32.7	32.5	32.3	33.1
23	25.6	29.2	31.2	27.8	24.9	25.2	24.8	26.1	31.1

Thermo-couple No.	22.9.60	23.9.60			24.9.60				25.9.60
	7.55 p.m.	8.40 a.m.	12.45 p.m.	7.15 p.m.	6.35 a.m.	12.20 p.m.	3.50 p.m.	8.15 p.m.	6.50 a.m.
1	30.7	29.6	29.4	30.0	30.4	29.9	30.3	29.3	27.6
2	30.6	29.9	29.9	30.3	31.2	30.7	31.7	30.9	30.9
3	35.3	34.0	33.5	33.6	34.9	34.6	35.2	34.0	31.2
4	36.6	35.3	35.1	35.5	36.1	35.9	36.1	34.3	31.7
5	30.4	29.7	29.8	29.8	30.9	30.2	30.6	28.9	28.2
6	29.7	28.8	29.0	29.0	29.2	29.3	29.6	28.9	28.8
7	30.2	29.4	29.4	29.5	30.0	30.3	30.2	29.4	29.7
8	28.6	28.2	28.5	28.5	28.9	29.1	29.0	27.7	26.7
9	28.3	28.0	27.9	28.2	28.4	28.7	28.5	27.7	28.1
10	28.2	28.1	27.9	28.2	28.5	28.6	28.6	27.8	28.1
11	30.1	29.5	29.1	29.3	30.5	30.1	30.2	29.0	28.2
12	29.4	28.4	28.3	28.6	29.0	29.6	29.5	28.3	27.1

TABLE 7
(cont'd 3)

Thermo-couple No.	22.9.60 7.55 p.m.	23.9.60 8.40 a.m.	12.45 p.m.	7.15 p.m.	24.9.62 6.35 a.m.	12.20 p.m.	3.50 p.m.	8.15 p.m.	25.9.60 6.50 a.m.
13	29.0	28.0	27.9	27.7	28.0	29.7	28.1	26.4	25.0
14	29.1	27.9	27.3	27.6	27.9	28.1	28.1	26.6	25.6
15	29.0	28.4	28.3	28.3	28.5	29.1	29.0	28.3	28.6
21	32.8	32.1	32.3	32.2	32.5	33.0	32.8	32.0	31.5
22	33.4	32.6	32.8	32.3	32.9	33.3	33.0	32.4	33.0
23	28.4	25.8	26.2	25.6	26.3	29.3	29.2	25.6	23.1

Thermo-couple No.	25.9.60 11.05 a.m.	3.30 p.m.	8.35 p.m.	26.9.60 6.35 a.m.	11.15 a.m.	3.30 p.m.	8.00 p.m.	27.9.60 7.25 a.m.	12.35 p.m.
1	27.0	26.6	27.0	26.8	26.8	27.6	26.8	26.0	26.5
2	30.9	30.7	31.3	30.6	30.5	30.2	30.1	29.2	29.1
3	30.7	30.8	30.3	30.0	30.1	30.1	30.9	31.0	31.4
4	31.0	31.3	31.4	30.5	30.5	30.8	31.7	31.5	32.1
5	28.0	27.6	27.9	27.9	27.5	27.5	28.0	27.3	27.8
6	28.3	28.5	28.8	29.1	28.5	28.5	29.1	28.3	28.6
7	29.0	29.4	29.3	29.6	29.3	29.2	29.5	28.8	29.0
8	26.0	26.1	26.1	26.4	27.6	26.4	26.9	26.6	27.6
9	27.7	28.2	28.4	28.5	28.6	28.6	28.8	28.4	28.7

TABLE 7
(cont'd 4)

Thermo-couple No.	25.9.60 11.05 a.m.	25.9.60 3.30 p.m.	25.9.60 8.35 p.m.	26.9.60 6.35 a.m.	26.9.60 11.15 a.m.	26.9.60 3.30 p.m.	26.9.60 8.00 p.m.	27.9.60 7.25 a.m.	27.9.60 12.35 p.m.
10	27.7	28.2	28.5	28.6	28.4	28.6	28.8	28.1	28.6
11	26.7	27.5	28.3	27.5	27.2	27.3	27.3	26.5	27.3
12	24.8	26.5	26.9	26.4	27.0	26.5	26.4	25.7	26.8
13	23.0	24.2	25.0	24.9	26.6	24.4	24.6	26.6	26.9
14	23.1	24.3	24.7	25.0	25.0	25.3	25.1	23.8	24.9
15	27.5	28.7	28.7	28.9	28.7	28.6	28.8	28.3	27.8
21	31.8	31.4	30.5	30.5	30.8	30.0	30.8	29.1	29.4
22	32.5	32.0	30.6	32.3	31.9	31.5	31.8	30.8	30.9
23	26.6	23.6	21.7	22.8	32.0	24.0	22.8	26.2	29.6

Thermo-couple No.	27.9.60 5.50 p.m.	28.9.60 7.05 a.m.	28.9.60 11.15 a.m.	28.9.60 3.15 p.m.	28.9.60 8.10 p.m.	29.9.60 7.20 a.m.	29.9.60 12.30 p.m.	29.9.60 5.55 p.m.	30.9.60 7.30 a.m.
1	25.9	25.4	25.7	25.2	24.7	24.3	23.8	23.7	21.3
2	28.4	28.5	28.0	28.4	28.1	27.8	28.0	27.8	27.4
3	30.8	30.3	30.1	30.8	30.2	30.1	29.8	28.7	27.8
4	31.6	31.1	31.0	31.7	31.1	30.8	30.4	29.8	28.6
5	26.9	26.8	26.7	26.2	25.7	25.3	25.3	25.2	22.9
6	28.0	28.0	28.4	27.5	27.8	27.4	27.2	27.0	25.6

TABLE 7 (cont'd 5)

Thermo-couple No.	27.9.60	28.9.60			29.9.60				30.9.60
	5.50 p.m.	7.05 a.m.	11.15 a.m.	3.15 p.m.	8.10 p.m.	7.20 a.m.	12.30 p.m.	5.55 p.m.	7.30 a.m.
7	28.2	28.0	28.1	27.8	27.7	27.4	27.2	27.1	26.1
8	26.0	25.5	25.6	25.2	24.3	24.2	23.8	23.7	24.9
9	28.2	28.0	28.0	27.8	27.4	27.3	27.2	27.2	25.6
10	27.8	27.5	27.6	27.3	27.0	26.3	26.5	26.4	24.5
11	26.3	25.5	25.8	25.8	25.2	24.7	24.8	24.7	21.9
12	25.8	25.0	25.9	25.5	24.7	24.2	24.1	23.8	21.9
13	24.3	26.4	28.2	24.6	23.2	23.0	22.9	21.6	21.0
14	24.5	23.2	23.5	22.5	22.4	22.0	22.0	22.3	17.0
15	28.0	27.9	27.7	27.5	27.5	27.2	27.2	27.2	27.0
16				27.9		27.9	27.7	27.8	27.8
17				27.0		26.7	26.7	26.7	26.5
18				25.8		25.3	25.2	25.2	24.8
19				21.3		19.1	19.1	17.8	27.3
21	29.4	29.4	29.2	29.0	28.8	29.5	29.1	29.0	28.7
22	30.9	30.2	29.9	29.9	29.8	29.3	28.9	28.5	26.9
23	23.9	25.6	32.6	24.9	21.0	20.7	20.2	18.9	19.3

TABLE 7
(cont'd 6)

Thermo-couple No.	30.9.60 12.35 p.m.	6.10 p.m.	1.10.60 8.20 a.m.	12.30 p.m.	6.30 p.m.	2.10.60 8.00 a.m.	11.40 a.m.
1	20.8	21.7	20.5	22.1	21.6	20.9	21.1
2	27.0	26.7	26.3	26.0	25.9	25.2	25.4
3	27.3	27.7	27.8	27.2	25.9	24.4	24.3
4	27.9	28.4	28.6	28.1	27.0	24.8	25.4
5	22.6	23.2	21.9	22.5	22.8	21.6	22.0
6	25.5	26.6	25.7	24.9	25.7	23.8	24.7
7	25.4	25.4	24.6	24.4	24.6	23.6	23.9
8	20.1	21.9	19.9	21.0	21.4	19.8	20.9
9	25.1	25.3	24.4	25.1	25.2	25.2	25.3
10	23.8	24.2	23.3	23.4	23.3	23.2	23.4
11	21.8	22.6	21.6	22.1	22.5	21.8	21.9
12	21.9	22.0	21.9	22.0	21.7	21.0	22.0
13	20.4	20.0	27.8	20.7	19.7	20.4	21.3
14	18.2	20.4	18.1	19.7	18.7	17.7	19.5
15	26.8	26.7	26.5	26.4	26.2	25.6	25.6
16	27.6	27.7	27.6	28.0	27.5	27.9	28.1
17	26.3	26.3	26.0	26.3	25.8	26.0	26.1
18	24.5	24.3	24.1	24.2	23.8	23.6	24.1

TABLE 7
(cont'd 7)

Thermo-couple No.	30.9.60		1.10.60			2.10.60	
	12.35 p.m.	6.10 p.m.	8.20 a.m.	12.30 p.m.	6.30 p.m.	8.00 a.m.	11.40 a.m.
19	23.0	(18.0)?	26.4	19.5	16.9	20.7	26.3
21	28.4	28.3	28.1	27.8	27.5	25.4	25.5
22	26.3	25.9	25.0	24.7	24.7	23.7	23.6
23	23.7	17.0	22.3	18.9	17.0	19.0	23.3

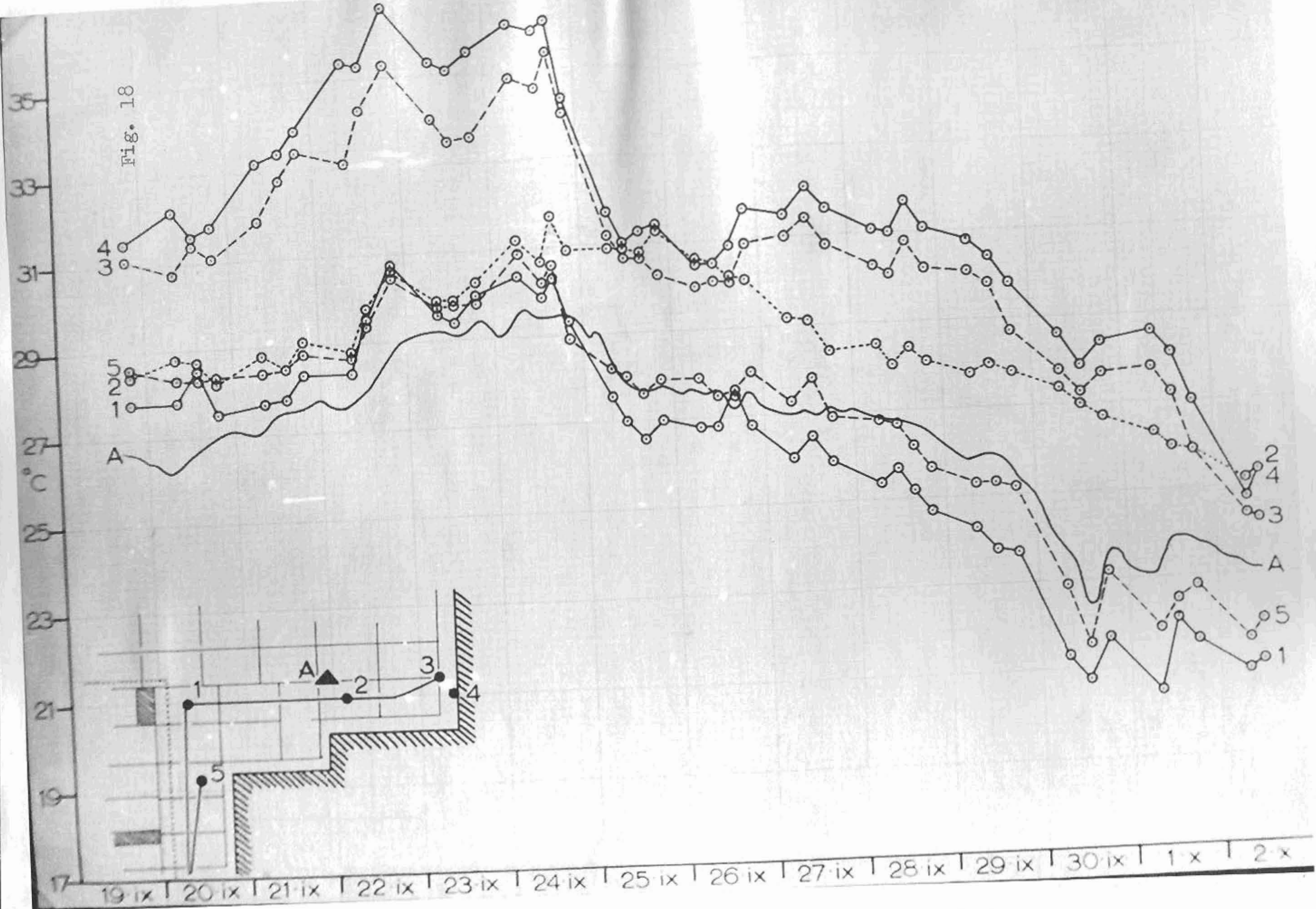

Fig. 18
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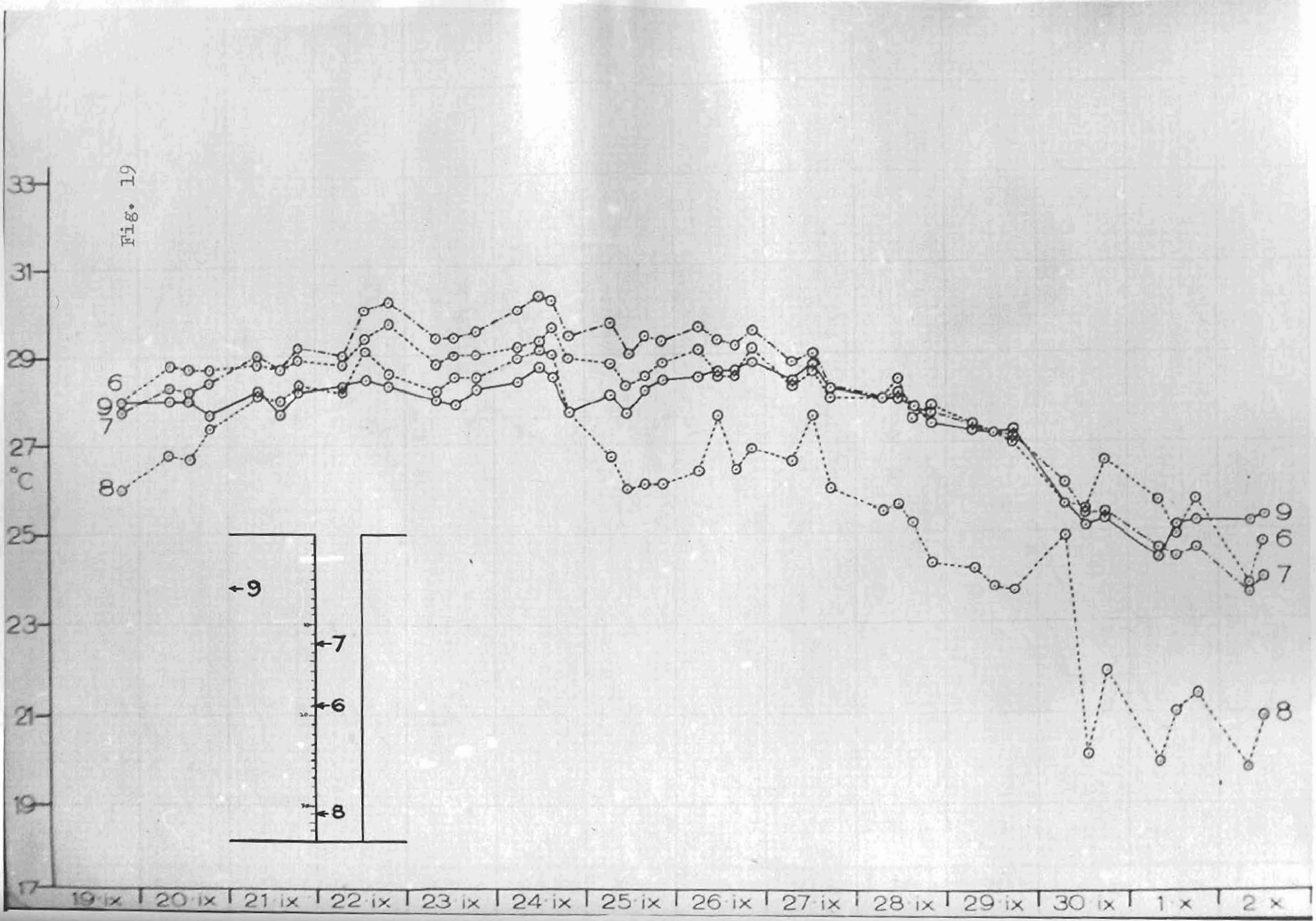

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20·ix
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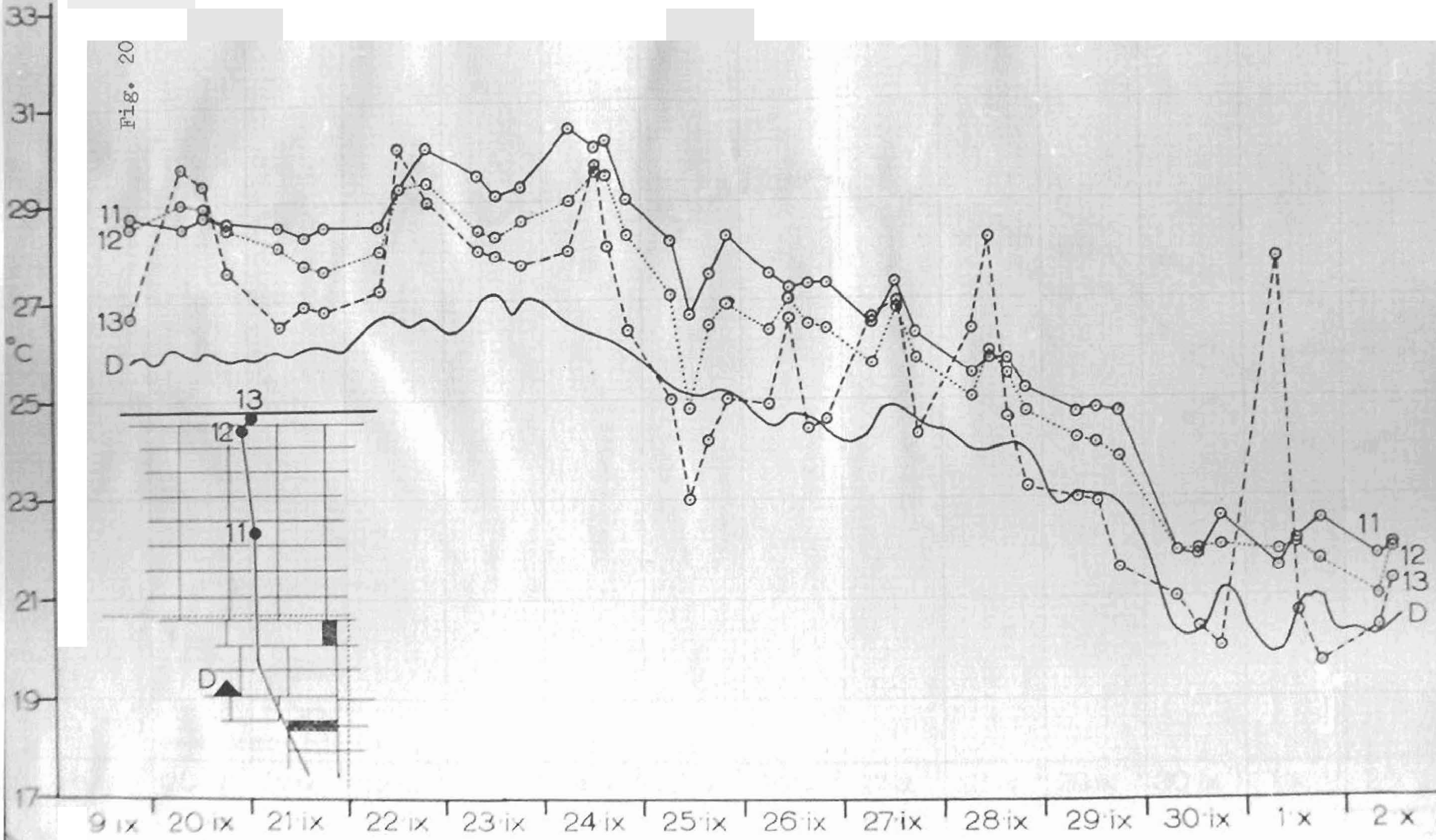
Fig. 19

Fig. 20



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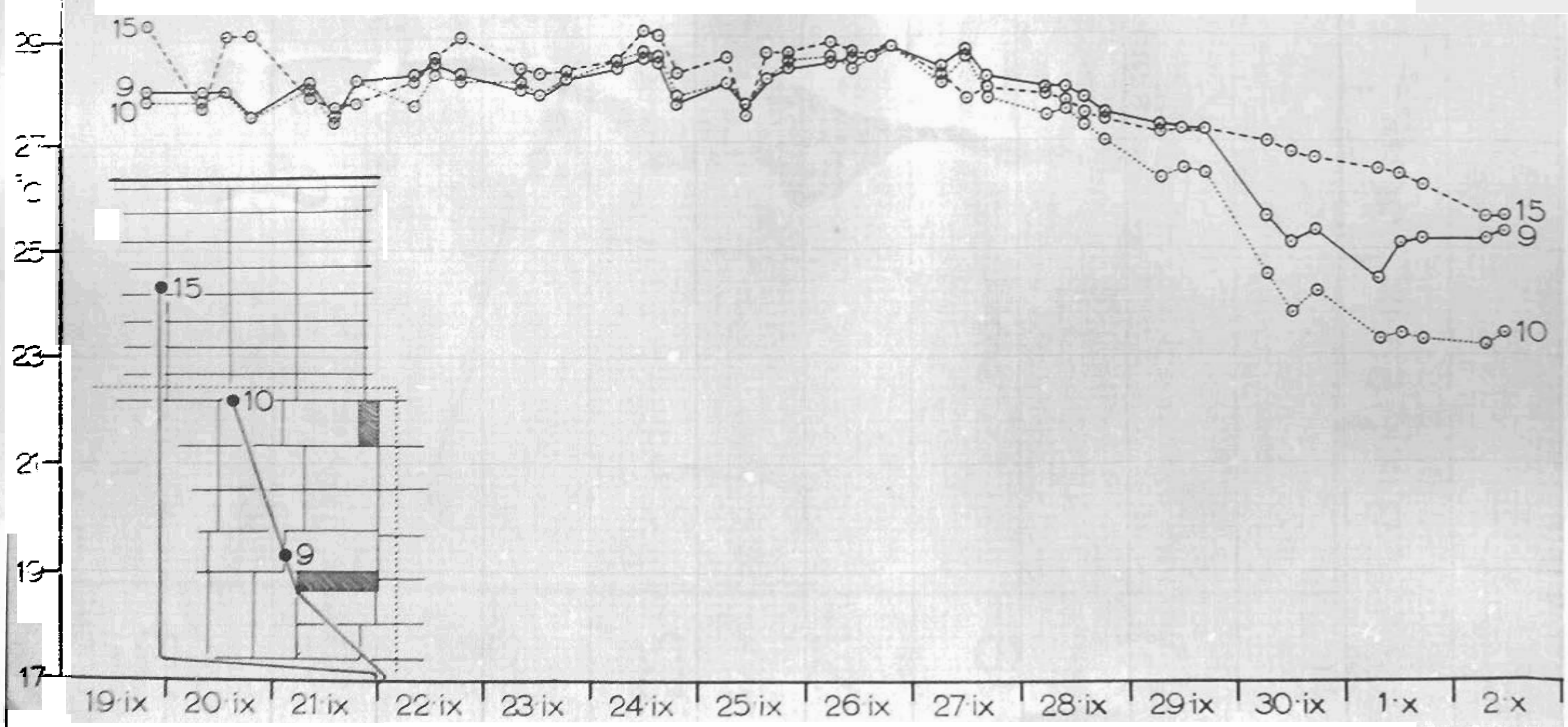

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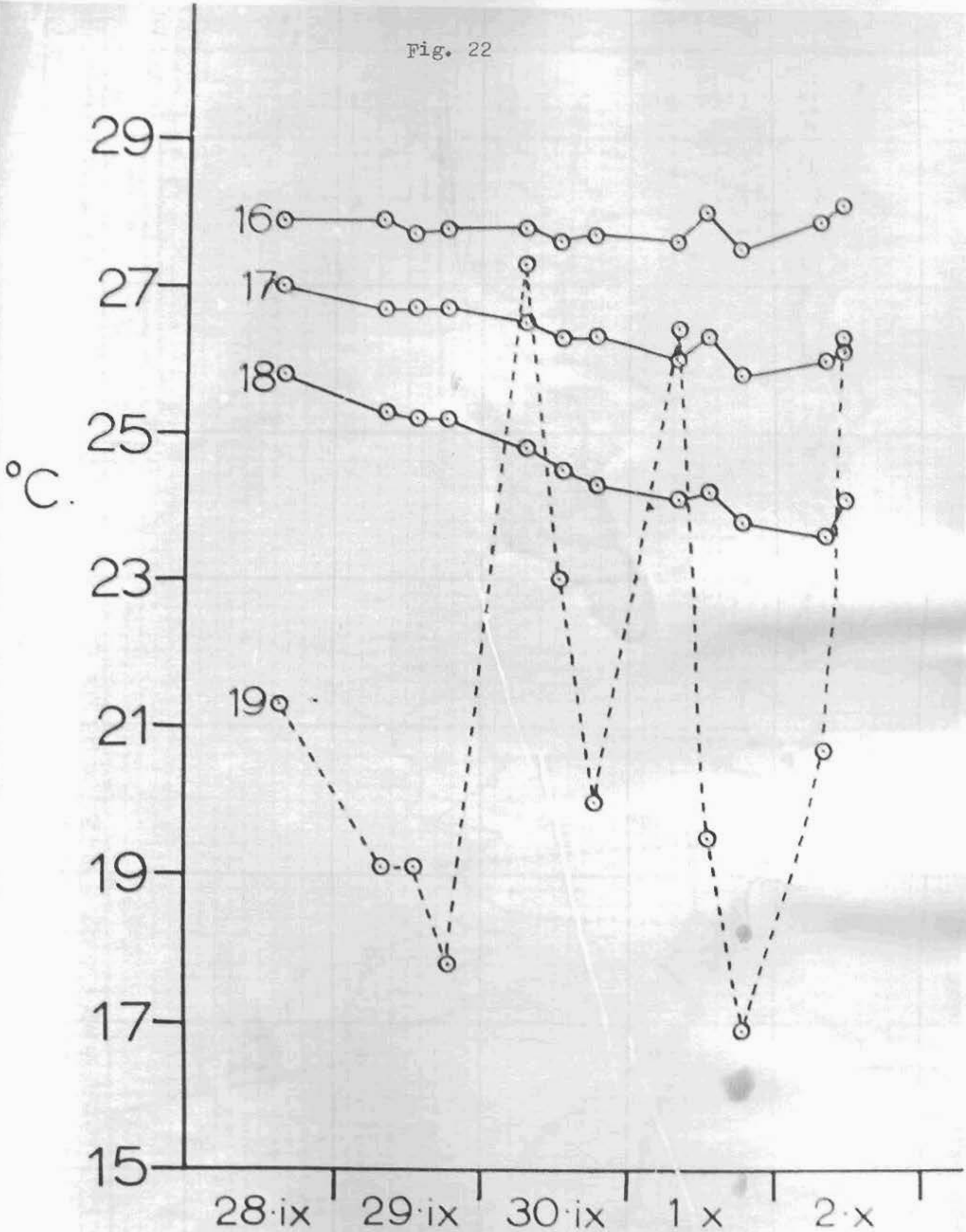
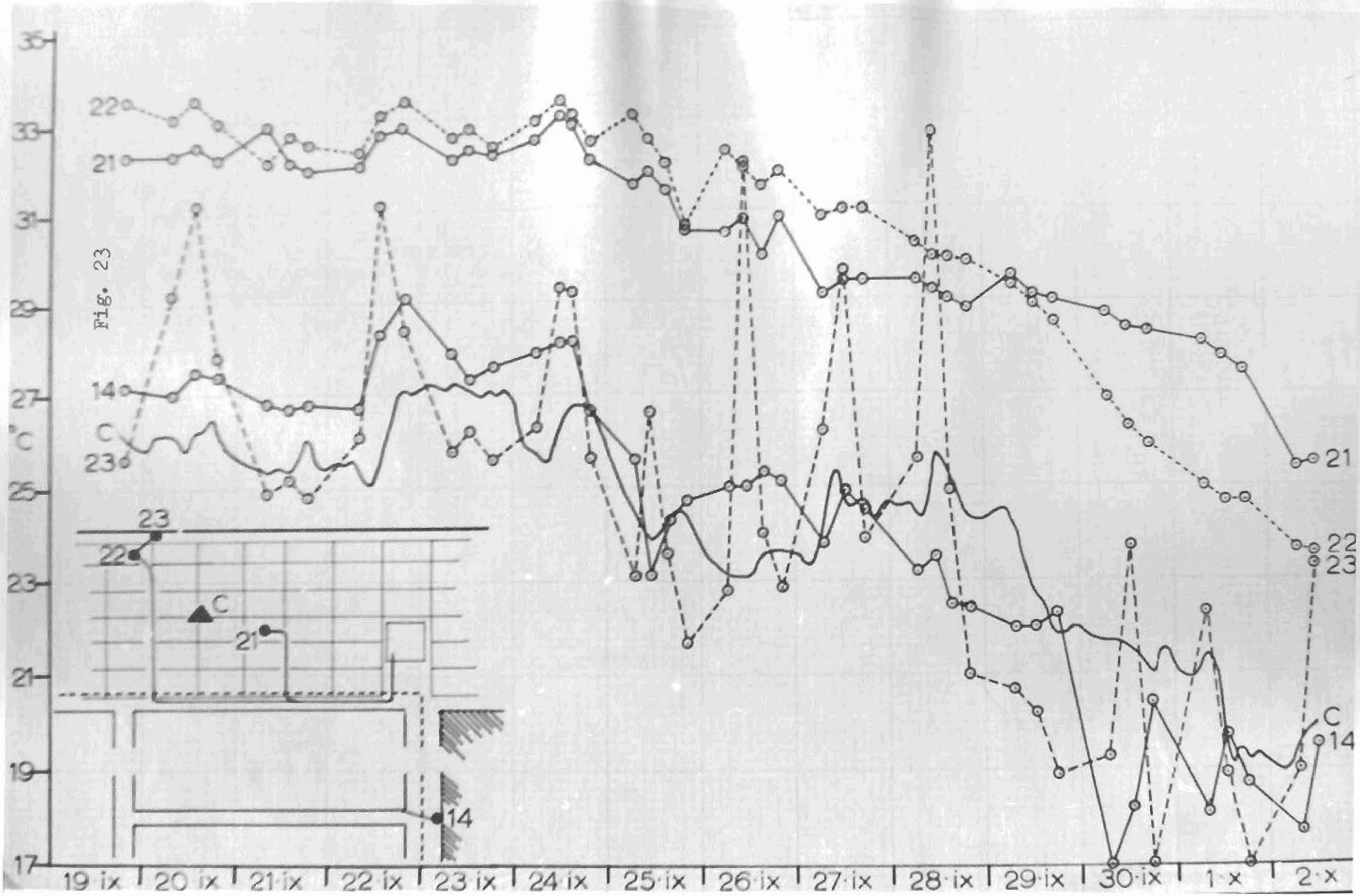
Fig. 21

Fig. 22





35
33
31
29
27
°C
25
23
21
19
17
22
21
14
C
23
22
23
C
21
14
21
22
23
C
14
19 ix
20 ix
21 ix
22 ix
23 ix
24 ix
25 ix
26 ix
27 ix
28 ix
29 ix
30 ix
1 x
2 x

Fig. 23

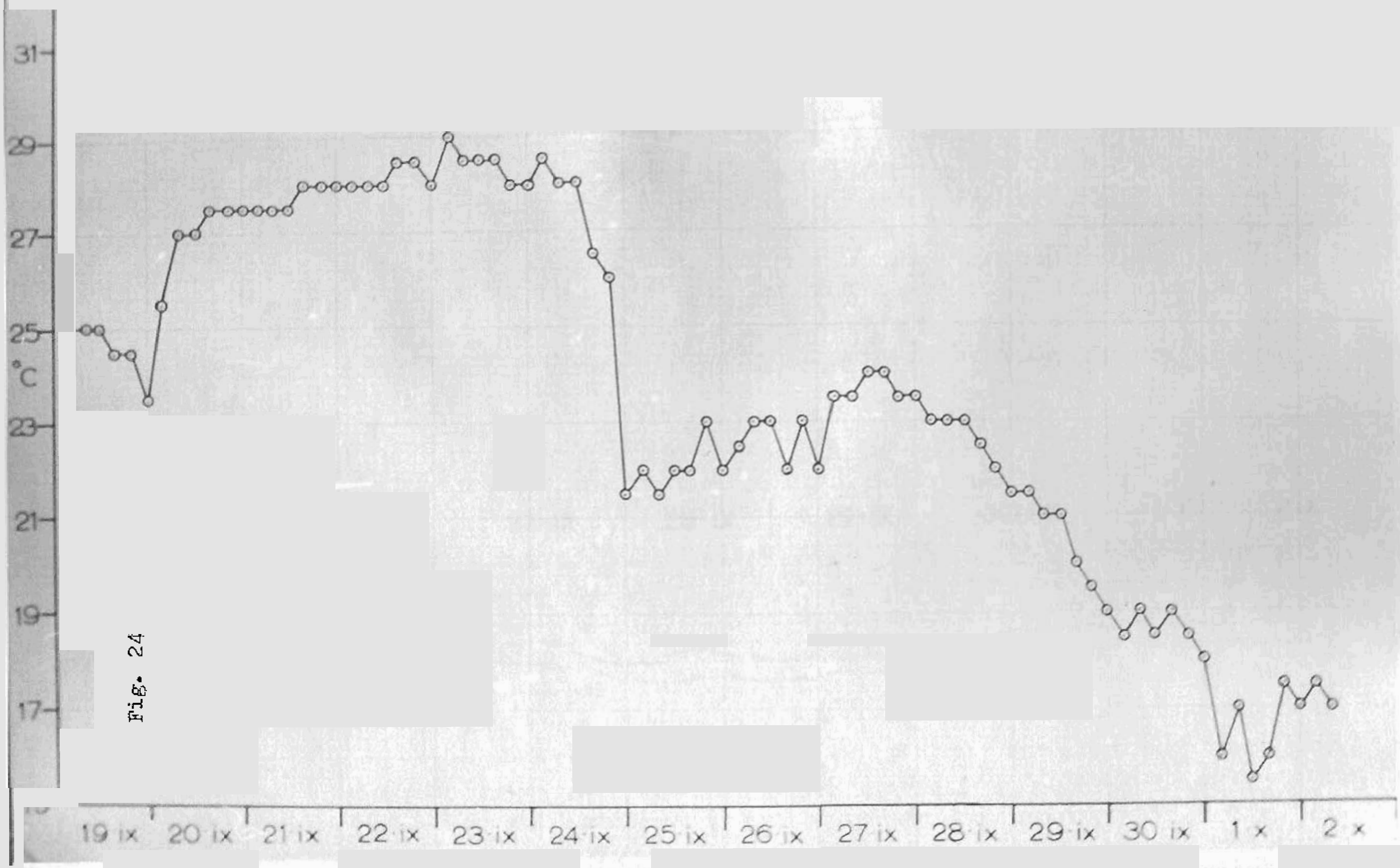
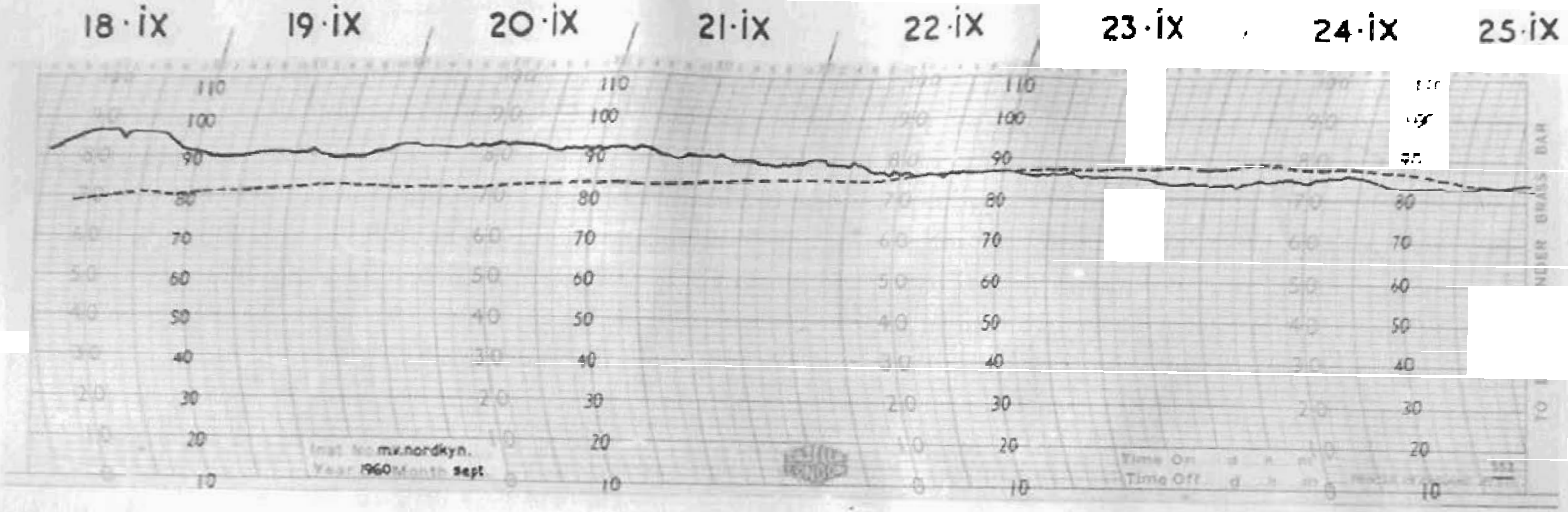

31
29
27
25
°C
23
21
19
17
19 ix
20 ix
21 ix
22 ix
23 ix
24 ix
25 ix
26 ix
27 ix
28 ix
29 ix
30 ix
1 x
2 x

Fig. 24

M.V. NORDKYN CASELLA A.



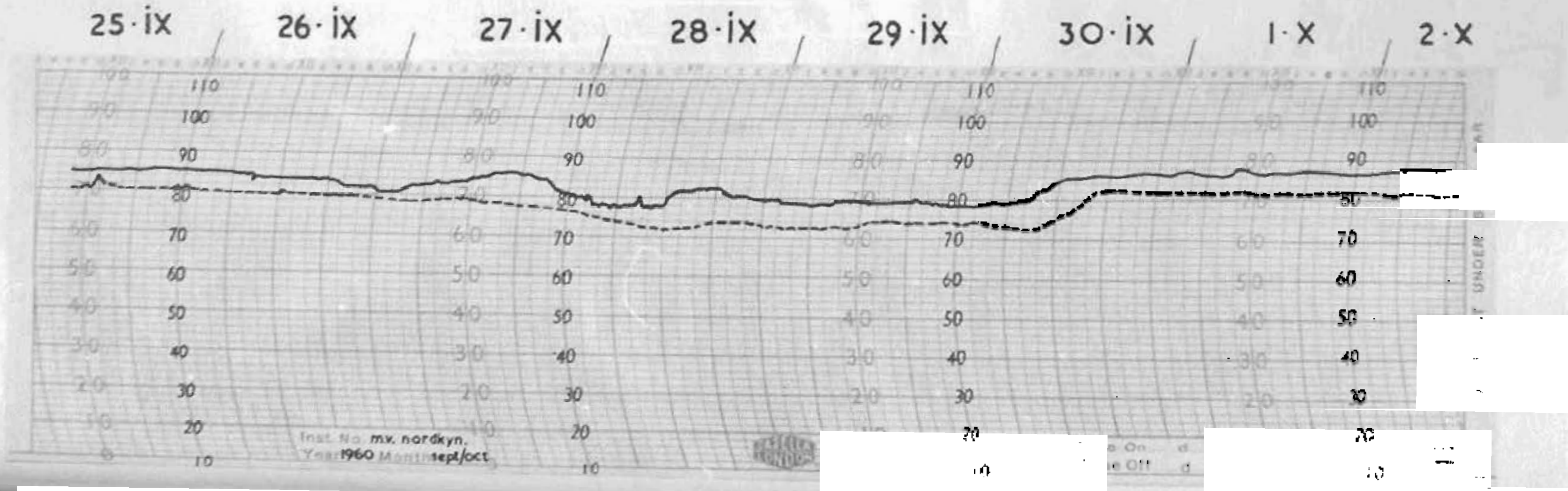


Fig. 25

M.V. NORDKYN CASELLA B.

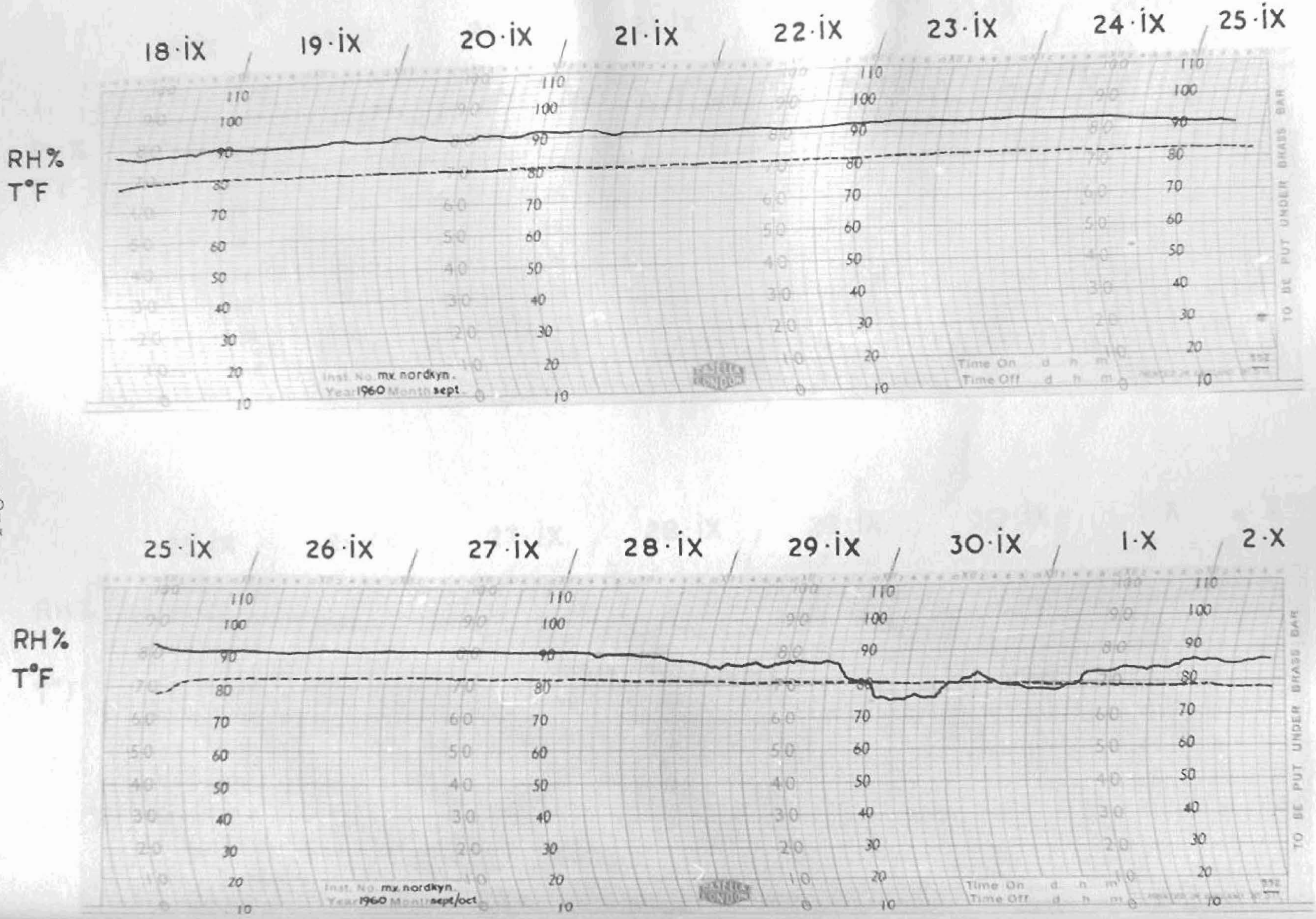
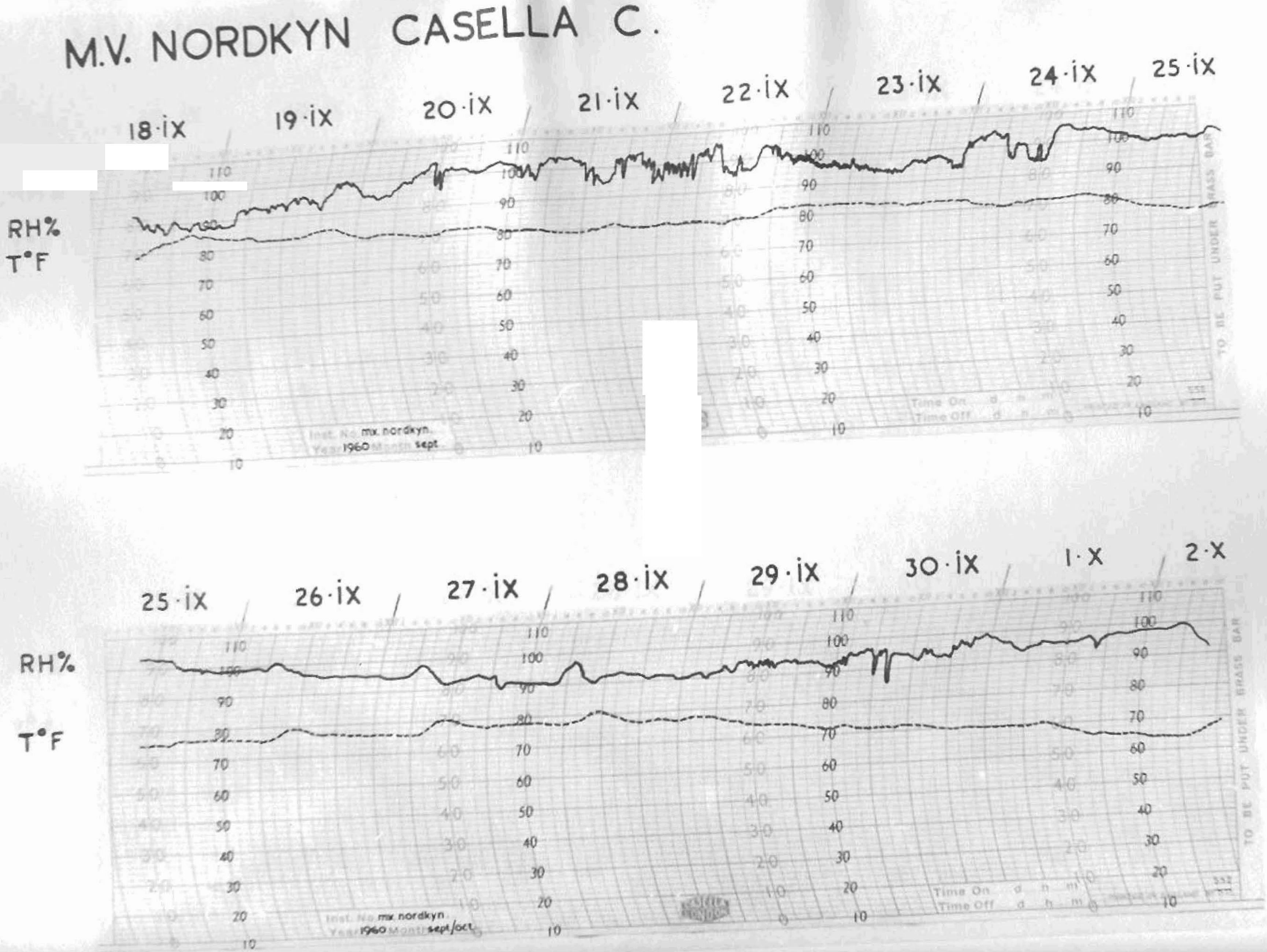


Fig. 26



M.V. NORDKYN CASELLA C.
18·ix
19·ix
20·ix
21·ix
22·ix
23·ix
24·ix
25·ix
RH%
T°F
mv. nordkyn
1960
sept
Time On d h m
Time Off d h m
TO BE PUT UNDER BRASS BAR
25·ix
26·ix
27·ix
28·ix
29·ix
30·ix
1·x
2·x
RH%
T°F
mv. nordkyn
1960
sept/oct

Fig. 27

M.V. NORDKYN CASELLA D.

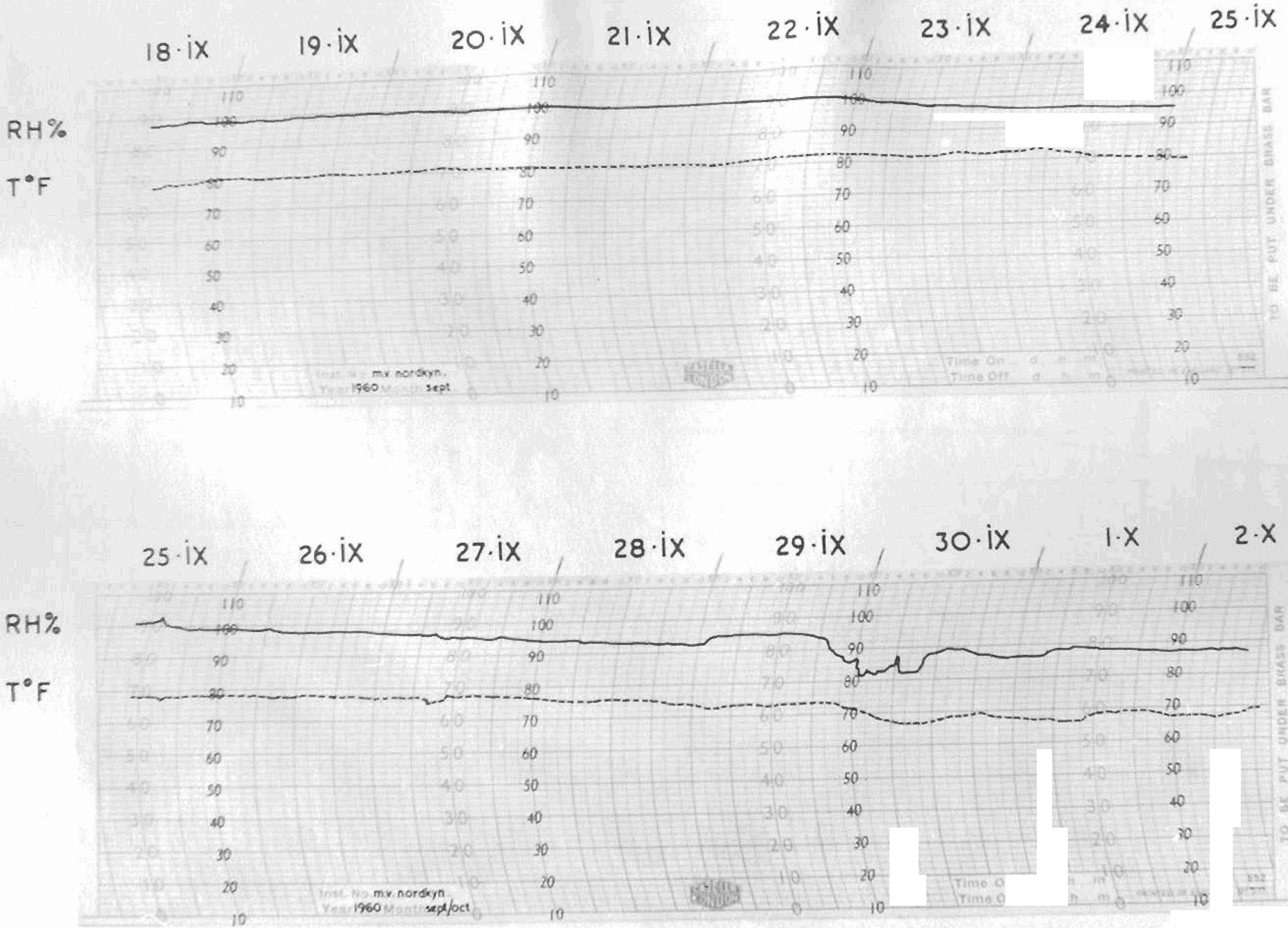
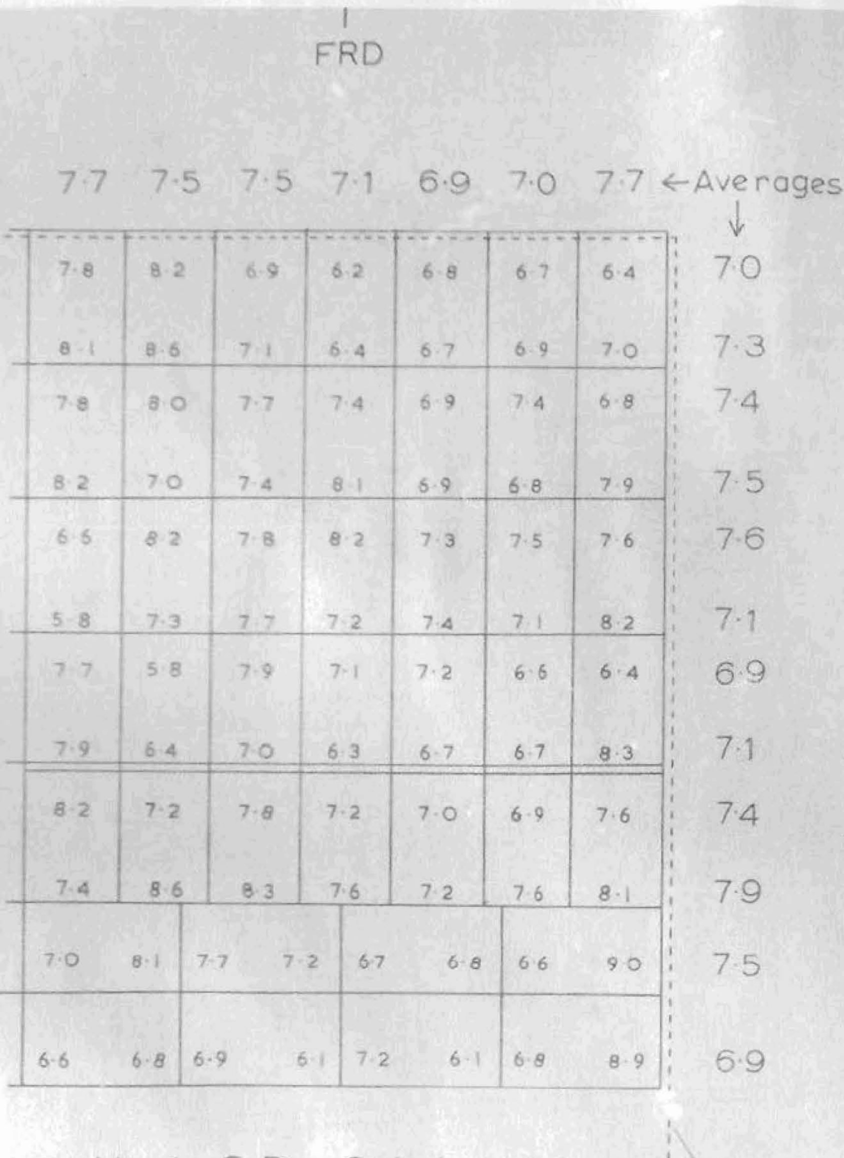


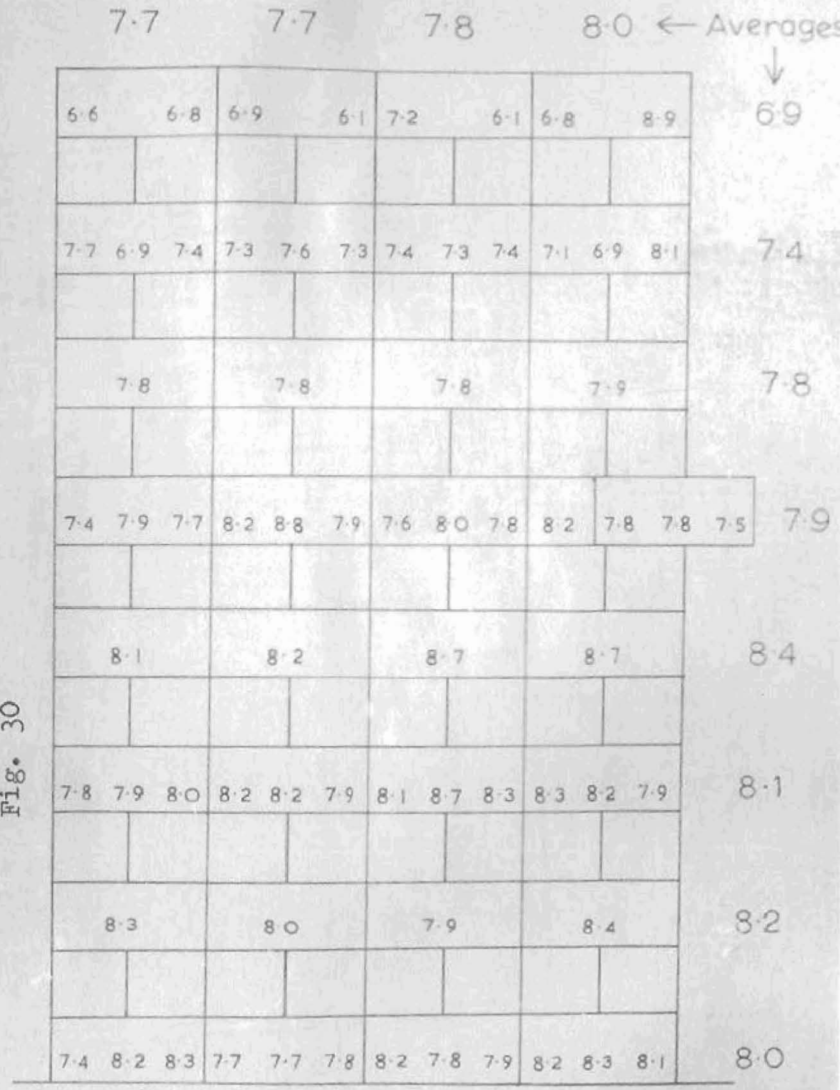
Fig. 28

Fig. 29



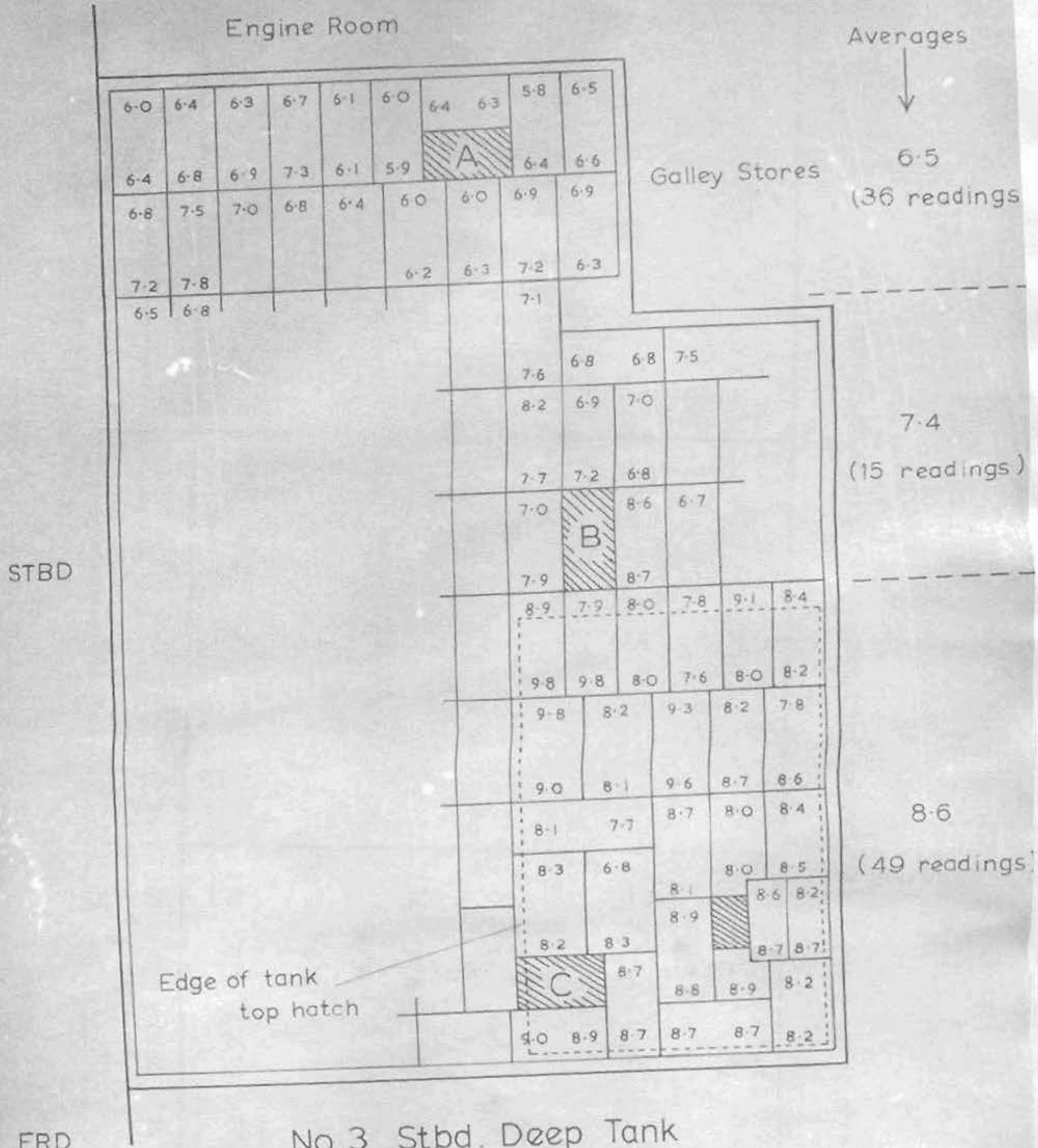
No. 1 S.D., Stbd. side.
Top of stack

Fig. 30



No. 1 S.D., Stbd. side.
Aft face of stack

Fig. 31



No. 3 Stbd. Deep Tank

Top of stack

TABLE 8 MOISTURE CONTENT READINGS FROM AIR SHAFTS

No of bags below top of stack	SHAFT A					B					C				
	PORT	AFT	STBD	FRD	AV	PORT	AFT	STBD	FRD	AV	PORT	AFT	STBD	FRD	AV
1	6.3	6.3 6.4	5.9	6.0	6.2	8.6 8.7	7.2	7.0 7.9	7.9	7.9	8.7	8.2	-	9.0 8.9	8.7
2	7.6	7.1	6.5	6.9	7.0										
3						9.3	9.3	8.8	8.9	9.1	9.6	9.6	8.2	8.9	9.1
4	7.8	7.9	7.8	7.2	7.7										
5						8.8	9.3	8.5	8.7	8.9	9.0	9.5	9.2	8.7	9.1
6	8.2	7.5	8.5	7.8	8.0										
7						9.1	9.1	8.5	7.9	8.7	8.3	8.6	8.7	8.8	8.6
8	8.2	8.0	8.3	8.3	8.2										
Shaft Average			7.3					8.6					8.9		

N.B. Top of Shaft C was 3 bags higher than the tops of the other Shafts.

T A B L E 9. Sample Insect Count Forms: Ghana Cocoa Marcketing Board Insect Control Unit Takoradi.

INSECT COUNT

SHIP Nordkyn DESTINATION Hamburg DATE 13.9.60 SEAL NO. 7

1959 - 60 L/C

	No. of Bags	Grade	Seal No.	Grader's No.	Lot No.	Tobacco Beetle	Cocoa Weevil	Cocoa Moth Adult	Cocoa Moth Pupae	Cocoa Moth Larvae	Tribolium	Other Insects	Total Insects	Average	Degree	Passed Failed
Harbour	100	I	7	318	14	2	5	-	-	-	1	-	8		S/L	Passed
	100	I	7	177	1	-	2	-	-	-	-	3	5		S/L	
	100	I	7	285	9	5	4	-	-	-	6	1	16		S/L	
	100	I	7	40	14	-	-	-	-	-	-	-	-		S/L	
	100	I	7	276	3	-	-	-	-	-	3	2	5		S/L	
TOTALS	500					7	11	-	-	-	10	6	34	6.8	S/L	
Takoradi	100	I	7	699	3	4	2	-	-	-	2	-	8		S/L	Passed
	100	I	7	285	7	-	-	-	-	-	4	2	6		S/L	
	100	I	7	177	2	1	-	-	-	-	-	-	1		S/L	
	100	I	7	276	5	-	3	-	-	-	1	1	5		S/L	
	100	I	7	285	10	-	-	-	-	-	-	-	-		S/L	
TOTALS	500					5	5	-	-	-	7	3	20	4.0	S/L	

TABLE 9 (cont'd 2) INSECT COUNT

	No. Of Bags	Grade	Seal No.	Grader's No.	Lot No.	Tobacco Beetle	Cocoa Weevil	Cocoa Moth Adult	Cocoa Moth Pupae	Cocoa Moth Larvae	Tribolium	Other Insects	Total Insects	Average	Degree	Passed Failed
M. C.	88	I	7	285	10	3	4	-	-	-	2	1	10		S/L	Passed
TOTALS	88					3	4	-	-	-	2	1	10	10	S/L	
G. F.																
TOTALS																

TO: INSPECTOR OF PRODUCE

NAME OF INSECT COUNTER D.K. Addo

SIGNATURE.

T A B L E 9 (con'td 3) INSECT COUNT

SHIP Nordkyn DESTINATION Hamburg DATE 13.9.60 SEAL NO. 7

1959-60 L/C

	No. of bags	Grade	Seal No.	Grader's No.	Lot No.	Tobacco Beetle	Cocoa Weevil	Cocoa Moth Adult	Cocoa Moth Pupae	Cocoa Moth Larvae	Tribolium	Other Insects	Total Insects	Average	Degree	Passed Failed
Harbour	100	I	7	237	6	4	3	-	-	-	1	-	8		S/L	
	100	I	7	602	4	-	7	-	-	-	-	3	10		S/L	
	100	I	7	344	12	2	1	-	-	-	4	-	7		S/L	
	100	I	7	344	12	-	-	-	-	-	-	1	1		S/L	Passed
	100	I	7	344	12	-	-	-	-	-	3	2	5		S/L	
TOTALS	500					6	11	-	-	-	8	6	31	6.2	S/L	
Takoradi	100	I	7	602	2	-	-	1	-	-	-	1	2		S/L	
	40	I	7	602	14	3	1	-	-	-	-	4	8		S/L	Passed
TOTALS	140					3	1	1	-	-	-	5	10	5.0	S/L	

APPENDIX

LIST OF INSECTS RECORDED ON M.V. NORDKYN.

No. 3 DEEP TANKS.

Araecerus fasiculatus DeG.	Very few on cocoa.
Lasioderma serricorne F.	" " " "
Tribolium castaneum L.	" " " "

No. 3 SHELTER DECK.

Necrobia rufipes DeG.	Fairly large number on copra.
Ahasverus advena Waltl.	Moderate " " "
Oryzaephilus surinamensis L.	Very few " "
Carpophilus dimidiatus F.	Few " "
Rhizopertha dominica F.	Very few " "
Dermestes ater DeG.	Few on fish residues on copra.
Dermestes maculatus DeG.	Very few " " " "
Sitophilus granarius L.	Very few in deck residues.
Niptus hololeucus Fald.	One adult " " "

No. 1 LOCKER (No. 2 SHELTER DECK)

Dermestes lardarius L.	One adult on bagged coffee. (ex. Victoria, British Cameroons).