R E P O R T

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THE ROYAL AIR FORCE SANDFLY FEVER COMMISSION

O N

PROPHYLACTIC MEASURES AGAINST PHLEBOTOMUS

AND PHLEBOTOMUS FEVER.

M A L T A, 1 9 2 2.

PROPHYLACTIC MEASURES AGAINST PHLEBOTOMUS.

It has been shown that Phlebotomus papatasii either inherits phlebotomus fever or else contracts the infection early in life, probably in the larval stage, from ingestion of the excreta or the dead bodies of the parent flies. (1) That is, the infection is handed on from one generation to another in the breeding grounds. From this it follows that prophylactic measures against phlebotomus fever must be directed mainly against the fly. A sound knowledge of the habits and habitats of the phlebotomus is the keystone to successful prophylaxis.

Apart from carrying phlebotomus fever and possibly oriental sore, phlebotomi have been inculpated in the causation of other tribulations which beset man in hot climates. Their bites and the consequent irritation cause a liability to septic skin infections and much loss of sleep which must inevitably reduce the effective man-power of any service.

Phlebotomi like many other pests of mankind depend on organic matter to complete their life cycle - in other words filth encourages them and with flies in general their prevalence is (in part) an index of the cleanliness or otherwise of any area; removal of their breeding places will automatically reduce the prevalence of other posts.

Throughout the prophylactic experiments to be described every advantage was taken of facts which had been gleaned regarding the habits and habitats of phlebotomi. The accurate control of these experiments proved full of difficulty, as there were so many factors which influenced the breeding and viability of phlebotomi, for which due allowance had to be made. Many of the prophylactic measures tried have been recommended by various writers in the past, but for the most part on inconclusive data or on purely theoretical grounds. The present aim has been, as far as possible, to test by experiment all measures suggested.

MOVEMENTS OF PHLEBOTOMI IN INHABITED BUILDINGS.

A knowledge of the mode of invasion of buildings by phlebotomi and of their movements after entering was required before any plan of action could be formulated. Briefly, the flies entered the buildings by apertures in the walls - windows, doorways, ventilators or even cracks. This invasion took place at night, roughly between subset and dawn. There was no invasion during the hours of daylight, except on those occasions when a strong wind had blown for two or three consecutive days and the phlebotomi had been held captive in their breeding haunts, then hunger apparently caused them to seek a feed of blood at the earliest opportunity.

Once the phlebotomi, attracted by the odour of man, had fained entrance to the building they proceeded to investigate more closely the course of the emanation. The females remained in the lower levels, of the room in quest of blood, while the males mounted the walls and collected near the ceiling to await the females for pairing purposes. When the females had fed, many mounted the walls and sought secluded, still spots, especially the corners of the ceiling, and hangings or fixtures on the wall such as kits on the kit-shelves, others escaped through the windows, doorways or ventilators and retired to their breeding grounds outside. From observations made on captive phlebotomi and also from a critical

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examination of three hundred flies caught at random in various parts of the camp it was apparent that those flies which remained in the huts were capable of biting again after an interval of from one to five days, depending on such factors as atmospheric temperature, humidity, pregnancy and amount of previous blood-feed. Some phlebotomi would feed only once or twice during their lifetime, others on even as many as twelve separate occasio[ns]. Gradually, after a period of about five to fourteen days many of the females either escaped outside to lay their eggs or else oviposited in the hut and then died; the rest of the females died either egg-bound or non-pregnant, inside or outside the building, eithin fourteen days. Death took place sooner in the case of the males, usually within seven days. Nightly the numbe[r] of flies indoors was augmented by a fresh invasion from outside. Unless some precautions were adopted an inhabited building became more and more densely infested with these pests as the phlebotomu[s] season wore on, due allowance being madé for certain fluctuations in the number of phlebotomi from the natural causes already cited.

The prophylactic measures tried were :-

1. Destruction of the insect in its various stages.
2. Prevention of the flies biting man.

SCHEMA OF PROPHYLACTIC MEASURES ON WHICH EXPERIMENTS WERE MADE.

I. WAR on the INSECT in its various stages.

A. Abolition of the breeding grounds (destruction of ovum, larva and pupa).

(a) Broken ground.

(i) Levelling.
(ii) Rendering the surface impervious.

(b) Walls and embankments.

(i) Facing.
(ii) Pointing.
(iii) Treating the surface (preservation).

(c) Buildings.

(i) Pointing and repairs.
(ii) Treating the surface (preservation).
(iii) Removal of insanitary buildings.

B. Destruction of the adult fly by

(i) Swatting
(ii) Spraying
(iii) Fumigation.

II. PREVENTION of BITING.

(a) Removal of hiding places.
(b) Nets.
(c) Repellants.
(d) Air currents.

(i) Natural - Winds.
(ii) Artificial - Fans.

EXPERIMENTS/

EXPERIMENTS BEARING ON PROPHYLACTIC MEASURES AGAINST PHLEBOTOMI.

I. WAR ON THE INSECT IN ITS VARIOUS STAGES.

A. ABOLITION OF THE BREEDING GROUNDS.

In order to test as far as possible the effect of measures taken to abolish the breeding places the portion of the Camp which contained the Men's Quarters was divided into two parts (see Chart No. 1). It was decided that the half which during the earlier rounds of inspection had contained the greater number of flies should be treated so that comparison could better be made.

Accordingly, work was commenced on the westward half on 12th June, 1922.

The measures taken were as follows :-

(a) BROKEN GROUND.

i. The ground surface was levelled and where necessary the surface was built up with road metal, all pits and hollows being filled in. The surface was then rolled with a heavy roller. Particular care was taken to ensure that the ground adjoining walls and buildings was properly rammed home; most of this part of the work was done by hand with iron rammers. (Photograph No. 1).

ii. Tar was used as a surface dressing to render the ground impervious and thus unsuitable for oviposition, larvation and pupation. Although possibly not the best dressing it acted very effectually, the only trouble occured when the ground underneath was not properly rolled in and the tar laid on a dusty surface. In these circumstances the surface layer of tar peeled off in a short time.
The tar was poured out from watering cans and spread by means of yard brooms; this somewhat cumbrous method being used as no spraying apparatus was available. (Photographs Nos. 2 and 3).

(b) WALLS AND EMBANKMENTS.

i. Where necessary, instead of leaving loose banks between different levels of the ground, sufficient of the bank was cut away to render a uniformly vertical surface which was then faced with a stone wall, crevices between the stones being carefully filled in. (Photographs Nos. 4 and 5). This was necessary as phlebotomi were frequently found resting in the crevices of banks and walls during the day time.

ii. Existing walls were repaired and pointed. Many of these walls consisted of a double row of stones with loose earth in between, so that unless the top of the wall as well as the face was closed in from the outside air phlebotomi still harboured in them. The top of each wall was rendered impervious by a layer of cement or else, after pointing, applying a good layer of tar.

iii. In some instances tar was painted on the walls as a preservative - otherwise the moist atmosphere caused the surface of the stone to crumble and crack, thus giving shelter to insects behind the crevices. (Photograph No. 6.)

(c) BUILDINGS.

i. All buildings were similarly repaired and the crevices filled up; in many cases although but recently erected the walls showed large cracks in the cement. (Photographs Nos. 7 and 8).

ii. Many of the walls were eroded, especially in the lower three feet of buildings, owing to dampness which was derived in part from the splashing up from the ground of condensation water which had fallen from the roof, and partly from the ground damp absorbed by the very porous coralline limestone of which the walls were constructed; probably the action of t sea air aided the process. To lessen the chance of erosion, the walls were tarred above the ground level for a distance of three feet. (Photographs Nos. 9 and 10).

iii. An old wooden building used as a barber's shop, situated just north of the Sick Quarters served as a refuge for insects Owing to this and because its presence interfered with the process of levelling, it was demolished. (Photograph No. 11).

Although every effort was made to get this work push on as rapidly as possible, various set backs delayed its completion. By the 8th August, 1922, these prophylactic measures had been applied around and for a distance of 15 yard beyond the huts in the westward half of the camp, except at th north-west corner where some broken ground was unfortunately not efficiently treated during the fly season.

The number of phlebotomi in the huts was estimated daily by counting the flies in the four corners of each hut at sunset. After the counting was completed the flies were kill by swatting. In this manner the daily counts gave an indicat of the rate of breeding of the phlebotomi in and around the ca and also their power of invading dwellings. Every hut in the experiments was trated in the same way by daily swatting - the only difference being that the ground and embankments around t huts and the walls of the buildings, in the westward half of the camp were specially treated as stated above, whilst the eastward half of the camp was left untouched.

The phlebotomus incidence in the treated part of the camp (Chart No. 2 continuous line) rose rapidly in the early days of June, a similar though less marked rise occurred in th untreated part of the camp (broken line in Chart). During th week immediately following the institution of the prophylactic measures (17th - 24th June) there was a marked drop in the number of phlebotomi in the treated half of the camp: this was not due to these measures, but to the north-west gale whic blew from 18th to 22nd June - this gale naturally effected the western (treated) more than the eastern half of the camp. The rise of the phlebotomus incidence in the next week confirmed this point regarding the effect of the gale. From the 22nd July to 5th August the number of flies in the whole camp was markedly diminished. This was a natural occurrence due to th phlebotomi hatching out in two waves which reached their maxim height in the early and late summer respectively, the second wave being normally greater than the first. The prophylactic measures were almost finished in the westward portion of the camp by 8th August. After that date the number of phlebotomi in this treated part of the camp was practically always less than half that obtained in the untreated part. Strong north-west winds blowing on the 17th and 25th August accounted to a

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certain extent for the fall in the fly curve in the western half of the camp during the period 19th to 26th August. It may be assumed that had these strong winds not occurred the fly incidence (continuous line) would have been represented by a line joining the points 12th August and 2nd September.

The striking facts were the large primary and small secondary wave in the treated, and the large primary and larger secondary wave in the untreated half of the camp. In short, the result of these prophylactic measures was a marked reduction in the number of phlebotomi in the treated portion of the camp.

The results obtained in this experiment were possibly somewhat vitiated by the difficulties encountered in getting the work concluded and also thethe fact that only a comparatively small area could be treated. Nevertheless, it was obvious that the principle involved was correct.

B. DESTRUCTION OF THE ADULT FLY.

(i) SWATTING.

Various methods of swatting the flies were tried - the one which was eventually found to answer the purpose best was by means of a damp cloth.

Strips of cloth measuring 12 by 24 inches, and of a fairly stout, pliable material were used. Ordinary surgical lint served the purpose excellently, but had to be renewed rather frequently, as it wore out after a few weeks use. The cloth was made into a loose roll, the two ends of the roll being brought together and grapsed. The free (striking) end was immersed in water for a minute or two and then gently squeezed to remove the excess of moisture.

With this weapon it was possible after a little practice to cause considerable destruction of the flies. The water rendered the end sufficiently heavy to give a smart blow, while owing to the pliable nature of the material it flattened itself well against the surface to which it was applied and killed any fly with which it came in contact.

As has been explained the daily counts of the phlebotomi in the camp were made by estimating those in the corners of the huts only. It had been ascertained that in any hut in which the men's kits were left lying on the shelves above each bed, the total count in the four corners equalled that in the rest of the room. However, when all the kits were removed and no clothes allowed to lie about during the daytime the number of flies in the corners greatly exceeded that found in the remainder of the hut.

To simplify the work, and because the counting of the flies was confined to the corners of the huts, only those flies occupying the corners were swatted. At times a few escaped by hopping towards the middle of the hut, but with daily and conscientious swatting the number that escaped was negligible.

Two ladders, each 8 feet long, were used to reach the flies at the ceiling level. The process of swatting was a somewhat arduous task. Two officers counted and swatted

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the flies, an orderly recorded the observations, and two Maltese labourers carried the ladders. It took this party between 1½ and 2 hours to complete the round of 28 huts. Even then only the corners of each hut were treated.

The reduction in the incidence of phlebotomi which was obtained as a consequence of swatting was very satisfactory. (Chart No. 3).

During the first sixteen days of the observations the corners of all the huts were treated daily by swatting and Hut A4 was if anything less troubled by flies than the others. The corners of A4 were swatted up till June 5th - after that date no treatment of any sort was used in that hut until the evening of the 28th June. Meanwhile the other huts were being swatted daily at sunset after the flies had been counted. The result was that the number of phlebotomi in A4 rapidly increased and it was only for a short period while a strong wind was blowing that the number approximated to that appertaining in the treated huts. When this hut did not receive treatment the flies were usually four or five times more numerous in it than in the other huts.

In order to further test the efficacy of this method, swatting was recommenced in Hut A4 after counting the flies on July 13th and an immediate drop in their number was very evident. Moreover, the reduction was maintained as long as the swatting was in progress (14th to 22nd July) but shot up again immediately it was discontinued.

B. (ii) SPRAYING EXPERIMENTS.

Various observers have recommended the use of sprays for the destruction of the adult phlebotomi. Several kinds of insecticide have been recommended, usually one of the commoner fluid disinfectants which are on the market. Little attempt has been made by experiment to prove the value of spraying or to show which solution was the most effective.

In order to throw some light on these points two series of spraying experiments were performed :-

(a) on a small scale in the Laboratory.
(b) on a large scale in Hut A4.

Certain observations which had been made on fumigants (vide infra) had a distinct bearing on these experiments. It was shown that phelbotomi had considerable powers of resistance so far as the emanations from various disinfectants were concerned they even withstood the odours of the full strength disinfectant for some time. To be of any practical value, both from the point of view of economy and the fact that spraying had to be done while the men were sitting about in the hut, the substance used had to be capable of killing the flies when in dilute solution. As the flies could resist the odours of the pure insecticide for some period it was obvious that to be effective it was necessary to spray them directly with the fluid used.

To estimate the part played by the disinfectant and that played by the fluid it was first necessary to conduct experiments with water alone for when studying the habits of the flies it was seen that if a drop of water came in contact with a fly, in many cases, the fly especially if a male, was killed.

(a) Small scale experiments in the Laboratory.

For these experiments a glass jar about 6 inches in diameter was covered with a butter muslin cover. Through this cover was a tube of muslin similar to that used by Waterston for breeding phlebotomi in pots.

The phlebotomi were introduced into the jar and then sprayed by means of a fine nasal spray the nozzle of which was held inside the tube of entry. As it was found that the flies flew against the muslin cover where the spray could not reach, a second spray was used at the time time to play through the muslin.

Various disinfectants were tried each being sprayed into the jar for a known period and the effect on the contained flies noted. Fresh flies were used for each experiment and the jar was thoroughly dried out before using it again. The method was undoubtedly very rough and difficult to control accurately but the experiments were repeated several times giving closely similar results on each occasion. The experiments performed on 2nd August, 1922, with a room temperature of 81°F. gave the results depicted in Table No. I.

TABLE I.

No. of experiment.	Fluid used.	Percentage strength of fluid.	No. of sprays used.	Duration of spraying.	No. of flies experimented on.	Results.
1.	Water	-	2	40 secs.	3 males 3 females	1 male alive.
2.	Cresol	1	2	20 "	3 males 3 females	1 female alive (moribund)
3.	Formalin	1	2	20 "	3 males 3 females	All alive.

(b) Large scale experiments in Hut A4.

Experiments with a large spray of the Meyer's knapsack type were carried out in Hut A4 on several occasions between 28th June and 16th August, 1922. Several yards of stout pressure tubing were necessary to connect the reservoir and the nozzle of the spray. (Photograph No. 12).

The spraying was done very carefully and methodically so that all parts of the walls and roof came under treatment. Special attention was paid to the wall ventilators and to the chinks behind and under lockers. The flies in the whole hut were counted immediately before spraying was commenced. When the spraying was finished only one or two flies could be seen. This did not necessarily mean that all the flies had been killed for if the men's kits had been left on the shelves a certain number sought refuge in these or similar hiding places. The importance of rendering such hiding places as few as possible could not be over estimated if the full effect of the spraying was to be obtained.

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The fluids used for spraying were sea-water, one per cent cresol solution and one per cent formalin solution with the results tabulated in Tables Nos. II and III.

The phlebotomus incidence in Hut A4 (Chart No. 3) shewed only slight daily fluctuations unless some special treatme wad administered. The marked drop in the number of flies was very obvious whenever spraying was carried out in the hut.

The first experiments (Nos. 1, 2 and 3, Table No. II) consisted of a series of sprayings with cresol, which were done on three consecutive evenings. On the first two evenings part only of the hut was sprayed; on the third evening the whole hut. There was a steady daily decrease of the fly count as a result of the three sprayings; at the end of the third day the number of flies had decreased by 174, that is from 220 to 46 (Chart No.

The result of isolated daily sprayings of the whole hut with cresol was, on each occasion, a marked drop in the number of flies (experiments Nos. 4, 5 and 6 in Table No. II and No. 4 of Table No. III).

The effect of spraying with water alone were seen in experiment No. 1, Table No. III. The immediate effect on the number of flies was undoubtedly much less after this spraying than after spraying with an antiseptic solution, as considerable numbers of flies could still be counted. The decrease which occurred after 4 hours was due more to the increase in force of the wind than to any effects of the spraying. This was borne out by the count after 10 hours which would have been much less if the spraying had had any real effect.

The infusion of Pennyroyal (Experiment No. 2, Table No. III) had certainly more effect than the water but nothing like so good as the cresol solution.

The same might be said of the results of spraying with Formalin (Experiment No. 3, Table No. III). There was a distinc decrease in the number of flies but not so marked or so lasting as in the case of cresol.

Of the fluids tested cresol was the most potent. The lethal action on the phlebotomi was to a certain extent due to the water added, but experiments with water spraying shewed that the action of water alone was only a small one. The chief letha factor was some inherent property in the disinfectant itself.

In the experiments with fumigants (vide infra) the vapour of formalin was found to be far more efficient than that of cresol. This led to the supposition that formalin would make the more efficacious spray (Marrett (2) and Newstead (3)) The marked superiority of cresol in the present series of experiments must therefore have been due more to physical than disinfectant action; its oily nature damaged the wings more than a watery solution and possibly acted also by closing up the openings of the delicate breathing apparatus of the phlebotomus.

From these experiments it was concluded that spraying was a most valuable weapon and that the fluid to be used should be of the nature of an emulsion rather than a watery solution.

TABLE NO. II.

PRELIMINARY SPRAYING EXPERIMENTS WITH CRESOL.

No. of experiment.	Date.	Time	Average temperature for the day in degrees Fahrenheit	Average relative humidity for the day.	Wind & Force.	Solution	Percentage strength.	Number of Phlebotomi in the four corners.		Remarks.
								before starting experiment	24 hours after spraying	
1	28.6.22.	7.30 p.m.	77	76.5	W1	Cresol	1	215	157	2 corners sprayed only.
2	29.6.22.	"	78	77	NW2	"	1	157	111	Half the hut sprayed.
3	30.6.22.	"	78.5	76.5	NW2	"	1	111	46	Whole hut sprayed.
4	3.7.22.	"	76	77.5	WSW1	"	1	124	20	" " "
5	7.7.22.	"	77.6	75	W2	"	1	186	40	" " "
6	10.7.22.	"	77.6	86.6	E1	"	1	140	20	" " "

This table shews the marked reduction in the number of phlebotomi in the hut after one spraying with one per cent Cresol solution.

TABLE NO. III.

SPRAYING EXPERIMENTS.

No. of experiment.	Date.	Time.	Average temperature for the day in degrees Fahrenheit.	Average relative humidity for the day.	Wind and Force	Solution	Percentage strength	Number of phlebotomi in the whole hut.				
								before starting experiment.	10 hrs after spraying.	24 hrs after spraying.	34 hrs after spraying.	48 hrs. after spraying.
1	10.8.22.	7.30 p.m.	87	43.8	N1-2	Sea-water	-	158	171	105	103	-
2	12.8.22.	9.30 a.m.	85.6	50.8	N1	Infusion of Pennyroyal.	7*	103	36	80	56	92
3	14.8.22.	-	85	76.0	Calm	Formalin	1	92	40	100	89	118
4	16.8.22.	-	84.5	62.5	NW2	Cresol	1	118	6	27	21	95

* The infusion of Pennyroyal was made by boiling a quantity of the dried crushed plant in half a gallon of water. The resultant infusion was diluted 1 part to 13 of water and thus used for the spraying.

B. (iii) FUMIGATION.

Various experiments were tried with this method of disinfectation although it was realised that it was unlikely to be of much value as a practical measure. The drawbacks were pointed out by Newstead who considered the method too expensive, and if a good concentration of gas was to be obtained, too laborious. However, it was considered that fumigants on a small scale might be of value in combating phlebotomi in private rooms or dwellings.

Attempts were made to ascertain the insecticide power (if any) of certain of the commoner disinfectants. In the first experiments plugs of cotton wool were soaked in various strengths of the disinfectant. Each plug was inserted into the bottom of a broken test tube and covered by an indiarubber cap to prevent the fumes escaping to the exterior. A thin layer of wool was then placed in the middle of the tube to partition it off into two chambers. The phlebotomi were introduced at the top end and kept imprisoned by an ordinary cotton wool plug. By this arrangement it was hoped to prevent the flies coming in contact with the disinfectant. It was found, however, that the flies tended to get entangled in the cotton wool partition where they died, in part at least from damage to their delicate wings.

To obviate any mechanical damage to the flies the following apparatus was devised (Figure No. 1). Two broken test tubes ¾ inch in diameter were taken, one was about 5 inches long the other about 2 inches. One end of the longer tube was closed by a piece of phlebotomus proof muslin and held in place by a piece of rubber tubing which also served as a joint between the two tubes. Several flies were introduced into the longer tube, the cotton wool plug pushed in and the end covered by a rubber cap to prevent the vapour of the disinfectant from escaping. Into the open end of the smaller tube was put a cotton wool plug soaked in the disinfectant; this end was then closed with a rubber cap.

In the first three experiments of the first series (Nos. 1, 2 and 3, Table No. IV) the insecticide was used in a strength of 1 in 20. It was soon found, however, that this concentration was valueless under the conditions in which the insecticide had to act. The remaining experiments were therefore done with the full strength.

Several series of experiments were necessary in order to test slight differences in the technique. Thus in the first two series different positions of the tubes were tried to allow any vapours lighter or heavier than air to act. In the third series an attempt was made to obtain concentrated action, while in the fourth the effect of increasing the humidity was tried.

In each series the superior value of formalin over cresol when used as a fumigant was demonstrated. Even in the tubes where the formalin vapour was not left to concentrate the phlebotomi were killed in three hours or less. It was only in the tubes with concentrated vapour that cresol seemed to have any effect (No. 1 Table No. VI); in all the other experiments with cresol no harm occurred to the flies. In fact it was in a tube in which the effect of cresol vapour was being tried that a pregnant female laid eggs, which subsequently hatched out normally.

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Apart from cresol and formalin the only other substance tested was turpentine. In the first three series of experiments comparatively little action was noted on the flies, but in the last series in which the humidity of the air was increased it had a distinct insecticide action.

Throughout these experiments it was noted that males were more readily killed than females.

From a consideration of the above experiments it wa apparent that, of the commoner insecticides used as fumigants formalin was the onw which, in most circumstances, would prov the most efficient.

Mention should be made of certain experiments on th same lines as those just considered using the plant known as Pennyroyal. This plant which grows abundantly in certain parts of the island has a reputation locally as a repellant o phlebotomi. When the truth of this observation was being pu to the test it was found that the plant had definite insectic action on the phlebotomus. This was shown to occur both wit the dried plant and with an infusion made from it with hot wa (See section on Repellants).

From these facts it was hoped that a cheap, easily worked and efficient insecticide might be produced. An experiment was accordingly tried on a large scale in one o the huts. The dried plant was placed in a bucket, some methylated spirit poured over it and after all doors and ventilators had been closed a lighted match was thrown on it. Although it burned for some little while, the amount of aroma vapour given off from a considerable quantity of the plant wa small. Little or no effect was found to have occurred in th total number of flies found in the hut before and after the experiment.

TABLE No. IV.

First Series of Fumigation Experiments.

In this series of experiments the tubes were laid horizontally on the bench for the first 24 hours, while during the following period they were stood erect with the fumigant in the tube below and the flies in the tube above.

No. of experiment.	INSECTICIDE.			NUMBER OF PHLEBOTOMI IN TUBE.					Remarks.
	Name	Percentage strength of	Amount used in ccs.	Before starting experiment	Alive after 1 hour	Alive after 10 hours	Alive after 24 hours	Alive after 4 hours.	
1	Cresol	5	1	1 female	1	1	1	Nil	Killed by accident.
2	Formalin	5	1	1 female	1	1	1	Nil	Killed by accident.
3	Turpentine	5	1	1 female	1	1	1	1	
4	Cresol	100	1	1 female 1 male	2	2	2	2	
5	Formalin	40	1	1 female	1	Nil	-	-	Died in 2½ hours.
6	Turpentine	100	1	1 female	1	1	1	1	

TABLE No. V.

Second Series of Fumigation Experiments.

Tube containing the fumigants was placed above the tube containing the flies - to allow any vapours heavies than air to act.

No. of experi-ment.	INSECTICIDE.			NUMBER OF PHLEBOTOMI IN TUBE.				Remarks.
	Name.	Percentage strength of	Amount used in ccs.	Before starting experiment.	Alive after 1 hour.	Alive after 10 hours.	Alive after 24 hours.	
1	Cresol	100	1	1 female.	1	1	1	
2	Formalin	40	1	1 female	1	Nil	Nil	Died in 3 hours.
3	Turpentine	100	1	1 female	1	1	1	

TABLE No. VI.

Third Series of Fumigation Experiments.

In this series the fumigants were left for 10 days in sealed tubes to concentrate the vapours. After addition of phlebotomi the tubes were placed vertically, the fumigant in the tube below.

No. of experiment.	INSECTICIDE.			NUMBER OF PHLEBOTOMI IN TUBE.			Remarks.
	Name	Percentage strength of	Amount used in ccs.	Before starting experiment.	Alive after 15 minutes.	Alive after 1 hour.	
1	Cresol	100	1	2 females 3 males	5	Nil	
2	Formalin	40	1	5 females 2 males	Nil	Nil	
3	Turpentine	100	1	3 females 4 males	5	2	

TABLE No. VII.

Fourth Series of Fumigation Experiments.

In this series of experiments both of the cotton wool plugs were moistened with water to render the atmosphere in the tubes as humid as possible. Fumigant tube above - fly tube below.

No. of experiment.	INSECTICIDE.			NUMBER OF PHLEBOTOMI IN TUBES.					Remarks.
	Name	Percentage strength of	Amount used in ccs.	Before starting experiment	Alive after 30 minutes	Alive after 1 hour	Alive after 2½ hours	Alive after 9 hours.	
1	Cresol	100	1	2 males 2 females	All	All	All	All	
2	Formalin	40	1	2 males 2 females	All affected	1 male 2 females	Nil	-	All died in 2¼ hours.
3	Turpentine	100	1	2 males 2 females	2 females	2 females	Nil	-	All died in 1¼ hours.
4	Turpentine	100	1	1 male 2 females	All affected	Nil	-	-	

II. PREVENTION OF BITING.

II. (a). REMOVAL OF HIDING PLACES IN SLEEPING QUARTERS.

After the nightly invasion by the phlebotomi those flies which remained in the hut nearly all collected into one of the following places :-

(1) The four corners especially at the roof level;
(2) The men's kits on shelves above the beds;
(3) Any cobwebs formed in the angle between roof and wall;
(4) Behind any big lockers;
(5) the angle between ceiling and supporting iron girders.

the above list has been arranged in the order in which most flies were usually to be found - by far the larger proportion occurring in situations (1) and (2).

On several occasions counts of whole huts were made to determine the proportion of phlebotomi which occurred at the corners compared with the sides. During these counts the kits on the shelves were vigorously disturbed and in nearly every case were found to be harbouring two or three phlebotomi. These observations shewed that roughly 50 per cent of the flies congregated in the corners of the hut when the kits were left on the shelves. (Table No. VIII).

TABLE No. VIII.

No. of experiment.	Date	Hut	PHLEBOTMI.				
			Total No. in Hut.	No. at four corners	No. at sides	percentage at four corners	percentage at sides.
1	4.6.22.	C2	143	71	72	50	50
2	4.6.22.	B2	51	32	19	62	38
3	5.6.22.	D4	11	5	6	45	55
4	5.6.22.	D4	6	3	3	50	50
5	16.7.22.	A4	138	64	73	46	54
6	14.8.22.	C2	198	76	122	38	62
7	14.8.22.	C2	157	74	83	47	53
Average of Seven Experiments.			100	46	54	46	54

To test the effect of removing the kit permission was obtained to have the shelves in Hut A4 cleared, the extra kit of each man being packed into a sound kit-bag.

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The result of this measure was that most (83 per cent) of the phlebotomi in the hut congregated in the corners, (See Table No. IX).

TABLE No. IX.

No. of experi-ment.	Date.	PHLEBOTOMI.					Remark
		Total No. in hut.	No. at four corners	No. at sides.	Percentage at four corners.	Percentage at sides.	
1	30.7.22.	60	51	9	85	15	
2	31.7.22.	147	121	26	83	17	
3	1.8.22.	138	104	33	76	24	
4	2.8.22.	158	126	32	80	20	
5	3.8.22.	137	110	27	80	20	19 of t 27 in o cobweb.
6	5.8.22.	170	153	17	90	10	
7	10.8.22.	158	131	27	83	17	
8	12.8.22.	103	91	12	88	12	
Average of 8 experiments		134	111	23	83	17	

Cobwebs acted in a similar manner to the kits, affording both a hiding place and a certain amount of protecti to the phlebotomi from air currents, natural or artificial. Phlebotomi did not become entangled in these webs and were abl to move out of them at will, nor did the spiders seem to notic or resent, their presence.

Frequently examples were seen of the shelter given t these flies by cobwebs. Thus on the 27th July, 1922, whilst carrying out experiments with electric fans, the artificial ai currents created drove the phlebotomi out of the hut, first of all by reducing their numbers in the corners of the hut. In fact, all the corners shortly were freed from the flies, excep one which had a large cobweb. This cobweb was gently broken down in order to disturb the flies as little as possible. The phlebotomi remained for some little time in the vicinity of t web shewing that it was not the act of breaking that frightene them away, but now exposed to the full action of the air curre they departed (See Chart No. 5).

It was therefore evident that cobwebs could and did act as a shelter for phlebotomi and their removal was followed by an immediate decrease in the numbers of flies in the area concerned.

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At any time during the day it was possible to dislodge a varying number of flies from behind the big lockers which were placed in some of the huts and in the evening the flies were often observed hopping up the wall from behind the lockers and taking refuge in the corners at the roof level. It was nearly always in those corners in which there were lockers that the largest number of flies were counted. (See Table No. X).

TABLE No. X.

Table shewing how phlebotomi congregate in the corners of huts, especially those occupied by large lockers.

OBSERVATIONS TAKEN FROM HUT A4 FOR A PERIOD OF A WEEK.

Date	No. of Phlebotomi.		Percentage of Phlebotomi.	
	In corners with lockers	In corners without lockers.	In corners with lockers	In corners without lockers.
30.7.22.	27	9	75	25
31.7.22.	78	33	70	30
1.8.22.	41	30	57.8	42.2
2.8.22.	51	42	54.9	45.1
3.8.22.	63	36	63.7	36.3
4.8.22.	81	31	72.4	27.6
5.8.22.	45	28	60.7	39.3
Average of 7 readings	55	30	64.9	35.1

II. (b) NETS.

The use of nets had usually been discountenanced on the grounds that material of sufficiently fine mesh to exclude phlebotomo was too oppressive to sleep under in the hot weather. In spite of this experiments were undertaken to ascertain the best type of cotton netting to protect man from the bites of phlebotomi. In order to test the size of cotton mesh through which phlebotomi could work their way test tubes, and glass jars (6 inches diameter) were loaded with known numbers of the flies and covered with nettings of various meshes with the results shewn in Table No. XI.

T A B L E No. XI.

No. of experi-ment.	No. of meshes to the square inch. (a)	NUMBER OF PHLEBOTOMI (FEMALES) at beginning of experiment	retained by netting after 24 hours.
1	33/34	12	0
2	34/35	12	0
3	35	12	0
4	36/37	12	0
5	39/40	12	0
6	40/41	12	0
7	41/42	12	1
8	42/43	12	4
9	43	12	3
10	44	12	10
11	47/48	12	12
12	53/54	12	12
14	54/55	12	12
14	63/64	12	12

(a) Measurements were taken in two directions; horizontal along the warp and obliquely down the way of the bobbi The corner hole was counted twice. This is the metho adopted in the Net Trade.

During the initial experiments males were observed to escape through the netting more readily than females, and it has been shewn that males never bite man all the experimen recorded above were carried out with female phlebotomi. The species of phlebotomus used was papatasii. From a considera of these experiments it was concluded that a cotton net of 45 meshes to the square inch was sufficiently fine to prevent phlebotomus papatasi from biting man. It should be remember that in these experiments the flies had to struggle to escape from imprisonment and the efforts made to penetrate the netti would be greater than those made to enter a net for the purpo of feeding on man. Probably in the latter case the fly woul seek an easier prey.

The authors slept throughout the phlebotomus season under netting of 54/55 meshes per square inch. The nets wer carefully tucked in before sunset and examined daily for phlebotomi. There was no evidence of bites nor could any phlebotomi be found in the net - a phlebotomus which had rece partaken of a feed of blood could not escape through a net of 40 meshes to the square inch. Similar nets were used in the sick quarters, the remainder were issued to some of the men,

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The men were most anxious to have these nets once they had experienced the protection afforded against these insects. In fact many of the patients in the sick quarters preferred to sleep under them during the day rather than be disturbed by house flies.

There was no doubt that nets when properly used and kept in repair gave the maximum of protection.

II. (c). REPELLENTS.

Numerous aromatic substances have been recommended for the purpose of smearing on the exposed parts of the body to repel phlebotomi and incidentally various other biting insects.

Before any experiments were done a striking example of the value of repellents was observed. An aircraftsman who had volunteered to be bitten by phlebotomi came to the laboratory after his work which had consisted of cleaning an engine with paraffin. His arm was introduced into a cage containing some 200 phlebotomi. , Before the arm was put in, the walls and roof of the cage were covered with the flies; immediately after there was not a fly to be seen. All had disappeared as if by magic into the loose stones and earth on the floor of the cage. So long as the limb remained in the cage, no flies could be seen. After an interval of ten minutes, the arm which had been thoroughly washed in the meantime, was re-introduced and the flies fed from it readily. Experiments carried out on similar lines with other volunteers gave corresponding results, as long as three hours after the smearing on of paraffin. Many of the phlebotomi appeared to be stupified by the fumes.

The substances tested as repellents were :-

1. Paraffin.
2. Camphor.
3. Thymol.
4. Linseed oil.
5. Peppermint oil.
6. Pennyroyal.

The experiments were performed in test tubes which were broken at the bottom end. The substance to be tested was placed on in the case of solids, or if a fluid soaked up by a cotton wool plug and thus introduced into one end of the test tube. Several phlebotomi were introduced by the open end of the tube which was then plugged with cotton wool. Thereafter the tube was placed vertically, first of all with the test substance in the lower part of the tube, and later reversed so that the test substance was in the uppermost part. The movements of the flies were noted at different times. Phlebotomi, always in the case of the male, and usually in the case of a not recently fed or pregnant female, after flying up and down the tube for a short time will settle in the highest part of the tube. With nearly all the substances which were tried the flies remained as far away from the test substance as they could in whatever position the tube was placed. At times, however, the movements of the flies were very erratic and in consequence the results were often difficult to interpret. (Figure No. 2).

Pennyroyal has locally a considerable reputation as a repellent. The Maltese bind bunches of the plant to the head of their beds to keep phlebotomi from biting. Several

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of the aircraftsmen tried this method, but all were certain that they were bitten despite the plant.

That Pennyroyal had a definite action on the fly was shown by the following experiment. A little of the crushed plant was put in the bottom of a test tube and one fly, a female, introduced. The fly was shaken to the bottom of the tube where it remained apparently stupified. After four minutes it was lying on its side giving a few convulsive movements. It was then shaken to the top of the tube and the plug removed. In three minutes during one of the convulsive movements it jerked itself out of the tube. It now lay on the bench, four minutes later it stood up but coul not fly. Complete recovery occurred after another fifteen minutes. In other experiments of a similar nature but using an infusion of Pennyroyal several of the flies were killed.

It was extremely difficult to judge the value of the various substances tried, but the opinion was formed that paraffin and camphor were the most efficacious.

II. (d). AIR CURRENTS.

(i) THE EFFECTS OF NATURAL AIR-CURRENTS.

The effect of natural wind currents on the occurren of phlebotomi has been noted by many workers. As isolated observations are valueless a definite system of observations was established at Calafrana, Malta, in May, 1922, and contin for six months from that date, that is throughout the phlebot season. The results showed a definite relationship between force of the wind and the number of flies found indoors; rou speaking, the flies were present in inverse proportion to the force of the wind. A force-four (Beaufort) wind, blowing fo two or three consecutive days, cleared the phlebotomi from th huts on the windward side of the camp - while in those to the leeward there was a considerable reduction. This reduction most evident in the upper storeys of the buildings, due in p to the lesser number of phlebotomi which gained access to the higher floors at all times, and in part to the more free circ tion of wind currents. The relatively small number of phleb found at any time in the upper storeys, was proved by countin daily the actual number of flies in each hut and confirmed by the few cases of phlebotomus fever which occurred amongst the men sleeping in such places. (Charts Nos. 6 and 7, Tables N XII and XIII). The flies bred and hatched out at the ground level and therefore had to mount to the higher, better venti levels to invade them. Such delicate light flies preferred calmer air of the lower floors.

A good illustration of the effect of air currents on phlebotomi was obtained in the huts inhabited by the Malte airmen. On alternate week-ends the port and starboard watch got 36 hours leave. Their huts, as a precaution against the had the doors and windows closed. This lack of ventilation caused a bottling up of the human odours emanating from vario articles of clothing bedding left in the hut. These odours attracted the phlebotomi which entered by means of wall-venti and chinks created by ill-fitting windows and doors. The fl were watched collecting here over a period of 36 hours, and w the windows at one end of the hut were opened most of them gradually moved to the sheltered end of the building. This process was repeatedly observed in these huts. Moreover, in any hut, the majority of the flies was always found in the most secluded corners, depending on the direction of the wind.

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TABLE No. XII.

TABLE SHEWING THE PERCENTAGE OF CASES OF PHLEBOTOMUS FEVER OCCURRING IN UPSTAIRS AND GROUND FLOOR HUTS.

(Incidence of the fever in the total personnel).

GROUNDFLOOR HUTS.					UPSTAIRS HUTS.				
No. of Hut.	No. of cases of Phlebotomus fever.	No. of men in Hut.	Percentage of men infected with Phlebotomus fever.	No. of cases of Phlebotomus fever which relapsed.	No. of Hut.	No. of cases of Phlebotomus fever.	No. of men in Hut.	Percentage of men infected with Phlebotomus fever.	No. of cases of Phlebotomus fever which relapsed.
A4	8	18	44.4	1	A3	3	8	37.5	0
B2	3	18	16.6	1	B1	3	15	20.0	0
B4	12	19	63.1	5	B3	0	15	0	0
TOTAL	23	55	41.8	7	TOTAL	6	38	15.9	0

Note the higher percentage of fever cases which occurred in the ground floor huts.

TABLE No. XIII.

TABLE SHEWING THE PERCENTAGE OF CASES OF PHLEBOTOMUS FEVER OCCURRING IN UPSTAIRS AND GROUND FLOOR HUTS.

(Incidence of the fever in newcomers).

DOWNSTAIRS HUTS.					UPSTAIRS HUTS.				
No. of Hut.	No. of cases	No. of New-comers	Percentage of newcomers infected.	Relapse.	No. of hut	No. of cases	No. of new-comers.	Percentage of newcomers infected.	Relapse.
A4	6	8	75	1	A3	3	6	50	0
B2	3	7	42.8	1	B1	3	14	21.4	0
B4	12	12	100	5	B3	0	8	0	0
TOTAL:	21	27	77.7	7	TOTAL:	6	28	21.4	0

Note the higher percentage of fever cases which occurred in the ground floor huts.

These observations suggested that the spacing out of buildings to gain the full advantage of natural air-currents would reduce the phlebotomus and fever incidence considerably. It was not practicable to suggest removal of any of the recently erected permanent buildings; as an alternative the creation of artificial air-currents by means of electric fans was tried; the results were most encouraging.

Here was, at least a partial solution of the problem - free ventilation, to make the most of the natural movements of the air; supplemented by artificial air-currents in the lower part of the room to repel the invaders and render the act of biting man a difficult one, and in the upper part to deprive them of their resting and pairing haunts. In order to obtain some practical information regarding the value of artificial air-currents and the minimum expenditure necessary for a satisfactory result certain electric fans were provided; two large overhead fans to act chiefly on the lower parts and four small oscillating desk fans for the upper parts of the room.

(ii). THE PRODUCTION OF ARTIFICIAL AIR-CURRENTS BY MEANS OF ELECTRIC FANS.

It was not until 26th July, 1922, that the electric fan experiments were started. Every inhabited hut in the camp had at that date been under a detailed observation for 66 consecutive days. By this time sufficient data had been collected to account for various minor fluctuations in the invasions of the huts by the phlebotomi. The chief error that was likely to occur was a reduction in the number of flies through a strong wind blowing. Fortunately, throughout the period of these experiments (26th July, 1922 to 10th August, 1922) there was either a dead calm or at most a wind-force of 1, except on the last day of the first set of small fan experiments (Chart No. 9A) when for part of that day the wind-force was 4. However, the experiment was repeated at a ;ater date (Chart No. 9C) and calm weather prevailed throughout. The results of these two series of experiments coincided.

Other factors which were liable to affect the fly incidence were the atmospheric, earth and water temperatures, and the atmospheric humidity; these were fairly constant and corresponded closely with those prevailing during the three previous weeks. The mean daily temperature varied from 76° - 83°F. This range had been shown by various observers to be favourable for the development of the phlebotomus and was confirmed by experiments at Calafrana. Throughout the experiments the earth (4 feet tube) and water temperatures were 74°F. and 76°F. respectively. The humidity varied daily from 40 to 90 per cent.

Description of Hut A4.

Hut A4, was chosen for the fan experiments as it was definitely the most heavily infested hut in the camp and was situated nearer to the natural breeding grounds of the phlebotomi than any of the others.

It was situated at the North-eastern corner of the camp, the ends facing almost due north and south built of Maltese stone with a wooden roof and a concrete floor. It consisted of two storeys. The lower one known as Hut A4, the upper storey as Hut A3. The latter was reached by an outside staircase situated on the North end of the building. Hut A4 was entered by two doors, one situated at each end of the building.

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The dimensions of the hut were as follows :-

Length 61 feet Width 20 feet Height 11 feet	Floor space 1220 square feet	Cubic space 13,420 cubic feet.

In each side-wall there were six windows 5 feet in height and 3½ feet wide. The distance from the floor to the lowerledge of the window was about 3 feet. Between the windows were small ventilators 9 inches by 6 inches in size. Two ventilators were 3 feet above the floor level and three 6 inches from the ceiling level. Similarly in each end wall there was one high ventilator and one low one. There were two further low ventilators in opposite corners of the hut. On the side walls between the windows, about seven feet up, there was a narrow shelf on which lay the folded-up kits. Below this was a row of coat hangers.

Each man had a kit box and a kit bag. At the end of the hut were three large lockers in the position shown in the diagram (Chart 8). It will be noted that during the experiments one of these was removed.

The particulars regarding the fans used for the experiments in the hut were :

	SMALL FANS.	LARGE FANS.
Type of fan.	Oscillating desk-fan swinging through angle of 180°.	Punkah ceiling fan.
Number of blades.	4	3
Overall diameter of blades.	18 inches.	54 inches.
Revolutions at top speed.	1000 per minute.	220 per minute.
Position of fans in room.	Supported on wooden brackets 3 feet from ceiling. One in each corner of the room.	Hung from roof 3 feet from ceiling and 8 feet from floor. The two fans divided the length of ceiling into thirds.
Number of fans used.	4	2
Plane of rotation of fans.	Vertical.	Horizontal.

Estimation of air-current produced by the fans.

The air-currents produced by the small and large fans were tested separately. To eliminate natural air-currents the doors and windows were closed and after an interval of fifteen minutes to allow the air to settle, the fans were set in motion at top speed. A piece of cotton thread with a small piece of cotton wool at its free

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end was suspended in the air at various parts of the hut to act as an anemometer. The air-currents were recorded for each area by noting the angle to which the cotton thread was deviated from the perpendicular; the angle of deviation in degrees gave the comparative force figure, for example an angle of 45 degrees gave a comparative force figure of 45. One series of readings was taken one foot below the ceiling level (where most phlebotomi congregated) and another three feet above the floor level at the head end of each bed (plane at which most of the bites occurred). Chart No. 8 was drawn up from the results thus obtained.

It was found in the case of the small fans that the air-currents produced one foot below the ceiling level were strong up to 10 feet from each corner giving a comparative force figure (C.F.F.) of 80, moderately strong between 10 and 20 feet from each corner (C.F.F.45). While at the central portion of the long walls of the hut, 30 feet from either end the air-current was relatively small (C.F.F.15). At the bed level (3 feet off the ground) and at the head end of bed the air-currents were much weaker; the readings at 10, 20 and 30 feet from each end of the hut giving a C.F.F. of 15, 10 and 5 respectively, or roughly ¼ of those at the corresponding positions in the upper part of the room.

As regards the large ceiling fans, one fan with aluminium blades worked much more efficiently than the one with wooden blades. However, the general results coincided in both cases, the difference being purely one of degree. The figures given by the more effective of the two large fans were accepted as correct as the other fan had a mechanical defect due to damage received in transit to Malta. Their effectiveness at ceiling level was almost nil, being greatest (C.F.F.15) on the portion of the walls opposite the point of their insertion into the roof. At the bed level they were considerably more effective giving a comparative force figure of 45 at the head end of the beds opposite their point of insertion into the ceiling, a figure of 30 ten feet further down the room in either direction and 20 at the ends of the room.

In short, the small corner fans acted efficiently in the upper part of the room, but less so in the middle and lower regions, whereas the large ceiling fans were effective where the smaller ones failed relatively. The correctness of these observations was born out by the results of the experiments with these fans on the movements and dispersal of phlebotomi from the same hut. (Chart No. 9).

(1) <u>Estimation of the number of phlebotomi in the hut</u>.

Practically all the phlebotomi in the hut gathered on the walls or their fixtures and hangings. In order to simplify the counting the walls were divided into areas, the delimiting mark of these areas being the centre of each window; in this way there were five areas in each long wall, a central area over the doorway in each short wall and four corner areas.

In order to minimise error as much as possible throughout the experiments all counting in the hut was done by one observer at definite hours and exactly the same routine was observed at each count. The routine adopted was to count the phlebotomi in each of the areas mentioned above, commencing at the foot of the wall and then by means of a ladder counting those at the higher levels. The ladder was used in each area and was found to be absolutely necessary in order to get near enough to distinguish the phlebotomi from other insects and also to determine the sex. So long as no undue movements

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of air were created the flies did not seem to mind how near the observer was to them but they were readily disturbed by such actions as the slamming of a door, although they rarely moved far from their original position.

Any kits on shelves or hanging on hooks were shaken and a short time allowed for any phlebotomi which had flown or hopped out of them to settle down. As it was found that large numbers of the flies sheltered in the kits which were folded up on a shelf above the beds and also in any clothes and equipment which were hanging up, arrangements were made to have all the kits removed. This lightened the task of counting the flies as they were much more easily picked up on the blank wall. Some difficulty arose when large numbers occurred in one corner, as was often the case, owing to movements among the flies. Unless disturbed, however, the majority kept quite still and it was only when twenty or more were clustered together that any error was likely to arise and even when the number greatly exceeded this the error must have been very small.

The flies were undoubtedly more difficult to count as the evening wore on owing to increased liveliness, while during the day they were often distinctly sluggish.

Actual fan experiments.

A. Small fans. i. (Chart No. 9, Column A).

The series of experiments was commenced with the smaller fans which were started, at top speed, on the 26th July, at 10.30 a.m. The total number of phlebotomi was counted just before the experiment and 138 flies, consisting of 76 females and 62 males, were found in the hut. There were rather more flies on the side walls than at the corners.

The fans were kept running continuously for 82 hours.

The result was a fairly constant diminution of the total number of flies in the hut. This diminution was seen first to affect chiefly the flies in the four corners of the hut, the number being reduced to less than half after the fans had been running one hour. (See Chart No. 9, Column A) No further reduction was shown at the ends in the next two readings, at 5 and 9 hours after the commencement. There was, however, a gradual decrease in the numbers at the sides due largely to the fact that the flies were driven out of their hiding places in the kits during the first count and so exposed to the action of the fans.

At the ends of the hut the constant count resulted mainly from the fact that flies which had gathered in the corners behind the fan were safe so long as they remained there. In these corners they were held prisoners and many gradually died as proved by the finding of their dead bodies on the wooden brackets supporting the fans. In another area outside the actual corner, a cobweb gave shelter to several phlebotomi, when the web was gently broken down the homeless flies were soon dispersed.

About/

About midday on the 28th July, all the kits and equipment were removed from the shelves and hangers and were stowed away in kit-bags. After this procedure the number of phlebotomi found on the side walls was always small, except in a few cases where a cobweb had formed and the flies had taken refuge therein.

The dry and wet bulb readings in the hut just prior to commencing were 81°F. and 69.5°F. respectively - the wind was south-west and about force 1. The fans shewed little or mo effect on the humidity of the atmosphere in the hut.

After 82 hours continuous running the hut was very thoroughly searched but only five flies could be found.

(B). Reaccumulation of flies (Chart No. 9, Column B).

An analysis of Chart No. 9, Column B. demonstrated two points regarding the reaccumulation of flies. Firstly it showed the decrease which occurred during daylight as a résult of some of the fed flies leaving the hut to go to the breeding-places. Secondly, it showed the value of removing all the kit, etc. from the walls. When the kit was on the shelves or hung up, roughly 50 per cent of the total flies in the hut were on the side walls - after the removal of the kit the percentage rarely rose above 25.

(C). Large Fans. (Chart No. 9, Column C).

The large fans were started at 10.30 a.m. on the 3rd August, and were run continuously for 48 hours. During this period they failed to produce any reduction in the total number of phlebotomi, in fact, the number gradually increased, especially at the ends. Despite this fact the men sleeping in the hut were definitely of the opinion that they were less worried by the flies while these fans were working than when the smaller fans were in action.

(D). Small Fans. ii. (Chart No. 9, Column D).

The small fans were started again at 10.30 a.m. on the 5th August, and the reduction in numbers which occurred coincided very closely with that obtained in the first experiment. After 72 hours continuous running the number of the flies had been reduced from 170 to 18.

As previously stated, the meteorological conditions were very constant during this experiment, in particular the windforce was rarely above force 1.

From a consideration of the above experiments and of the effect of natural winds on phlebotomi it was evident that, if properly used, electric fans afforded an excellent means of protection from the bites of these flies.

S U M M A R Y.

I. WAR ON THE INSECT IN ITS VARIOUS STAGES.

A. Abolition of the breeding grounds.

The levelling and rendering impervious the surface of the ground, and the facing and pointing of walls and buildings materially reduced the number of phlebotomi in the camp. These measures were only carried out for a distance of 15 yards beyond the huts, had this distance been extended to 50 yards the reduction in the flies would have been greater. That this further reduction would have occurred was evident from the fact that in one part of the camp flies collected despite these prophylactic measures and a survey of the ground around shewed a phlebotomus haunt about 20 yards from the huts, this was treated and the fly incidence dropped immediately.

B. Destruction of the adult fly.

(1) Swatting at the phlebotomi which gathered in the corners of each hut was a very satisfactory method of killing large numbers of these flies. Even when the kits were allowed to remain on the shelves fifty per cent of the total number of flies in a hut foregathered in the corners, and were easily killed.

(2) Spraying by means of such an instrument as a Meyer's knapsack sprayer was a very efficient means of dealing with these flies. A one percent solution of cresol acted best. This prophylactic measure had the advantage of acting against other pests such as fleas, house flies and even bed bugs.

(3) Fumigation on a large scale had little effect on the phlebotomus.

II. PREVENTION OF BITING.

(a) Removal of hiding places in sleeping quarters.

Kits, cobwebs and large articles of furniture that could not be easily kept clean gave protection to phlebotomi. Their removal reduced the number of phlebotomi in the huts and made the other prophylactic measures more easy to carry out.

(b) Cotton-net of at least 45 meshes to the square inch had to be used to attain proper protection.

(c) Repellents aided to a certain extent. Paraffin or camphor were the best.

(d) Air-currents had a marked affect on phlebotomi as was shewn by the great decreases in the number of flies whenever a strong wind was blowing and also by the few flies found in the upper storeys of buildings. As regards electric fans the small fans produced the strongest currents and gave apparently the best results. This type of fan acted chiefly in the

upper/

upper part of the hut and prevented the flies from settling there after they had had a blood-feed on the men below. There was no evidence to show that the flies did not enter the hut, bite man and depart as they had come. In fact, several of the men affirmed that they were bitten despite these small fans. Had the small fans been mounted three or four feet above the floor level it would have been difficul if not impossible, for the flies to bite the occupants of the hut. However, the small fan experiment proved definitely that such fans could prevent phlebotomi from collecting in a room provided the walls were kept clear of hangings. On the other hand the large fans prevented the flies, to a certain extent, from biting the men but failed to stop them entering, leaving or collecting in the hut.

RECOMMENDATION FOR A CAMPAIGN AGAINST THE PHLEBOTOMUS.

From a survey of the foregoing experiments it is possible to make certain recommendations for a campaign against the phlebotomus. No one measure can be hoped to produce complete eradication - each is dependent to a certain extent on some other and to attain success as many measures as possible should be brought into use. It cannot be too strongly emphasized that the campaign is an even more arduous one than that which is being waged against the mosquito, the breeding places of phlebotomi are as numerous and more difficult to treat, while the smaller size of the insect adds greatly to the difficulty.

No campaign will succeed unless the directing officer gives his very careful personal attention to all details and had behind him the support and assistance of the other branches of the service. Half-hearted measures will inevitably end in failure.

Further, there is evidence that other pests such as lice, bed bugs or mosquitoes may in some circumstances act as vectors of phlebotomus fever. Hence in conjunction with the campaign against the phlebotomus, measures must be taken to deal with these other creeping and winged pests.

The ideal of sanitary efficiency must be the highest and kept continuously in front of every member of the Royal Air Force, in tropical or subtropical climates.

The hope of success will depend largely on the situation and local conditions of the Station in question. It is quite realised that the Air Force Station at Calafrana is an ideal place for a campaign against the phlebotomus, owing to its comparatively isolated position, and to the fact that it is bounded by the sea on three sides. In other places certain of the measures recommended will be impracticable or useless, but some of the measures such as the use of electric fans or punkahs, swatting and spraying will be of great value anywhere. Further researches by Medical Officers in the areas concerned, on lines similar to those detailed above, are necessary to attain the maximum of success.

(1) WAR ON THE INSECT IN ITS VARIOUS STAGES.

(A) ABOLITION OF BREEDING GROUNDS.

Certain facts have emerged from the study of the life history of the phlebotomus regarding the conditions necessary for its successful breeding; briefly, the requirements are :-

(1) organic matter,
(2) a certain amount of moisture,
(3) a definite range of temperature.

Of these factors the first can be influenced most, the second is more difficult, while the third is almost impossible for man to vary.

The object ito be aimed at is to eradicate all breeding places for as large an area in and around the camp, as is practicable. Every inch of the ground in this area must be treated.

<u>Treatment of the ground in the camp area.</u>

(a) Broken ground.

The ground surface should first of all be levelled - no areas of waste land should be permitted to remain within 30 yards of any dwelling. The surface should, wherever possible, be made up with small stones or road metal which should be rolled in with a heavy roller. Places inaccessible to the roller, especially the junction of buildings and walls with the ground surface, should be thoroughly rammed in by hand. In those places where the surface is of sand some other method of consolidation must be used which will depend on the local conditions.

After the surface has been made level, some dressing must be applied to render it impervious and prevent crumbling. This dressing will vary with the character of the soil, the cost in the locality, and the means of application. The commoner dressings are concrete, tar or some crude oil.

Concrete is undoubtedly the best dressing so far as eradication of phlebotomi is concerned. At Calafrana a large area is already concreted and should, if possible, be extended to include the whole of the camp. If this were done the camp could be hosed down daily with sea water thus removing dust and organic debris. There are undoubtedly certain disadvantages in connection with the use of this material. The initial cost ois great, but considering that repairs are only necessary at long intervals there is ultimate economy. It tends to reflect heat and the glare from its surface is injurious to the eye and leads sooner or later to impairment of vision with consequent liability to faulty landings. This element of glare could be partly remedied by the use of green or black concrete. Despite these drawbacks concrete is undoubtedly the best surface dressing for a station such as Calafrana.

Tar makes an excellent dressing and would probably be more suitable for sandy soils. It is also cheaper than cement, but it does not last so long and would require to be resprayed at yearly intervals. The cost of tarring at Calafrana worked out approximately at 1½d per square yard - this being the total inclusive cost. The objection has been raised that during the hot weather the surface would become sticky; at Calafrana during the hottest weather experienced this was not found to be the case; the tar sinks into and binds together the porous soil. Like cement it reflects the heat, but the black colour is more restful to the eye.

Crude oil and waste engine oil could be used in temporary stations. In such a station as Calafrana there are 10 gallons of waste enginê-oil each week. This could be sprayed over the ground from watering cans and if properly done would be quite effective. It would, however, have to be done frequently, and is not suitable for a permanent camp, except as a dressing to apply to waste areas beyond the zone of active treatment. This spraying tends to kill off larvae and pupae, and should be done weekly.

Apart/

Apart from lessening the incidence of the phlebotomus, the above measures will help to keep down dust and dust-borne diseases.

(b) Prevention of breeding in walls and embankments.

Loose stone walls should be demolished in the camp area and in the case of boundary walls should be replaced by iron or wire fencing, or by a properly constructed stone wall.

Old stone walls, which cannot be removed, shoul be repaired and pointed, and tarred in their lower three

Loose banks should be faced with stones, pointe and tarred. If the embankments are of such a size that foregoing recommendation is impossible, they should be built up with stones and the interstices filled with eart rammed tightly home. In an endeavour to prevent phlebot from breeding in such a bank, pennyroyal or thyme, both o which act as repellents to these insects, should be thick planted thereon, or the surface should be sprayed weekly with waste engine oil.

(c) Construction and maintenance of buildings.

Walls of buildings should be properly faced and all cracks filled up with cement. To preserve the stone the lower 3 feet of the wall should be tarred. The mone spent in procuring the better quality Maltese stone and by using a good wearing cement amply repays itself, both as regards the life of the building and the health of the personnel. This statement is borne out by a critical examination of the present conditions of two types of buildings, situated practically side by side at Calafrana The Admiralty Torpedo Works, erected 18 years ago, presen an unbroken surface, the cement being as good as new. On the other hand the barracks of the Royal Air Force, built during the last two years have already begun to crack badly, the cement dropping away in large pieces and the face of the stones flaking off leaving innumerable hiding places for insects.

The frames of windows and doors should fit accurately and any crevices due to such conditions as warping of the frames should be immediately repaired. Private individuals may attain a considerably degree of protection by covering the open windows with butter musli of 20 or more meshes to the inch; this material should be carefully tacked to the window frame.

All ventilators of buildings should be accessib and of large size; their corners should be as few as possible and rounded off to prevent accumulation of dist and dirt. They should be cleaned daily and have their sides frequently rubbed with a rag moistened with paraffi The frames and fly-proof netting of ventilators must be kept in good repair.

Openings in walls for the ingress or degress of pipes should have careful attention. Should a certain amount of space be required to allow for expansion of the pipe the orifice left should be guarded with finely meshe netting. It would be an advantage to conduct pipes through a ventilator so as to have room to clean the spac left around them.

Where,

Where possible the roofs of buildings should be of stone. Wooden roofs gradually gather moisture, partly by leakage of water through the canvas or other material used to cover them, and partly by absorption of the condensation moisture which gathers on their inner surface. The amount of moisture absorbed in Scirroco weather is considerable. Dust lodges in the inter-spaces between the planks forming the roof and with the moisture provide the necessary conditions for the breeding of the phlebotomi and bed-bugs. These insects gradually find a home in the stone work, especially in crevices between the stones forming the walls. Gales, which are of frequent occurrence in Malta, exert considerable pressure on these wooden roofs and their supporting joists; the cement binding together the stones in the vicinity of these joists breaks away and by a vicious circle the building deteriorates. The use of temporary wooden roofs is much to be deprecated.

Knowing the amount of moisture necessary for the development of the phlebotomus in its various stages, proper provision should be made for the disposal of all waste water, rain and dew. Eaves-gutters should be fitted where required to prevent water dripping to the ground adjoining the house walls. Further, as numerous phlebotomi are found to breed in the ground in the immediate vicinity of buildings, it is necessary to carry a cement channel all around the foot of each building to collect condensation and other waters. These channels should be properly aligned, kept clear and discharge into a well constructed drain. The habit of throwing waste water on the ground to percolate away should be strictly forbidden.

All woodwork, walls and ceilings of buildings should be painted, distempered, tarred or whitewashed yearly, preferably at the end of the rainy season (April to May in Malta). These measures preserve the surfaces treated and tend to kill off any eggs or other forms of insect life infesting them.

It cannot be too strongly emphasized that gardens in the immediate vicinity of buildings, in tropical and sub-tropical climates, should not be permitted from a sanitary point of view. The daily watering of this manured soil provides the moisture necessary for the breeding of the phlebotomus, while the foliage gives shelter to innumerable pests. Creepers on the walls of buildings should be strongly condemned - they are injurious to the soft limestone forming the walls, and aid midgets and mosquitoes to reach the upper storeys.

The keeping of fowls or similar animals within the area of the camp should not be permitted. Fowl runs, formed of soft ground containing much organic material and repeatedly moistened are ideal breeding places for phlebotomi, especially as these insects feed on the blood of fowls and other birds. As such animals are known to suffer from spirochaetal diseases they may possibly act as a reservoir for infection.

Until more is known of the limits of flight of the phlebotomus the area of the camp treated should be as extensive as possible. To this end every attempt should be made to get the parade grounds, playing fields, etc. adjoining the men's quarters, for by this means a large area of ground around the camp could be rendered unsuitable for the breeding of the phlebotomus. Moreover, air currents would have full play upon the camp.

Building/

Building operations and other works which disturb the surface of the ground should, if possible, be done in the cold weather, otherwise crannies are created in which all manner of insects will breed. Any breakage of the surface that does occur in the summer, should be sprinkled with crude oil and speedily closed up. The practice of commencing digging and building operations and then leaving the work for months before completion is strongly to be deprecated.

B. DESTRUCTION OF THE ADULT FLY.

It has been shewn that a war on the adult fly has every hope of success if carried out methodically and diligen

(i) Swatting, though a somewhat laborious method, is of undoubted value as a part of the campaign. By breaking the camp up into small areas, (e.g. Flights) each with a swatting party, the amount of individual labour will be considerably reduced. The method employed should be that outlined in the foregoing pages. Each swatting party should consist of two men supervised by an N.C.O. and should be provided with an 8 foot ladder and suitable material for making swatters. The swatting should be done daily during the hour prior to sunset. The Medical Officer in charge of the Station can easily keep a check on this work by means of surprise visits any neglected corners are detected immediately.

(ii) Spraying should be carried out at least twice weekly, by the party detailed to do the swatting; a one per cent solution of cresol is the best fluid for this purpose, and sh be applied by either the Meyer's knapsack or the Mackenzie's fly-spray. The spraying should be started in the corners of each room, first at the ground level and then working up the wall to the ceiling. Ventilators and all spaces behind the larger articles of furniture should be well treated, for many phlebotomi shelter in such situations. Daily treatment is to be recommended, if the cost can be defrayed, and in this case swatting could be dispensed with. In this connection it is necessary to bear in mind the lethal action that cresol spraying has on flies, fleas and insects in general.

II. PREVENTION OF BITING.

(a) The removal of hiding places of phlebotomi in sleeping quarters renders the disinfestation of any hut easier, for these insects deprived of other places of shelter gather in the corners of the room, where they can be swatted or sprayed readily.

The chief hiding places are in the kits, and behind cobwebs and large articles of furniture. In hot, moist and dusty climates it seems absurd to keep spare kit hanging about in the huts. This kit, being chiefly winter clothing is not worn for five or six consecutive months, and simply serves to harbour dust and moisture; the kit fades in colour and by its impregnation with organic matter from su sources as the sweat forms an ideal breeding site for all manner of insects.

All/

All spare kit should be packed in a properly labelled kit bag and handed in to a kit store until required; should this not be practicable, as in temporary camps, all kits should be shaken and dusted daily. The kit question is a difficult one; the continual display of kit, apparently considered necessary by the sister services, seems to outweigh any benefit to health that would be obtained by its removal.

All huts should be thoroughly cleaned daily - cobwebs removed, ventilators cleared, floors and especially corners and areas behind large articles of furniture washed. To aid the cleansing all large pieces of furniture should be raised about 4 to 6 inches off the floor on legs, and an air space left between the article and the wall. The addition of 0.5 to 1 per cent of cresol, or a little paraffin, to the cleansing water is to be recommended.

(b) Cotton nets of 45 or more meshes to the square inch give a considerable amount of protection against the bites of phlebotomi. The netting may be fastened to the frames of windows to keep these midges from entering the rooms, or erected over and around beds to give protection to the occupant. Unless these nets are kept in good repair and properly tucked in before sunset they will probably do more harm than good (photographs Nos. 13 and 14). All cases of phlebotomus fever should be compelled to sleep either under such nets or in a phlebotomus proof room, for although this insect has been shewn to inherit or become infected in its breeding haunts with the virus of the fever, passage from fly to man and vice versa is liable to exhalt the virulence of the disease.

(c) Repellents, such as paraffin or camphor, could be used as an additional protection against midges. Paraffin smeared over ventilators, bedsteads, and the lower corners of rooms aids in part by repelling, in part by killing the ova or larvae of any insects with which it comes in contact; spread lightly over the skin it is of considerable efficacy, but somewhat objectionable owing to its odour and greasy nature. Camphor may be used in bed either in a sachet placed under the pillow, or worn as an amulet around the neck.

(d) Air currents, natural and artificial, should be fully utilised. If possible, all sleeping quarters should be upstairs; in this manner the maximum effect of natural air currents is obtained. The advisability os this measure is shown by the relatively few phlebotomi and cases of fever occurring in the upstairs huts compared to those occurring on the ground floors (Chart Nos. 6 and 7). The ground floor rooms should be used for such purposes as recreation rooms, messes, canteens, wash houses, bath houses and kitchens.

The distance between huts should be as wide as possible, certainly wider than the height of the building; moreover, there should be space for the free circulation of air currents all round each hut. The partial or complete blockage of passages between huts by annexes should not be allowed. (Photograph No. 15).

It is recommended that a combination of the large and small types of electric fans should be used for large barrack rooms. This would entail the use of six fans, 4 small and 2 large, for a floor space of about 1000 square feet.

Electric fans are not a measure directed solely against phlebotomus fever. It should be remembered that the phlebotomus is not injurious only as a transmitter of that fever, but also by its irritating bites it causes considerable loss of sleep, septic spots and perhaps oriental sore. Fans greatly aid in lessening these disease conditions, and by repelling mosquitoes

decrease/

decrease the incidence of malaria; in addition, their use in assisting evaporation and so reducing heat-effects is well-known. Nevertheless, electric fans have certain drawbacks; their noise may interfere with sound sleep and the draught the set up may act injuriously on the chest or abdomen - for these and economical reasons the smaller the number of fans used in any room the better.

Although these considerations lead to the recommenda tion of the general use of fans overseas, it is realised, that however efficiently controlled, they will not absolutely preve man being bitten; they should be used in conjunction with the various other prophylactic measures detailed above.

It is difficult to draw up a definite scale of equipment of fans for all rooms without knowing the constructi and size of each. For instance, rooms on the second storey with a relatively better natural ventilation and consequently smaller number of flies will need fewer fans that ground-floor rooms. The easiest solution of the problem is to give figure for rooms of various sizes; the numbers given are those stron recommended for adoption by units serving in Irak, India, Palestine, Egypt and the Mediterranean.

Scale of electric fans recommended for R.A.F. dwelling rooms in tropical and subtropical climates.

Floor space of room in square feet.	No. of large ceiling fans (54 ins. span) required.	No. of small desk fans (18 ins. span) required.
1500	3	2
1000	2	2
500	1	1
less than 500	-	1

The position of the fans will have to be modified according to the room and its contents. Direct draught on to the body must be avoided.

In the case of a room of 1000 to 1500 square feet floor space the large fans should be placed so as to divide the ceiling into three or four equal parts, depending on wheth two or three fans are used. The blades of the fan should revolve at a height of ten to twelve feet above the floor leve this height gives the fans a good sweeping radius. The small type of fan should be erected as near as possible to the middl of each of the shorter walls of the room, either on a support three feet from the ceiling or three feet above the floor - this will bring the centre of each fan in one case two feet below the ceiling and in the other four feet above the floor level. Although time did not permit of actual experiments being made with the small fans erected four feet above the flo a consideration of the air-currents produced by these fans (Charts Nos. 8 and 10) shews that, if the fans were used at th level, flies would have great difficulty in entering and movin about in the lower parts of the building. If the flies in th upper parts of the room are efficiently dealt with by other prophylactic measures and due precautions taken to avoid direc draughts this undoubtedly would be the better position for the small fans.

For/

For rooms of 500 square feet floor space one large ceiling fan should be hung from the centre of the ceiling about ten feet above the floor. In addition, only one small fan is necessary and should be placed at one corner of the room in such a way that it will sweep the whole area of the room; this can be easily accomplished by a fan swinging through an gangle of 180°. The corner chosen for the fan should be one which will allow the fan to play directly on the window or windows during part of its swing; in this way phlebotomi will be hampered in their attempt to enter the room. (Chart No. 10.C).

Smaller rooms than the above, such as officers' bedrooms, should be provided with one small desk fan. This can be placed wherever desired. If supported on a table in one corner it can be made to sweep the whole area of the room as described above. The bed can be placed so as to get sufficient air-current without draught. (Chart No. 10.D.)

Fans will not be necessary in all buildings, for instance, large lofty workshops and stores will not require them. It is suggested that it would simplify matters if the provision of electric fans for overseas were dealt with under two separate headings :-

(1) Those issued according to establishment;
(2) Those required for special reasons.

1. A definite establishment of fans should be laid down for all sleeping rooms, messes, canteens, recreation rooms and kitchens. The fans should be issued according to the scale given above (p.37).

2. If it is considered that other buildings require fans they should be specially indented for; the indent to be supported by the recommendations of the Medical Officer and Commanding Officer of the Station.

As these fans would be provided purely for health reasons, the Medical Officer of the Station should inform the Commanding Officer when it would be necessary for the fans to be put in operation; such conditions as atmospheric temperature, humidity and fly incidence would guide him in his decision.

It is suggested, that as the switches of the fans may be tampered with, they should be enclosed under a locked cover, preferably a central one for the whole camp. The key of this cover should be in the charge of a N.C.O. who should be responsible to the Medical Officer for the proper use of the fans. The hours of operation of these fans will vary perhaps daily, in many instances their working will be required only between the hours of sunset and dawn.

The initial expense of providing the necessary fans will soon repay itself by the improved health of the personnel. Health means the maximum of working hours and better work which is true economy.

The wearing of suitable clothing after sunset aids in preventing many bites from phlebotomi. Shorts should not be worn after sundown; when sitting about in slacks it is advisable to fold them in at the ankles and pull the socks up on them. Another method would be the wearing of a short ankle puttie as worn with the Norwegian ski-ing costume. The Wellington type of mess boot for officers is a great protection during the evening. Pyjamas should be provided for all ranks.

Bathing/

Bathing should not be indulged in after sundown. Many people are bitten by phlebotomi whilst lingering about the shore after an evening bathe. There is adequate time during the day to bathe, in fact, bathing is much overdone at many places abroad and frequently predisposes to abdominal trouble.

It is suggested that the older residents, probably those who have already had the disease, should sleep in the corner beds; the new-comers occupying the beds towards the centre of the room. This measure is necessary as most of the phlebotomi foregather in the corners of rooms, a considerable percentage of the early cases of phlebotomus fever in a camp occur amongst men sleeping in the corner beds of huts, and new comers are less immune to the fever than older residents.

SUMMARY OF RECOMMENDATIONS.

To attain the best results concomitant with the minimum expenditure of labour and money, the prophylactic measures detailed above must be carefully planned and supervised. For the purpose of administration these measures come under two headings :-

(1) General (to be carried out by the unit as a whole).
(2) Personal (to be carried out by the individual).

(1) General measures are to be preferred as they are more fully under control; they should be carried out in part by the Works and Buildings Department, in part by squads supervised by specially trained sanitary orderlies. Sanitary squads may be formed overseas out of the more intelligent of the native menial personnel. The N.C.O. in charge of this work should immediately report any defects in these measures to the Medical Officer in charge.

The Works and Buildings Department should inspect the camps at the end of the rainy season each year - that is, in the case of Malta early in May. During the inspection special attention should be paid to the following :-

(1) The ground surface, as regards levelling, impermeability and drainage;

(2) Buildings for cracks and holes in the walls; ill-fitting frames of windows, doors or ventilators; eaves-gutters; holes in any fly-proof screens fitted;

(3) Walls and embankments as regards necessary facing, pointing or tarring.

All the necessary repairs, tarring, painting and limewashing must be carried out immediately before the warm weather sets in. Each year the interior of all rooms should be washed down and painted or limewashed, the lower three feet of the outside of the walls of all buildings tarred, and the ground surface sprayed with tar for a distance of 20 feet beyond the living quarters. This last measure would not be required in a Station where the ground surface around the men's quarters is covered with concrete.

Sanitary Squads should see daily :-

(1) That the phlebotomi in the corners of huts are swatted, or sprayed with a one per cent solution of cresol;

(2) that ventilators are kept free from dirt, and are smeared with paraffin;

(3) that all gulley traps are kept clear;

(4) that the ground at the junction of walls of buildings is free from organic debris and dust;

(5) that all refuse in the camp is properly disposed of.

Moreover, this squad should, at least once weekly spray the whole of each hut with cresol, and sprinkle crude oil over outlying broken ground for a distance of 50 yards from the men's quarters.

The/

The N.C.O. in charge of each hut should see daily

(1) that the hut is thoroughly cleansed, especially the corners;

(2) that all cobwebs are removed;

(3) that all kits are shaken and dusted;

(4) that all beds are kept clean.

The framework of the beds should be thoroughly tre with paraffin, at least once a week.

(2) Personal measures :-

All members of the R.A.F. should be instructed :-

(1) to wear slacks after sundown;

(2) not to bathe after dusk;

(3) not to leave rubbish about or spill water on the gro

(4) to report sick immediately they feel ill during the hot weather;

(5) to use sandfly-proof nets when ill with fever;

(6) to use repellents such as camphor in their beds.

Finally, natural air-currents must be fully utilis and a liberal supply of electric fans or punkahs granted.

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A C K N O W L E D G M E N T S .

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(Sd.) Harold E. Whittingham,
Wing Commander, R.A.F.M.S.

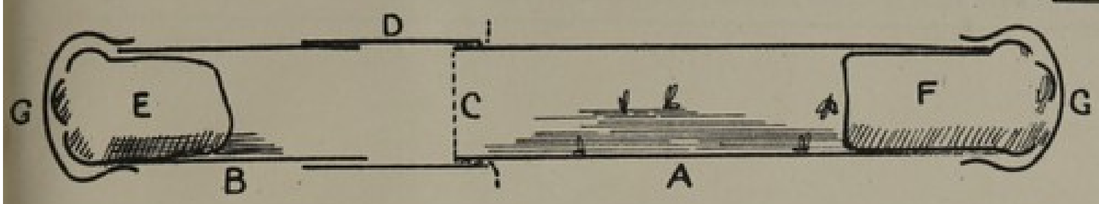
(Sd.) A.F. Rook,
Flight Lieutenant, R.A.F.M.S.

R.A.F. Central Laboratory,
Finchley, N.W.3.

20.2.23.

APPARATUS FOR TESTING THE ACTION OF FUMIGANTS ON PHLEBOTOMI.

FIGURE I



A. TEST TUBE CONTAINING PHLEBOTOMI.

B. TEST TUBE CONTAINING FUMIGANT UNDER TEST.

C. BUTTER MUSLIN PARTITION.

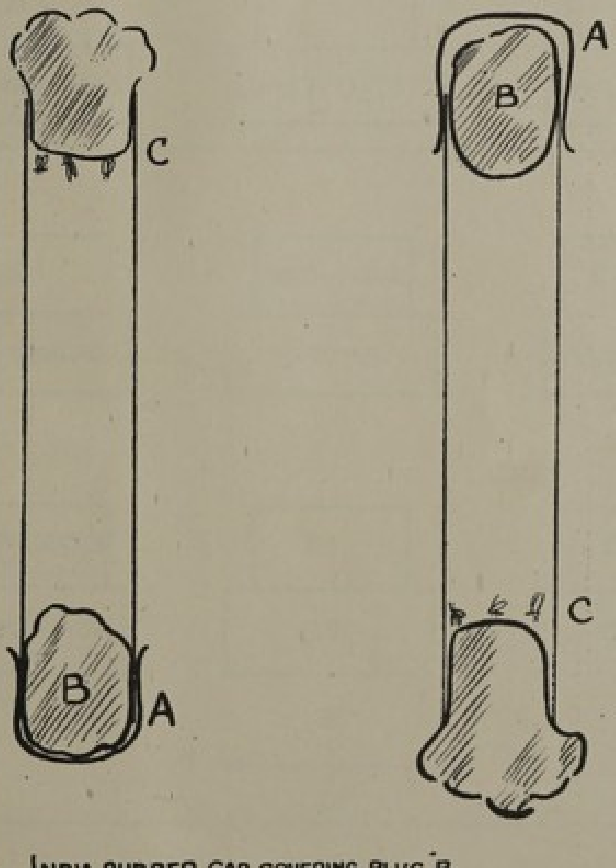
D. INDIA RUBBER TUBING FORMING JOINT BETWEEN THE TWO TEST TUBES.

E. COTTON WOOL PLUG MOISTENED WITH FUMIGANT.

F. COTTON WOOL PLUG.

G. INDIA RUBBER CAPS TO RETAIN FUMES

FIGURE 2.

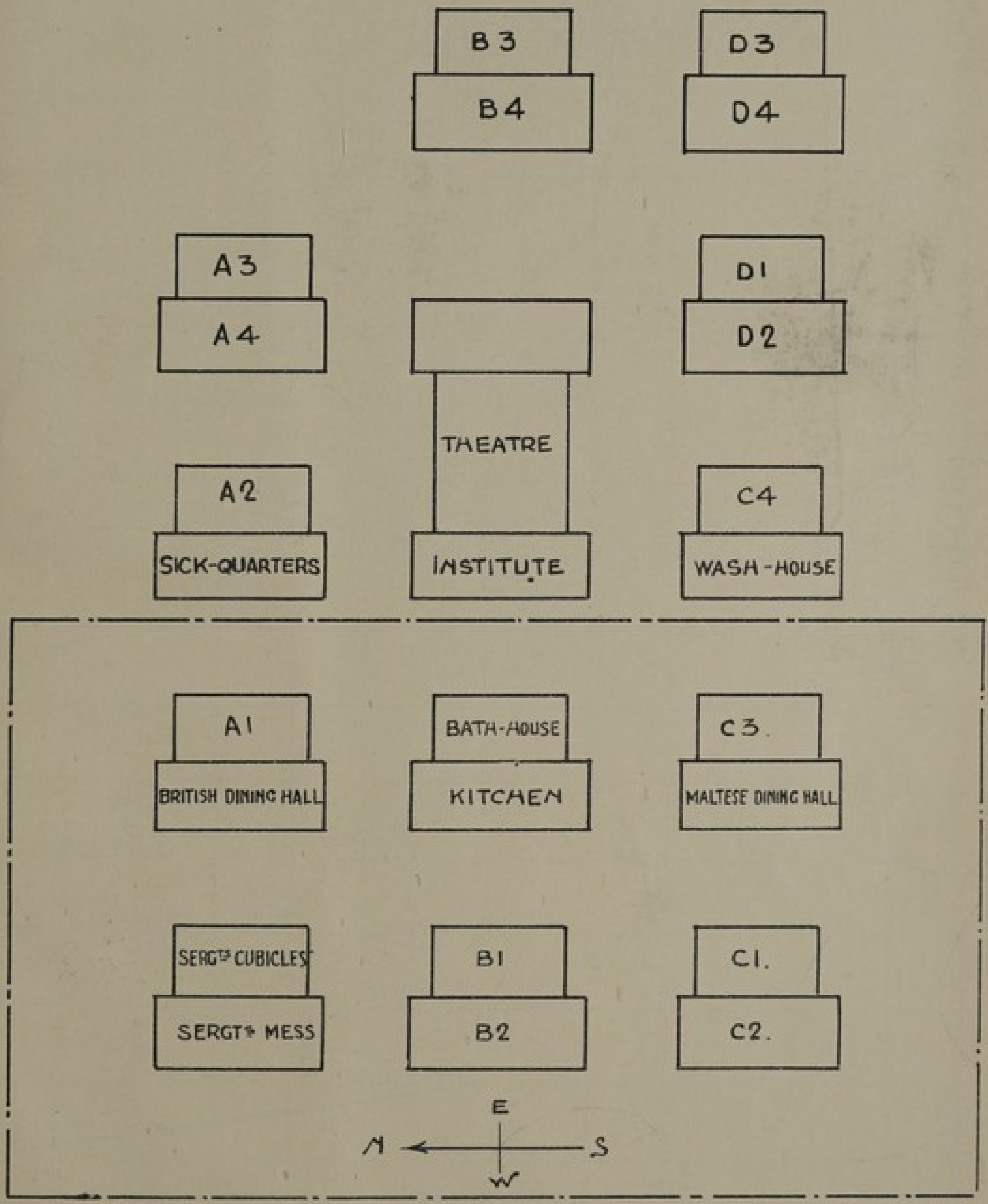


A. INDIA RUBBER CAP COVERING PLUG B

B. COTTON WOOL PLUG SOAPED WITH REPELLENT

C. PHLEBOTOMI KEEPING AS FAR AWAY FROM REPELLENT AS POSSIBLE.

PLAN OF R.A.F. CAMP, 267 SQUADRON, CALAFRANA, CAMP.

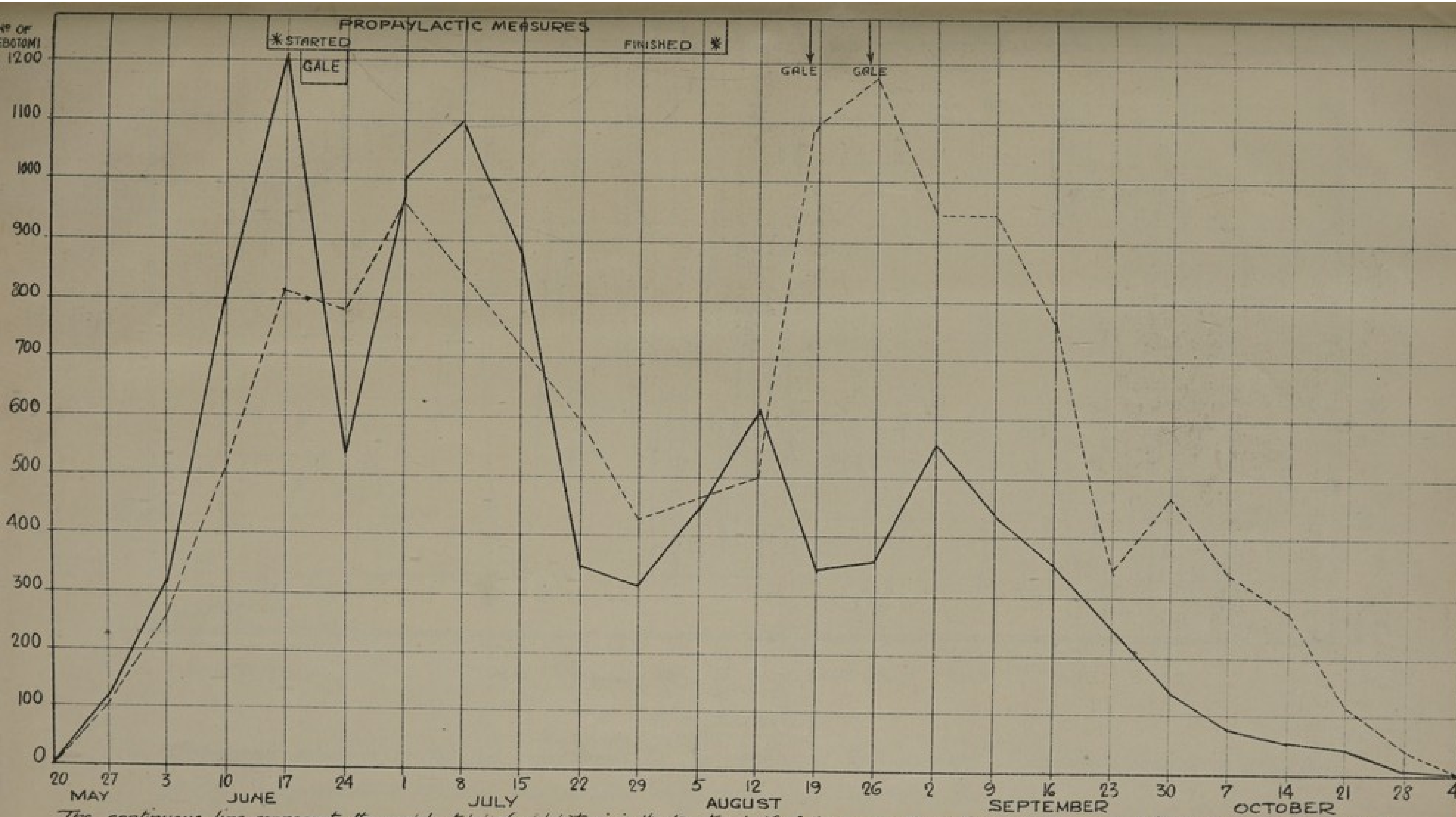


Represents Western half of camp which was specially treated to abolish the breeding grounds of phlebotomi.

The Eastern portion of the camp did not have the ground, buildings or walls specially treated.

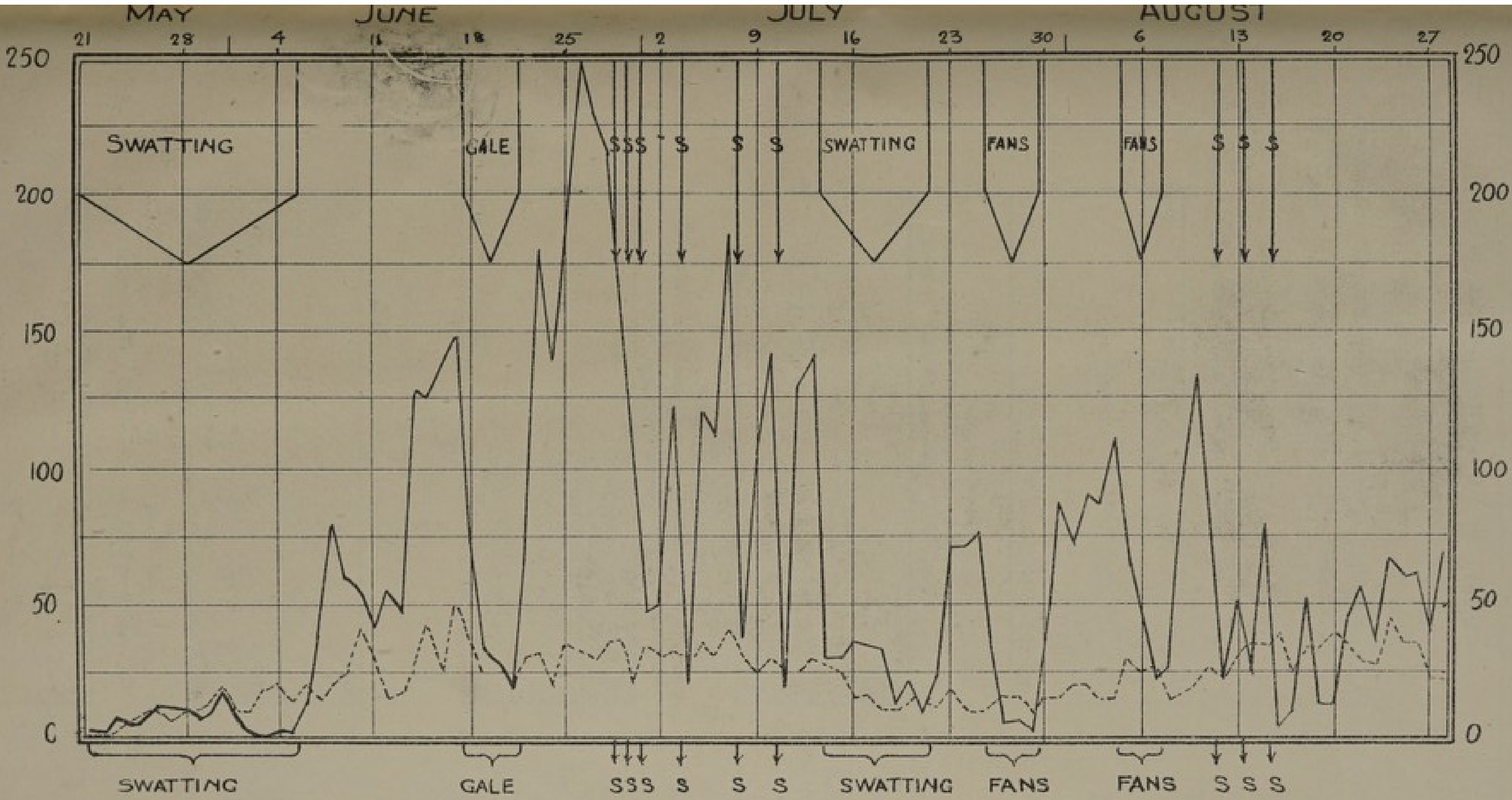
The upstairs huts are shewn as small rectangles mounted on top of larger rectangles, which represent the ground floor huts.

CHART No 2



The continuous line represents the weekly total of phlebotomi in the treated half of the camp; the dotted line the weekly total in the untreated half of camp

CHART No. 3.



Phlebotomus incidence in Hut A4 represented by the continuous line; average phlebotomus incidence in 5 huts strictly comparable to Hut A4, but swatted daily represented by the dotted line.

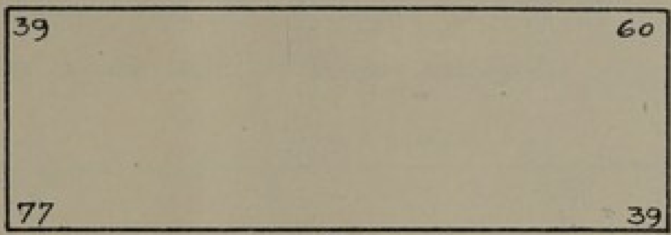
DIAGRAM SHEWING THE EFFECT OF CRESOL SPRAYING ON THE INCIDENCE OF PHLEBOTOMI IN BUILDINGS.

The numbers inside the rectangles represent the phlebotomi in the corner of the hut indicated.

I

28.6.22 7.30 p.m.

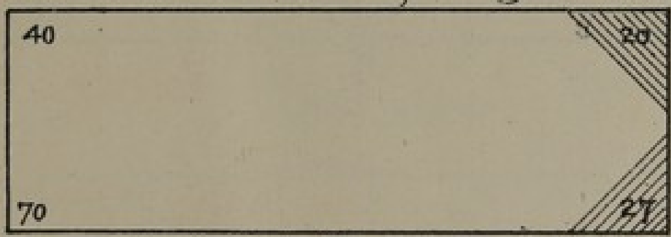
Condition of hut just prior to spraying.



II

29.6.22 7.30 p.m.

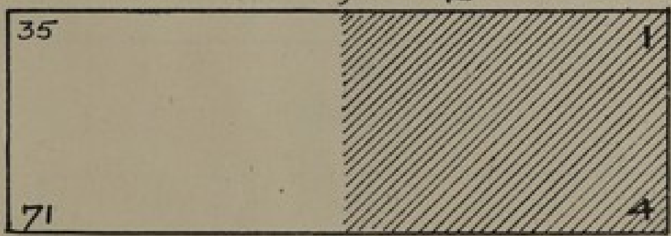
Two corners of hut (shaded) were sprayed with 1% cresol solution 24 hours previously.



III

30.6.22 7.30 p.m.

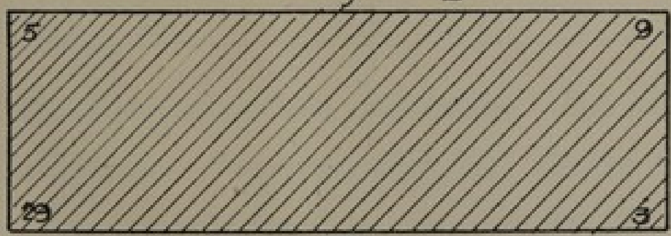
Half of the hut (shaded) was sprayed with 1% cresol solution 24 hours previously



IV

1.7.22 7.30 p.m.

Whole hut (shaded) was sprayed with 1% cresol solution 24 hours previously.



V

2.7.22 7.30 p.m.

Condition of hut 48 hours after last spraying

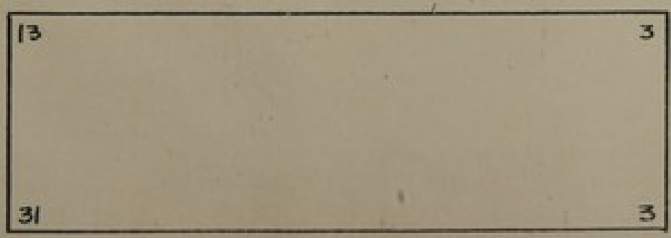


Diagram shewing the accumulation of phlebotomi in corners occupied by cobwebs and the dispersal of the flies when the cobwebs

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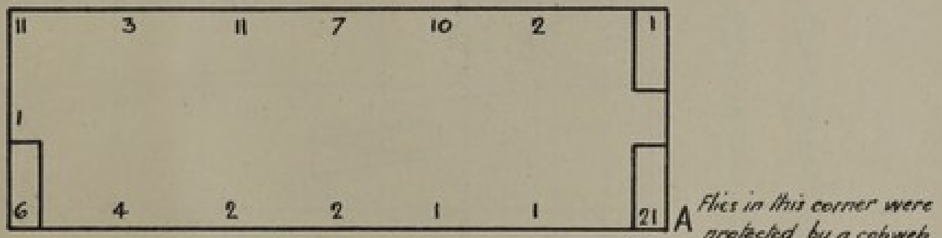
Observations made during experiments with small fans. The figures inside inside the rectangles refer to the number of phlebotomi in the part of the hut indicated.

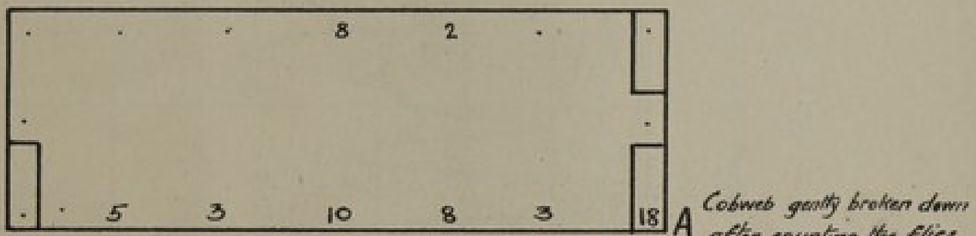
I

26.7.22 3.30 p.m.



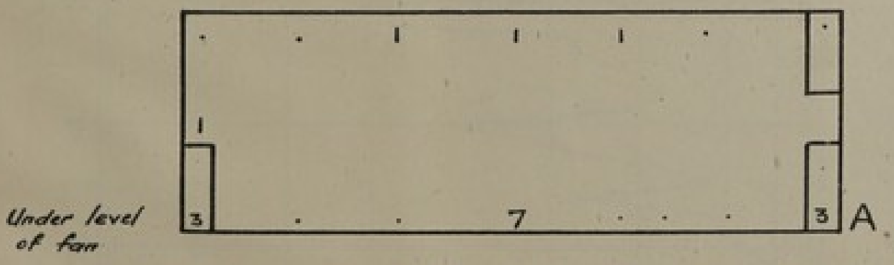
II

27.7.22 9.30 a.m.



III

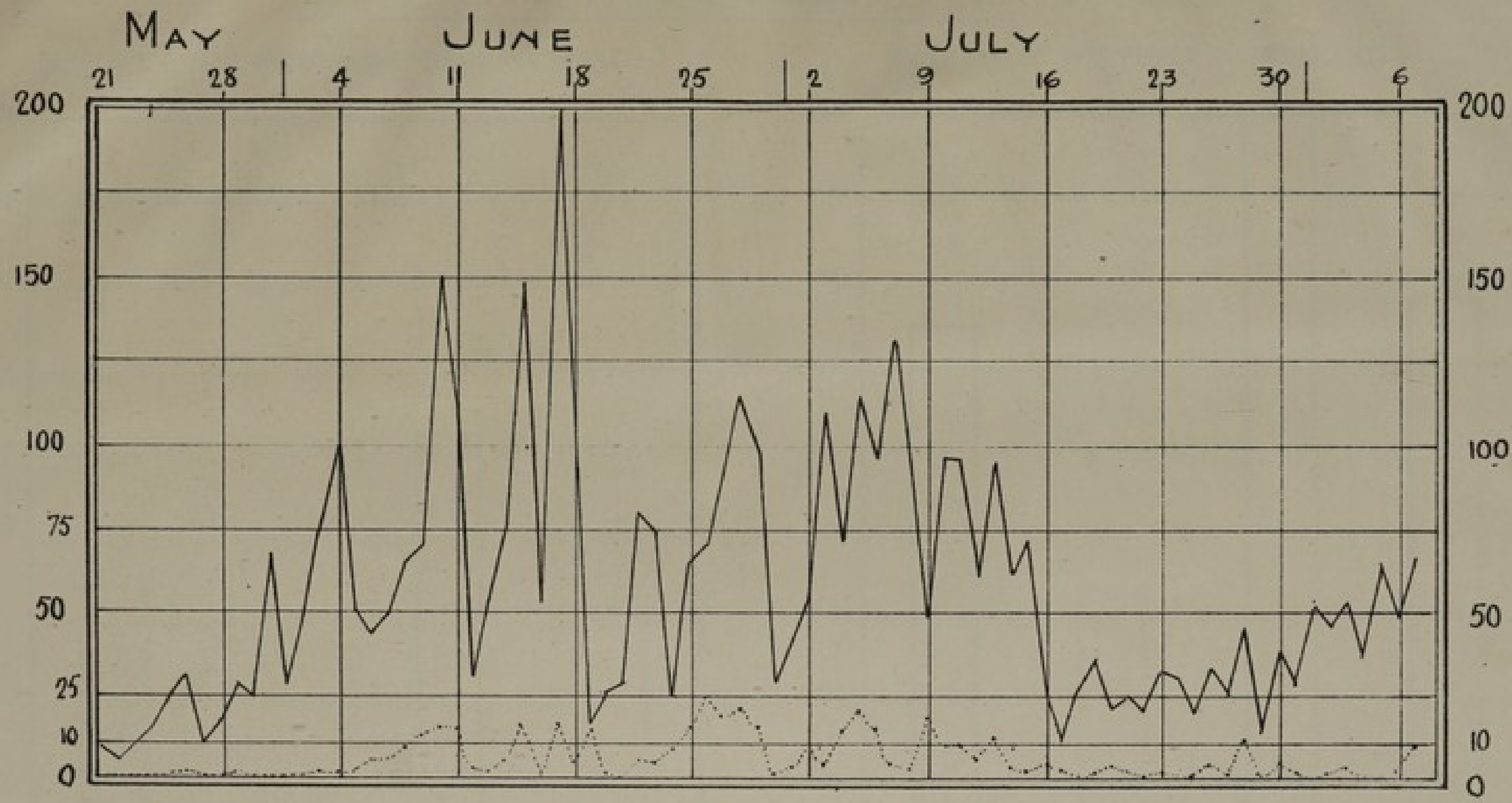
27.7.22 7.30 p.m.



Note the dispersal of the phlebotomi from the corners of the hut, except from corner A (c.f. figures I & II). After removal of cobweb in corner A the flies were soon dispersed.

CHART Nº 6.

CHART TO SHOW THE INCIDENCE OF PHLEBOTOMI IN DIFFERENT STORIES OF BUILDINGS.

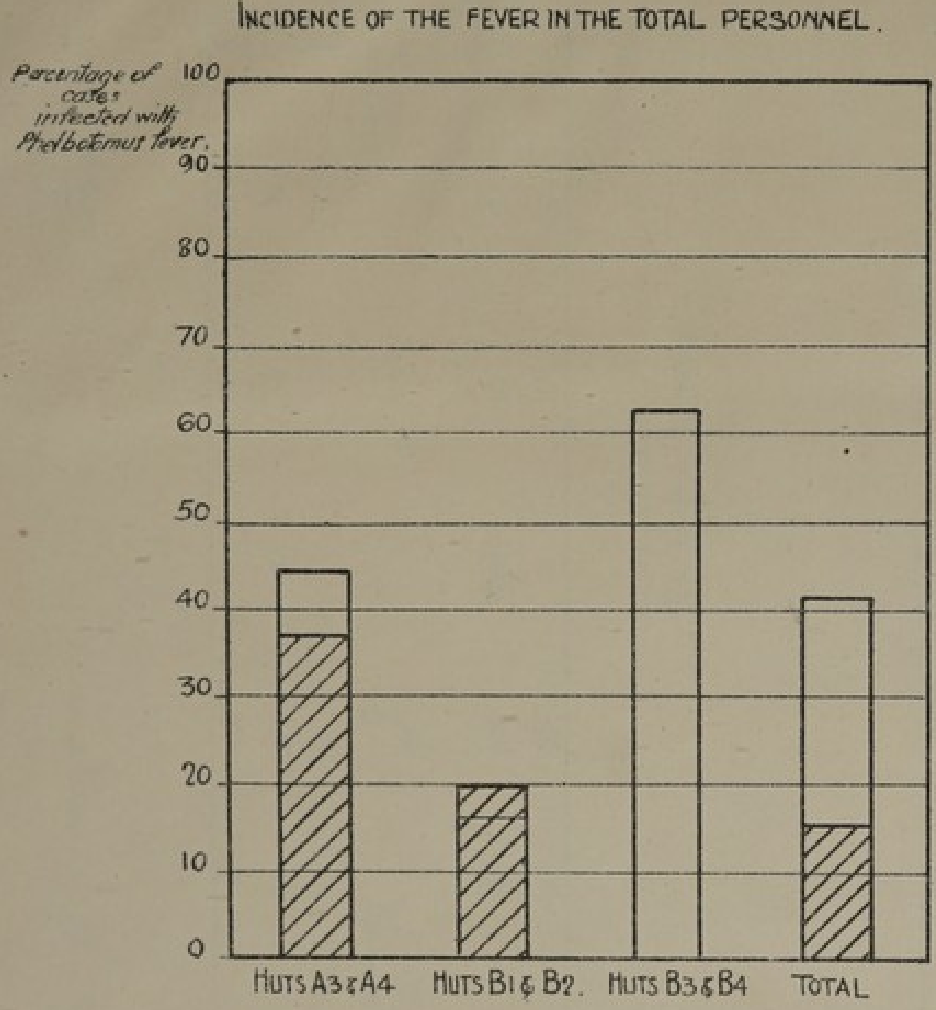


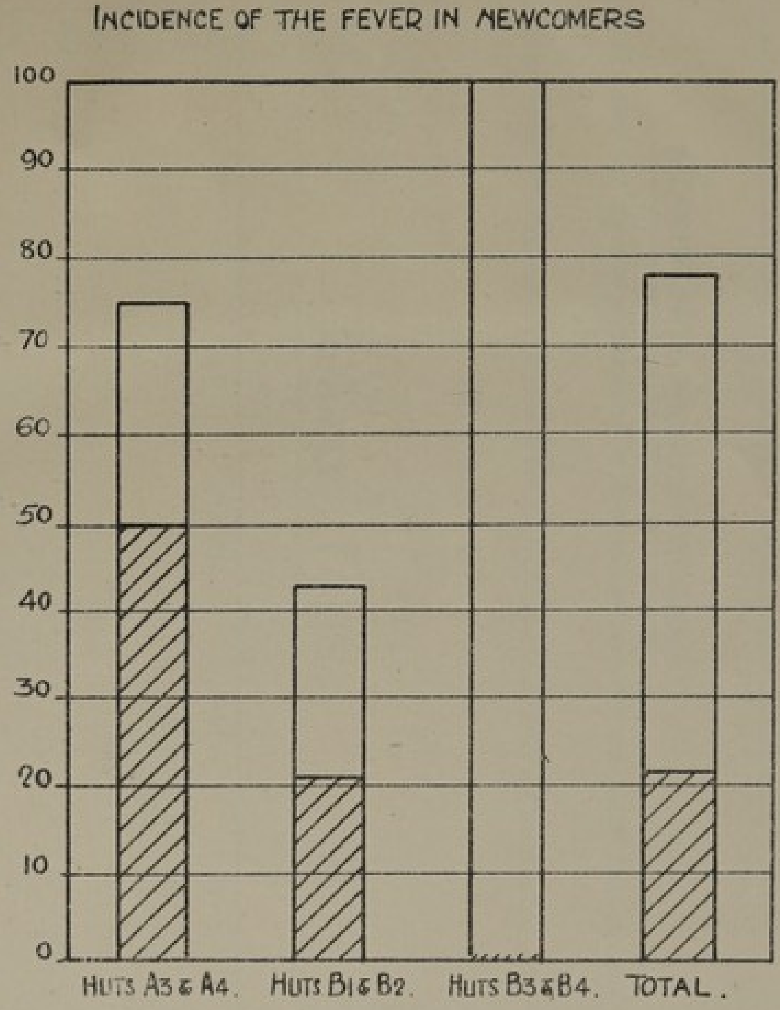
Total number of Phlebotomi in two ground floor huts, C2 & B2, represented by the continuous line

Total number of Phlebotom in two first floor huts, C1 & B1, represented by the dotted line

CHART No 7.

TABLE SHEWING THE PERCENTAGE OF CASES OF PHLEBOTOMUS FEVER OCCURRING IN UPSTAIRS AND GROUND FLOOR HUTS.





The shaded '/// columns represent upstairs huts, the clear columns the ground floor huts.

CHART № 8

FAN EXPERIMENTS.

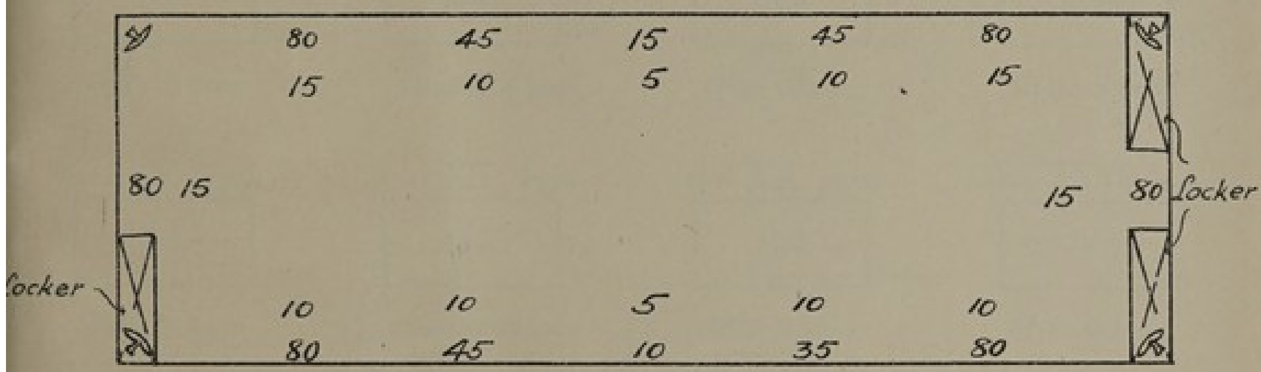
PLAN OF HUT A4, R.A.F. STATION, CALAFRANA, MALTA.

AIR CURRENTS PRODUCED BY FANS.

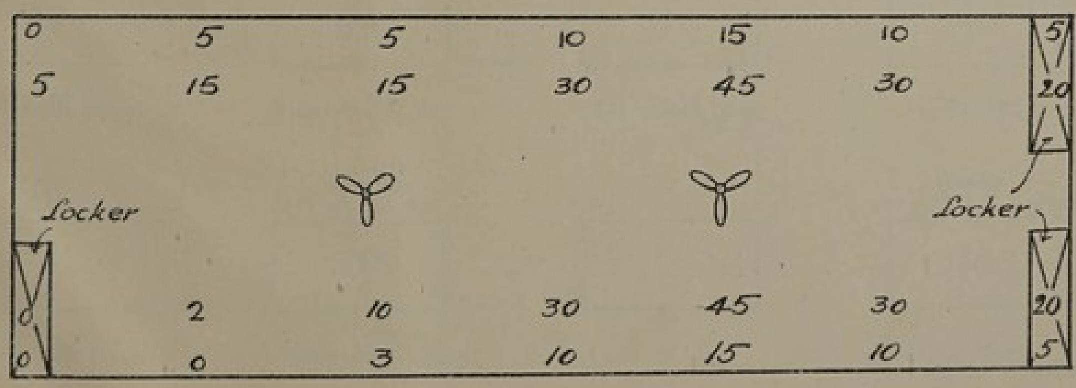
1. *Outer ring of figures = comparative force of air currents one foot from ceiling.*

2. *Inner ring of figures = comparative force of air currents at level of head of bed.*

SMALL FANS.



LARGE FANS



SCALE:- 1 INCH = 10 FEET

FANS SHEWN

FAN EXPERIMENTS

CHART No 9

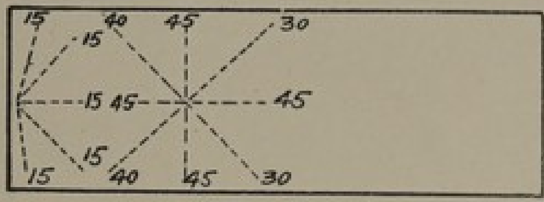
A Small fans i.	B Small fans stopped	C Large fans	D Small fans ii
26.7.22 I 10.30am **138** S.W.1 Before starting	30.7.22 IX 9.30am **60** N.W.2 Stopped 12 hours	3.8.22 XVII 10.30am **137** N.W.1. Before starting	5.8.22 XXIII 10.30am **170** E.2 Before starting
26.7.22 II 11.30am **93** S.E.1. After 1 hour	30.7.22 X 7.30pm. **43** S.E.1. Stopped 24 hours.	3.8.22 XVIII 11.30am **125** N.W.1. After 1 hour.	5.8.22 XXIV 11.30am **102** E.1.2. After 1 hour
26.7.22 III 3.30pm **76** S.1. After 5 hours	31.7.22 XI 9.30am. **147** S.1. Stopped 36 hours	3.8.22 XIX 3.30pm **99** W.1. After 5 hours	5.8.22 XXV 3.30pm **63** S.W.1. After 5 hours
26.7.22 IV 7.30pm **74** N.W.2 After 9 hours	31.7.22 XII 7.30pm. **111** S.E.1. Stopped 48 hours	3.8.22 XX 7.30pm **110** Calm. After 9 hours	5.8.22 XXVI 7.30pm. **78** S.W.1 After 9 hours
27.7.22 V 10.30am **57** S.1. After 24 hours	1.8.22 XIII 9.30am **137** S.E.1. Stopped 60 hours	4.8.22 XXI 10.30am. **156** N.W.1. After 24 hours	6.8.22 XXVII 10.30am. **74** N.N.E.1-2 After 24 hours
28.7.22 VI 10.30am **27** S.W.1. After 48 hours	1.8.22 XIV 7.30pm **89** N.N.E.1. Stopped 72 hours	5.8.22 XXI 10.30am **170** E.2. After 48 hours	7.8.22 XXVIII 10.30am **45** E1-2. After 48 hours
29.7.22 VII 10.30am. **17** N.N.W.3-4 After 72 hours.	2.8.22 XV 9.30am **158** W.S.W.1. Stopped 84 hours		8.8.22 XXX 10.30am. **18** S.S.E.1. After 72 hours
29.7.22 VIII 7.30pm **5** N.N.W.4 After 82 hours	2.8.22 XVI 7.30pm **118** N.W.1. Stopped 96 hours		

DIAGRAMATIC REPRESENTATION OF THE POSITION & RADIUS OF ACTION OF ELECTRIC FANS IN ROOMS.

ELEVATION PLANS

GROUND PLANS

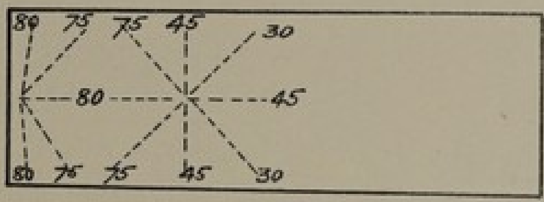
60 x 11 feet



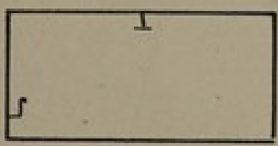
60 x 20 feet
1200 sq feet

B

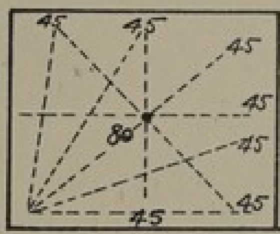
60 x 11 feet



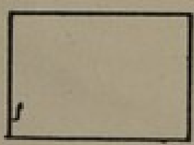
60 x 20 feet
1200 sq feet



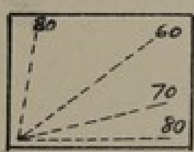
25 x 11 feet



25 x 20 feet
500 sq feet



15 x 11 feet



15 x 12 feet.
180 sq feet

Scale = 1/16 inch to a foot.

--------- Air currents

80 = comparative force figure