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THESIS FOR THE DEGREE OF M.D.

submitted by

Douglas Brock Peterkin, M.B., Ch.B.(1937).

OBSERVATIONS ON THE OUTBREAK OF LOUSE-BORNE TYPHUS FEVER AT BELSEN CONCENTRATION CAMP, APRIL, 1945.

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Introduction and Scope.

The difficulties of finding original material in general practice on which to write a Thesis made the author review his Service experience and choose the aforementioned subject.

Whilst serving with the 11th Light Field Ambulance the author had the dubious privilege of working in the huts of Belsen camp from the day of liberation onwards until the last hut was burned down by the British after complete evacuation of the Camp. Few people who worked there can at any time have seen a greater wealth of clinical material. The death rate whilst evacuation was proceeding between April 20th, 1945 and May 17th, 1945, numbered some thirteen thousand in Camp I alone. In perusing the small amount of literature existing on the subject it is surprising that no real intensive clinical investigations seem to have been carried out at the Camp. The reasons for this are not far to seek. The magnitude of the problem which existed and smallness of resources of the liberating forces in men and material made the problem largely an administrative one of extreme urgency. Everyone in the area was employed in providing the daily wants of an average community to the internees. Food, water and clothing had to be provided. Some semblance of hygiene and order had to be brought to the Camp and an attempt made to evacuate the seriously ill

ill/ estimated at some twenty eight thousand in Camp I and three thousand in Camp II. Along with another officer the author was responsible for the collection and evacuation of the sick from Camp I to Casualty Clearing Stations and General Hospitals in the neighbourhood. The appalling conditions of filth and squalor in the camp and a death rate of five hundred a day at the outset made speed in evacuation the prime consideration.

Under these circumstances and because of language difficulties it was impossible to carry out a detailed examination of all patients, nor was it possible to keep clinical records. Many cases were examined in detail however and several visits were paid by the author to general hospitals where conditions were considerably more suitable for examination. Naturally no special investigations could be carried out by the author and cases were examined solely by clinical means. Where necessary, reference is made to the work of those who were able to carry out special investigations at the Casualty Clearing Stations and General Hospitals. Whilst a description of the many diseases seen at Belsen is included in the Thesis louse-borne typhus fever is the main subject of discussion. Several factors have determined the choice. These were the first cases of louse-borne typhus seen by the author, and prompt modern measures successfully and abruptly ended

ended/ the epidemic which by experience in previous wars should have become widespread. In addition the author along with seventeen other members of the 11th Light Field Ambulance and six medical students working in the camp had the misfortune to contract the disease.

It was originally intended that the eighteen army cases in themselves should form the subject of a Thesis. However requests to the War Office for a perusal of clinical records have been refused, the reason given being that the author is no longer a serving soldier and is not called in his capacity as a doctor to treat these men now. In spite of this certain observations mentioned below can be made on these cases even though the case sheets are not available.

The Thesis starts with a brief account of the typhus group of disease and the classification thereof.

A full description of Belsen camp is then given in regard to its layout and the conditions existing at the time of liberation. A clinical description of the diseases encountered there is given and also of the typhus cases occurring among the British personnel. The measures adopted to cope with the situation are detailed especially in respect of the typhus epidemic. Particular attention is drawn to methods used for the disinfestation of

of/ internees and of preventing louse infestation and typhus infection in workers.

From these observations at Belsen certain aspects of typhus fever are discussed and the work of other authors reviewed. The first of these aspects are the factors which led up to the outbreak of typhus at Belsen and the mode of infection in the case of British personnel who developed the disease. The use of 2-2-bis(parachlorophenyl) 1,1,1-trichloroethane (hereafter referred to as D.D.T.) as an insecticidal powder is evaluated and its toxicity to man reviewed.

An account of the various vaccines which have been employed against typhus fever is included in the Thesis and observations are made on the Cox type vaccine as a result of experience at Belsen.

All conclusions arrived at by the author are outlined in the appropriate section on page 111.

The Thesis ends with a short summary of the subject matter and embodies the author's conclusions.

An alphabetical list of authors and writings referred to in the text is to be found on page 119.

Photographs, charts and tables are included throughout the text.

S E C T I O N I.

THE TYPHUS FEVER GROUP OF DISEASES.

Louse-borne Typhus Fever.

The Endemic or Zootic Typhus Fever.

Classification of Typhus Fever Group.

The Typhus Fever Group of Diseases.

There are two main sub-groups of typhus fever. These are the classical or epidemic or louse-borne typhus fever and the zootic or non-epidemic typhus fever.

Louse-borne Typhus Fever.

(Synonyms:- Typhus Fever; Typhus Exanthematicus; Epidemic Typhus; Camp Fever; Jail Fever; Famine Fever)

The disease is one of great antiquity. One of the oldest epidemics often regarded as typhus is the Athenian Plague of the Peloponnesian Wars in 430 B.C., which is described in the Second Book of Thucydides. This disease was characterised by the sudden onset of severe headache. Redness of the tongue and respiratory catarrh followed and at the height of the fever a papular rash appeared. Sequelae described were necrosis of the toes, fingers and genitals. Zinsser (1937) believes this epidemic to have been smallpox but not so Haeser (1882) who regards it more like typhus than any condition familiar to us. Hecker (1865) also believes it to have been typhus but states it to have been a form from which typhus has altered in the following centuries.

The earliest clear account of louse-borne typhus is written by Frascatorius who in 1546 described a "febris pestilens" which occurred in Italy in 1508 and 1528. Since then many accounts of epidemics of the disease have been written. These epidemics have usually occurred in military camps,

camps,/ jails and ships; they have nearly always been associated with famine. Epidemics are especially liable to occur after wars; in the Serbian retreat of 1915, one hundred and thirty-five thousand out of a population of two and a half millions died of the disease. In 1916 to 1919 hundreds of thousands died of epidemic typhus in Rumania, whilst in Russia, Tarassevitch (1922) states the annual incidence rose from one hundred and fifty thousand in 1914 to six million six hundred thousand in 1919.

The accounts of the earlier epidemics are confused because of typhoid fever, relapsing fever and plague, which had not then been differentiated from typhus fever. The name typhus fever was first introduced by Sauvage in 1760 but was not universally employed until after 1837. About that time both Stillé (1838) and Gerhard (1837) showed typhus and typhoid to be separate clinical entities. In 1884 Henderson differentiated relapsing fever and typhus and in 1873 Murchison wrote his classical description of the disease stressing its contagious nature. Nicolle first transmitted the disease to animals in 1909 when he produced the disease in a Bonnet monkey by subcutaneous inoculation of blood from a typhus patient. Working with Comte and Conseil in the same year he first proved the louse to be a vector by producing the disease in a monkey following the application of lice which had fed on an infected

infected/ monkey. In 1910 Ricketts and Wilder first described certain organisms which they found on infected lice and they were later accurately described by Prowazek and da Roche Lima . They were given the name of Rickettsia Prowazeki by da Roche Lima (1916).

In 1910 Wilson isolated certain bacteria of the coli group from typhus patients and found that they were agglutinated by high dilutions of the sera of patients suffering from the disease. Later Weil and Felix (1916) using a different organism (Proteus X) which had also been isolated from typhus patients described the agglutination reaction which is now known as the "Weil-Felix Reaction" and which is widely used in the diagnosis of the disease.

In 1898 Brill first described a fever which resembled a mild attack of typhus and which occurred sporadically in New York. The nature of the disease was not finally settled until 1934 when Zinsser showed the organism to be R.Prowazeki and that more than 95 per cent of the patients had originally lived in areas of Europe where epidemic typhus was common. The disease is now recognised as a late recrudescence of an old attack of typhus due to the virus persisting in the bodies of patients. For some unknown reason it flares into a mild attack of typhus years later. The disease is not transmitted by lice.

Zootic Typhus Fevers.

The first of these diseases to be described was Rocky Mountain spotted fever. It closely resembles louse-borne typhus in its manifestations; the rash however is more conspicuous and involves the palms, soles and face; it is frequently papular in type. The temperature rises and falls more slowly than in louse-borne typhus and the daily remissions tend to be greater. In 1904 Wilson and Chowing found the disease was conveyed to man from wild rodents by the bite of a tick, now known to be Dermacentor Andersoni. In 1909 Ricketts described the causal organism R. Rickettsi which he found in infected ticks. It is known that the disease occurs throughout wide areas of the United States of America apart from that area from which the disease derives its name. Similar diseases closely resembling Rocky Mountain spotted fever have been described throughout the world and altogether some twenty to thirty different names are in existence for this disease. A mild form occurring in Tunis was described by Conor and Burch in 1910. This was later known as "Fievre Boutonneuse" and is now known to occur in most countries around the Mediterranean Sea. In 1930 Durand, Conseil and Burch demonstrated the vector to be a tick Rhipicephalus Sanguineus. Until 1943 it had been impossible to confer complete immunity to Rocky Mountain spotted fever on a guinea-pig

guinea-pig/ inoculated with the organism of fievre boutonneuse. In that year however Parker found a strain of Rocky Mountain spotted fever Rickettsia against which inoculation with fièvre boutonneuse gave complete immunity. This suggests that the organisms of the latter disease is either the same as or merely a different strain of R. Rickettsii.

In 1917 and 1921 Megaw described a disease in India which was conveyed by the bite of a tick and which closely resembled Rocky Mountain spotted fever in its clinical manifestations. Topping, Heilig and Naidu (1943) reporting the results of complement fixation tests on the disease consider it to be the same as or closely related to Rocky Mountain spotted fever. R. Rickettsi has also been found to be the casual organism of the virulent form of typhus which exists in Brazil and Columbia and and which is known as Sau Paulo Fever or Exanthematic Typhus of Brazil . The disease is spread by tick bites and the organism is identical bacteriologically with R. Rickettsi found in virulent forms of Rocky Mountain spotted fever (Rogers and Megaw, 1944). The anomalous form of paratyphoid fever described by McNaught in 1911 and known as Tick Bite Fever of South Africa or Tick Typhus of Kenya is essentially similar to fievre boutonneuse both clinically and bacteriologically in that cross-immunity exists between the two diseases.

For many years a disease has occurred in Japan which closely resembles Rocky Mountain spotted fever in its clinical features, with the difference that the rash does not appear on the soles and palms but there is a local necrotic lesion; the blood picture is one of leucopenia. The disease is known as Japanese River Fever or Tsutsugamushi Disease. Smithson (1910) described a similar disease in Queensland. In 1918 Kitashima and Miyajima found the vector of Japanese River Fever to be a larval mite Trombicula Akamushi. By its bite the disease is transferred from infected bandicoot rats, mice and other rodents to man. In 1923 Hayashi and Takeuchi discovered the casual organism R. Orientalis.

A pseudo typhoid fever described by Schuffner in 1909 in Sumatra is now known to be a form of typhus conveyed from rats to man by a mite Trombicula Deliensis.

In 1926 whilst working in the Federated Malay States, Fletcher (1930) described a form of typhus to which he gave the name Tropical Typhus. The disease is now also known as Scrub Typhus. It differs from Japanese River Fever which also occurs in the Federated Malay States, in the absence of local lesions. In 1936, however, Lewthwaite and Savoor showed the virus of the two diseases to be essentially similar, cross-immunity existing in the experimental animal. A similar disease not

not/ associated with local lesions has also been described in certain parts of India. It is known as Indian Mite Typhus.

Since some years prior to 1926 a sporadic typhus-like fever has existed in North America. Maxcy first suggested in 1926 that the disease was transmitted to man from infected rats and that a flea was the vector. This was proved in 1931 by Dyer and others who infected guinea-pigs by the bites of fleas taken from rats caught in infected areas. Nicolle described a similar disease in 1932; it occurred in the French Navy at Toulon. The disease resembles mild louse-borne typhus, the onset being gradual and the mortality low. Nicolle gave the disease the name "Typhus Murin". Mooser isolated the organism calling it R. Mooseri. Although the disease has only been recognised a few years it is now known to occur throughout many parts of the world. Many cases have been reported from the Mediterranean areas in the recent war.

R. Mooseri bears close immunilogical and serological relationship to R. Prowazeki and Mooser, Castaneda and Zinsser (1931) regard it as a variety of that organism rather than a different species. They further believe that when a person has been infected with Mooseri by rat fleas the organism can then be transmitted from man to man by lice, thus causing louse-borne typhus. Rogers and Megaw (1944)

(1944)/ disagree with this view pointing out that no such transmission has ever been recorded in the areas where flea typhus exists, except in Mexico; they believe the suspected transmission in Mexico is not really a man to man transmission of R.Mooséri by lice but due to the fact that flea typhus and louse-borne typhus both exist in that country. The point is beyond the scope of this thesis but is mentioned as being one of great importance since it suggests a very close relationship between the demic and zootic groups of typhus.

Classification of Typhus Group of Fevers.

It can be appreciated from the above historical resumé that considerable confusion existed at one time with regard to the typhus fevers. On the one hand, there was louse-borne typhus fever which was a well recognised disease of known aetiology and, on the other hand, were numerous diseases whose names were usually derived from that part of the world in which they occurred. These diseases do resemble classical louse-borne typhus in their pathological and clinical features; moreover they are all caused by Rickettsias and are all conveyed to man by Arthropod vectors. On the other hand, they are primarily diseases of lower animals from which they are transferred to man incidentally, hence unlike louse-borne typhus they are sporadic in nature; since man to man infection does not exist,

exist/ widespread epidemics of these diseases such as are seen in the case of louse-borne typhus do not occur.

This relationship of louse-borne typhus on the one hand and tick-borne and mite-borne typhus on the other was not appreciated till 1917 when Megaw suggested that all these diseases should be grouped together. Since then various classifications have been suggested but the one now generally accepted is that based on the vectors of the diseases suggested by Megaw in 1921. His table is shown below. He rightly objects to the name "epidemic typhus" for the louse-borne variety on the grounds that it also occurs endemically. He suggests it is more correct to use "demic" which means "human" and is moreover in contrast to "zootic" or "animal" types. This classification he points out has the advantage of being simple and of differentiating the louse-borne variety, where man to man infection occurs, from the other types where man to man infection does not occur. This differtiation is in fact the most important point to be established in any outbreak of typhus fever.

Tables showing a classification of the typhus group of diseases and the differences in clinical features and agglutination reactions are shown on the following pages. A map showing their geographical distribution is given on page 17.

Classification of Typhus Fevers.

(from Rogers, L., and Megaw, J.W.D., Tropical Medicine (J. & A. Churchill) 5th ed. 1944).

The Typhus Fevers.
- Demic Typhus.
  - Louse Typhus.
- Zootic Typhus Fevers.
  - Flea Typhus.
  - Tick Typhus.
  - Mite Typhus.
  - Zootic typhus of unknown vector.

Average Type of Agglutination Reaction.

(from Rogers, L., and Megaw, J.W.D., Tropical Medicine (J. & A. Churchill) 5th ed. 1944).

	Louse Typhus.	Flea Typhus.	Tick Typhus.	Mite Typhus.
Proteus OX19	++++	+++	− to ++	− to +
Proteus OX2.	+	+	− to ++	− to +
Proteus OXK.	− to +	− to +	− to ++	+++
Rickettsia Prowazeki.	++++	++	+	?
Rickettsia Mooseri.	++	++++	+	?
Rickettsia Rickettsi.	+	+	++++	?

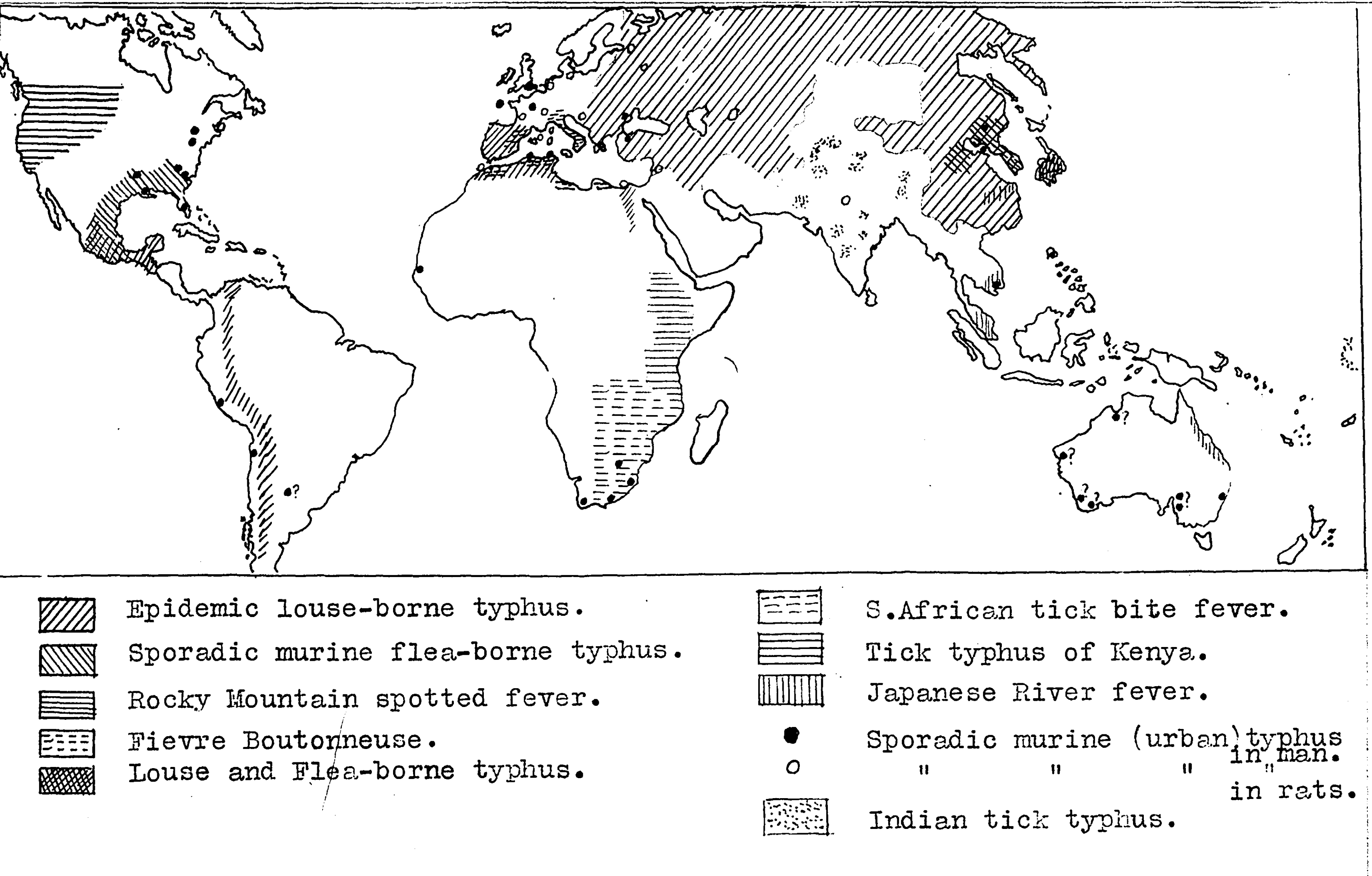
The General Features of the Demic and Zootic Groups of Typhus Fever.

(From Roger, L. and Megaw, J.W.D.(1944) Trop. Med. (J. and A. Churchill) 5th ed.).

Sub Groups	Demic(human)Typhus	Zootic(animal)Typhus Fevers.		
Special features of sub-groups	Man-to-man transmission. Associated with lice, poverty and overcrowding. Often epidemic. Not common in tropics.	Transmission from lower animal to man. Associated with life in open country and forests, or with contact with rats, dogs etc. Sporadic or in local outbreaks. Common in tropics and subtropics.		
Names	Louse Typhus. (Epidemic typhus, typhus exanthematicus, louse-borne typhus.)	Flea Typhus (Murine typhus, endemic typhus).	Tick Typh. Rocky Mountain spotted fever, boutonneuse, fever, etc. etc.	Mite Typh Japanese river fever, tsutsugamushi, scrub typhus etc.
Casual organisms	Rickettsia prowazeki	R. mooseri	R. rickettsi.	R. orientalis.
Vectors	Human louse.	Rat flea.	Ticks.	Larval mites.
Animal reservoirs	Man	Rats and mice	Various rodents.	Rats and mice.
Rash	First on trunk, not common on palms, soles and face.	As in louse typhus but less conspicuous	First on limbs, common on hands, soles and face.	Variable often first on face and trunk.
Local sore	Absent.	Absent.	Uncommon, except in boutonneuse type.	Usual, but often absent.
Severity	Usually severe.	Seldom severe.	Mild to very severe.	Mild to severe.

Geographical distribution of fevers of the typhus group.

(From Epidem. Rep. Hlth. Sect. L. of N., Nos.7 to 9.).



SECTION II.

CONDITIONS IN BELSEN CONCENTRATION CAMP.

1. General and Historical.
2. General layout of the Camp.
3. Conditions prevailing at time of liberation of the Camp.
4. Diseases prevalent in the Camp.
5. Measures adopted to deal with the situation.
6. Measures adopted to deal with the epidemic of louse-borne typhus fever.
7. Incidence of louse-borne typhus among British and German personnel working in the Camp.

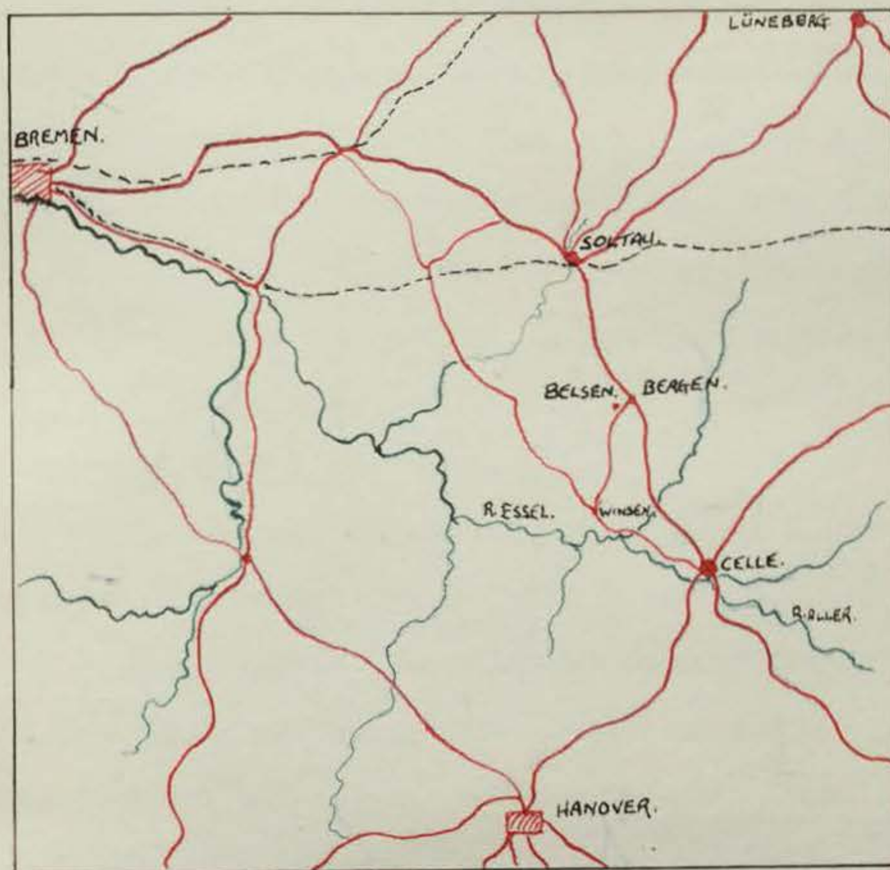
1. General and Historical.

In March 1945, the Allies crossed the Rhine and after a brief battle on the eastern bank the final forward sweep through Germany commenced. So rapid was this advance that the enemy's communications, his civil and military administration were completely disrupted.

On the 12th April, 1945, representatives of the First German Parachute Army approached a high ranking officer of the British Army stating that a terrible situation had arisen at Belsen Camp, and requesting the British to take over control. The battle in Northern Germany was still being fought at the time; therefore a special truce was drawn up on 13th April, 1945 and first British unit, and anti-tank battery moved into the Camp on the 15th April, 1945. On the 17th April, the first medical units arrived in the Camp, a Casualty Clearing Station, the 11th Light Field Ambulance (in which the author served), a Field Hygiene Section and a Mobile Bacteriological Laboratory. These units were followed some ten days later by another Field Ambulance and Casualty Clearing Station, two General Hospitals and two Field Hygiene Sections. In addition detachments of the British Red Cross Society, ninety six volunteer medical students and a section of the American Field Service arrived in the area. All these units were housed some distance from the Camp, some under

under/ canvas, others in the Wehrmacht Barracks.

Belsen Camp lies about fifteen miles north west of Celle and some three miles south of the village of Bergen which lies on the road leading from Celle to Soltau. Its entrance opens on a minor road and the Camp is completely concealed by pinewoods.



It would appear from statements made by internees that at one time the Camp had been relatively well administered, and conditions had not been too bad compared with other camps. The Camp was originally used as a labour camp whence the internees were transported for short periods, to repair bomb damage and clear debris in the north

north/ German cities. However, as the war progressed and the Allies closed in on central Germany from east and west, conditions progressively deteriorated. More and more concentrations camps and prisons were evacuated from the perimeter of German held territory the internees being transferred to camps in central Germany. Thus Belsen Camp contained many former inmates of the concentration camps of Auschwitz, Nordhausen and Sachsenhausen. In November, 1944 the administration of the Camp began seriously to fail and in the six weeks prior to liberation by the British, the German authorities either did nothing or could do nothing to retrieve a situation which was quite out of control.

2. General layout of the Camp.

In the area of Belsen there were two separate "built up" areas. The first of these, Camp I, constituted the original concentration camp and consisted of wooden huts. Approximately one mile distant lay a vast barrack area of stone buildings which normally was a tank training depot for the Wehrmacht and S.S.Panzer Grenadiers. Part of this constituted Camp II.

Camp I covered an area three quarters of a mile long by half a mile wide and was surrounded by a double barbed wire fence with watch towers at intervals. It consisted of some two hundred huts each ninety feet long, thirty feet wide and twelve

twelve/ feet high. The huts were arranged as follows:-

a) An administrative block near the entrance to the Camp consisting of offices, living huts, ablution benches, fifteen shower baths, medical inspection room and dental centre. In addition, four big disinfestation chambers each capable of disinfesting sixty sets of clothing were situated here. This block of huts was solely for the use of the Camp guards.

b) Five compounds of hutted camps, two for women and three for men, each separated by a double barbed wire fence.

Certain huts had bunks of the two or three tiered type. The majority had none. In all there were some two thousand four hundred bunks in the Camp; these were mainly concentrated in the hospital huts. The bunks were closely packed in blocks, eight bunks long and three deep. Between each was a small passage not wide enough for a stretcher. The hospital huts differed in no way from the ordinary huts excepting for a fading red cross painted on the side. They were distributed throughout the compounds as follows:-

Men's No. 1. Compound - four hospital huts.
Men's No. 2. Compound - three hospital huts.
Men's No. 3. Compound - nil hospital huts.
Women's No. 1. Compound - five hospital huts.
Women's No. 2. Compound - one hospital hut.

These huts were staffed by internee nurses

nurses/ and ninety internee doctors. They had no medical equipment whatsoever.

Most of the huts were in a state of marked disrepair with missing or rotting floor boards and leaking walls and roofs. Few windows could open, most of them being nailed up by the internees to retain some warmth in the huts. In certain huts electric light fittings were present but no form of heating was provided.

A few huts were provided with crude bucket latrines, improperly flyproofed. The main latrine accommodation consisted of unscreened large open pits with cross poles as seating. They were provided in quite inadequate numbers and certain huts were three to four hundred yards distant from the nearest.

There were six cookhouses in the Camp each containing six or twelve large boilers of one hundred gallon capacity. They were staffed by internees under supervision of the guards. Food was consumed in the huts, no dining accommodation being provided.

The water supply to the Camp was provided by three open concrete ponds served by an electric pump. Thence the water was hand carried to the huts there being no taps.

No proper roads or paths remained and in wet weather the Camp was a quagmire.

At the southern end of the Camp was a small crematorium with one oven.

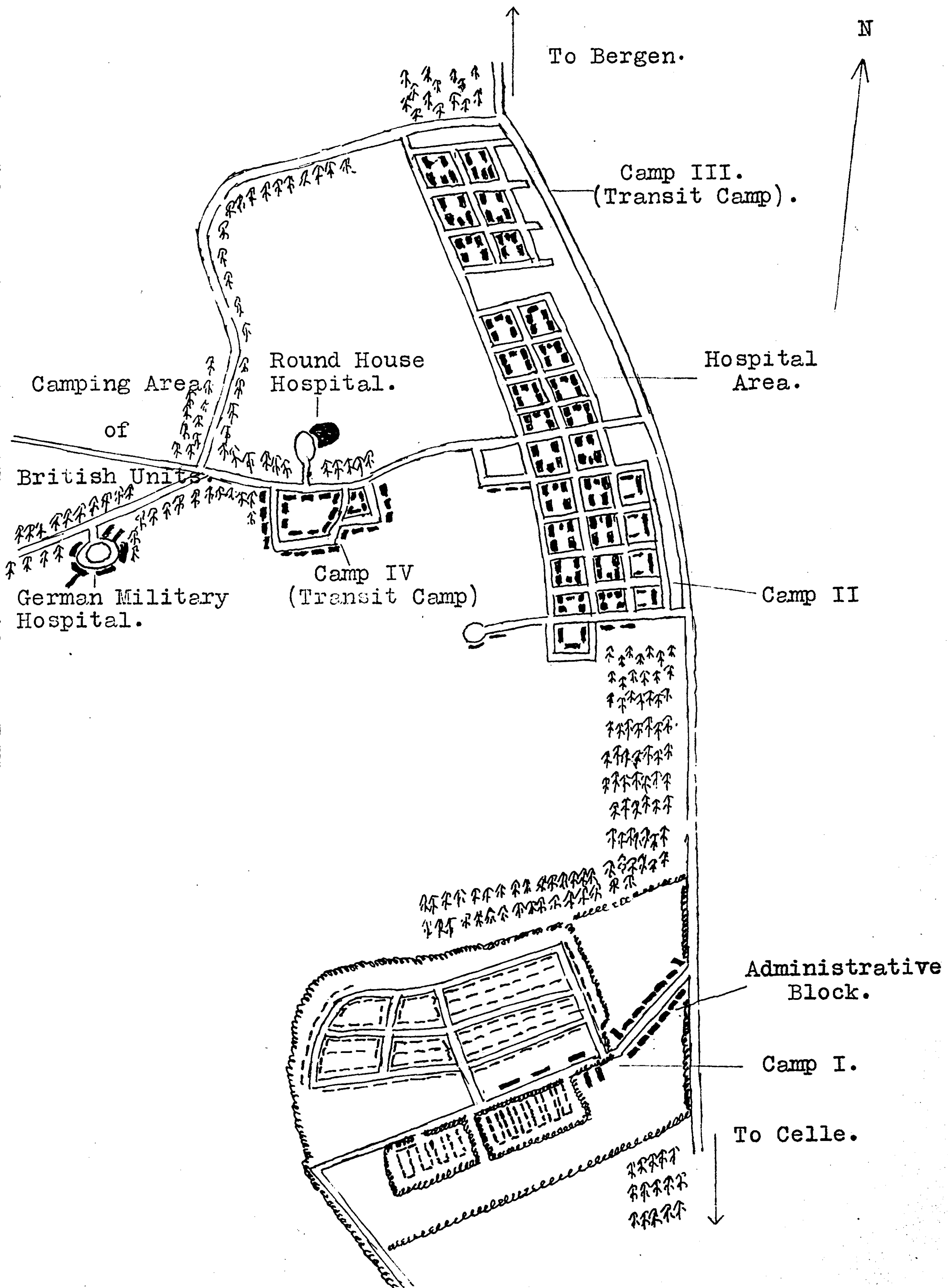
Camp II consisted of part of the barrack area approximately one mile from Camp I. It had been converted to a concentration camp and wired off by the Germans ten days before the arrival of the British at Belsen. The buildings were modern and brick built; the rooms were large, each capable of housing one hundred and fifty persons with adequate lighting, heating and latrine accommodation for such numbers.

The Wehrmacht barracks consisted of modern brick built blocks. There were large well equipped kitchens and recreational canteens for each block of five buildings. The Germans had converted eight buildings to hospital use and some two hundred sick and wounded occupied them.

About half a mile from the barrack area there was situated a well equipped military hospital with full laboratory and radiological facilities. Although normally a two hundred bedded hospital, it contained about six hundred German Army sick and wounded.

A plan of the Belsen area is given on page 25.

Plan of Belsen Area.



3. Conditions prevailing at time of liberation of the Camp.

The numbers quoted in this section are only approximately accurate. In part they have been derived from various army memoranda and notes published in Belsen at the time. From the description of the prevalent conditions it will be apparent that no accurate assessment of numbers was possible. Moreover the major part of the Camp records had been destroyed by the Germans prior to the arrival of the British.

The internees numbered some fifty eight thousand. Of these twenty nine thousand women and twelve thousand men were in Camp I and some seventeen thousand men were in Camp II.

All nationalities were represented, the majority being Poles and Russians, with a considerable number each of French, Dutch, Belgians, Yugoslavs, Norwegians and Danes. Approximately one third of the Russian and French males were military prisoners of war; otherwise the internees were all political prisoners and those taken for forced labour. The vast majority were of Jewish race. All professions, trades and walks of life were represented. The duration of internment varied from ten days to five years.

Camp I.

By far the worst conditions existed in this camp. Hygiene was non-existent. Scattered

Scattered/ throughout the camp were ten thousand unburied bodies. Some were clad; the majority were naked. In places the bodies were arranged in piles up to two hundred in number but most lay where they had died, by the roadside and pathways, in the bunks and even beneath the rotting floor-boards of the huts. All the bodies were grossly emaciated showing complete absence of subcutaneous fat and little muscle tissue.

Inside the huts conditions were even worse. In all there was gross overcrowding. The maximum number seen by the author was nine hundred and eighty four persons in a hut but numbers of over one thousand have been recorded by Dixey (1945). By British Army standards of 1945 the maximum numbers in the huts should have been one hundred and twenty. In those huts without bunks a mass of internees lay huddled together on the floors where rags, lice, faeces and urine abounded. Some wore filthy rags or blankets as clothes; others were completely naked. In those with bunks the common practice was for two or three persons to share a bunk; not infrequently the living shared bunks with the dead being too ill to be aware of or concerned with the fact. The majority were incapable of moving from where they lay. They passed urine and faeces in the bunks. With few exceptions all the internees in Camp I were louse infested.

Normally there was an internee "blockleiter" in each hut responsible for the discipline and running of the hut. The system had completely broken down and the situation was far beyond the efforts of the remaining physically fit internees.

Mollison (1946) states that in January, 1945 the diet consisted of one loaf of black bread (weighing 1.4 Kilograms) per six internees and one tin of meat per week per twelve internees. Occasionally extra meat was added to the watery soup which was issued daily. By February the meat had stopped and only soup and a little margarine, on three nights a week, were issued. Eventually for the last fortnight mangel wurzel was the sole diet, whilst for five days prior to liberation neither food nor water was available. In fact, the situation was much worse for most of the internees as food supplies depended on one's ability to fetch it or on the goodwill of the "blockleiters"; the latter were quite unable to cope with the situation which arose.

Camp II.

Conditions in this camp were comparatively better. Again there was marked overcrowding but general hygiene and the nutrition of the internees was somewhat better. This was largely due to the fact that they were recent arrivals. Disease was less rife here and there was no typhus. Since the author had no experience of this camp, apart from

from/ a brief visit, no further reference will be made to it.

The Wehrmacht Barracks and German Military Hospital.

The barracks housed four thousand Hungarian troops and seven hundred Wehrmacht. Hygiene conditions were excellent and there was no disease. The German Military Hospital was overcrowded but work proceeded satisfactorily there with a full staff of doctors, orderlies and nurses. Food and wine were plentiful.

The following photographs were taken in Camp I at the time of liberation.

General View of Camp I.

General Views of Camp I.

- View of Main Road of Camp I.

- Interior of a Camp I hut - note overcrowding.

-Interior of a Camp I hut - note overcrowding.

4. Diseases prevalent in the Camp.

The most prevalent disease was undoubtedly the clinical syndrome of starvation. The most obvious deficiencies were those of protein, carbohydrate, fat and water. Vitamins and salts were deficient in varying degrees and no case attributable to deficiency of any single factor was seen. The starvation resulted in extreme emaciation with complete loss of subcutaneous fat and muscular atrophy. The latter was most evident in the glutei muscles where extreme wasting left a hollow between the sacrum and the greater trochanter. All the bony eminences of the trunk, limbs, extremities and face could easily be seen as well as palpated.The eyes

eyes/ were sunken and the cheeks hollow. The thoracic cage was covered with a thin layer of atrophied skin. The abdominal wall was atrophic and markedly retracted giving a scaphoid abdomen. Whilst a few of the more recent arrivals in the Camp and of the more robust internees did not show these features it was noted that such was the picture in the vast majority of cases. Mass weight taking was unnecessary but the following figures quoted from Mollison (1946) give a fair indication of weights. The average weight of eighteen males was 44 Kilograms (extremes of 38.7 to 59.7Kgs.); of eleven females the average weight was 35.3 Kilograms (extremes of 25 to 45.5 Kgs.). In eleven cases where the previous weight was known the average loss was 38.8 per cent (extremes of 45 to 18 per cent).

Many cases of starvation showed oedema of the extremity and face, in degrees varying from slight pitting of the ankles to gross anasarca. Whilst several of these cases gave a history or signs compatible with a cardiac or renal lesion in the form of a gross valvular lesion with disturbed cardiac rhythm or casts and haematuria, the majority were undoubtedly nutritional in type. Lipscomb (1945) gives the incidence of oedema in an unspecified but large number of cases as six per cent. Many of the non-oedematous cases however developed oedema after admission to hospital. Mollison

Mollison (1946) gives a table showing the relation of serum protein levels to oedema. This table is set out on the next page - p.35. It shows a lowering of the average serum protein concentration in each group of cases, proportional to the degree of oedema. Two cases encountered by the author showed oedema of the hands and feet associated with absent ankle jerks, tender calves, tachycardia and enlargment of the heart.

Vitamin Deficiencies.

No frank single deficiency was seen and many suggestive manifestations could be attributed to constant scratching of the skin, infections of the eye and the fact that many cases had been lying in the darkness of the huts for weeks.

Vitamin A. No frank skin lesion to suggest phrynodermia were observed but dry skin with follicular hyperkeratosis, especially of the extremities, was a common manifestation. Keratomalacia was not seen but xerophthalmia, conjunctivitis and photophobia were observed in several cases.

Aneurin. Angular stomatitis and painful red glazed tongues were frequently seen but no true magenta coloured "geographical" type of tongue. No corneal vascularisation was observed. As mentioned above follicular hyperkeratosis was a common manifestation.

Relation of Serum Protein Levels to Oedema.
from Mollison, P.L. (1946). Brit. Med. J., 1, 6.) see p34

Group	No. of Cases	Average Serum Protein Concn (g.%)	Range of Serum Protein Concn. (g.%)
Severe oedema	4	4.0	3.6 - 4.4
Moderate oedema	10	4.7	3.5 - 6.5
Slight oedema	13	5.1	4.5 - 5.9
No oedema	23	5.8.	4.5 - 7.5

Nicotinic Acid. Though diarrhoea was prevalent and tongue changes as described above and neuritis manifestations were seen, no typical pellagra rash was ever observed.

Ascorbic Acid. Mouth lesions of a septic nature were extremely common but no frank advanced case of scurvy with bleeding gums and haemorrhages was seen. Practically all cases showed debility and anaemia but this could in no way be attributed solely to Vitamin C deficiency.

Vitamin D and Calcium. No osteomalacia or rickets was encountered. Tetany however was observed. It varied in degree from the fully developed case with carpopedal spasms to the latent case with positive Chovstek's and Trousseau's signs.

Anaemias.

The vast majority of cases showed pallor of the conjunctivae and mucous membranes. Mollison (1946) investigated the bloods of seventy five cases and found all to be anaemic. The anaemia was of a normochromic, normocytic type suggestive of a diminution of marrow output rather than a defective maturation. His findings are shown ~~are shown~~ on the next page - p.37.

Skin Diseases and Lesions.

These conditions were extremely prevalent. Bites by lice, fleas and bedbugs were universal and in the majority of cases constant scratching caused

Summary of Blood Findings .
(from Mollison,P.L.(1946).Brit.Med.J.,1,6.)--see p.36.

Group	No. in Group	R.B.C. per c.mm.	Hb (%)	Hb (g.%)	Hmt. (%)
Starvation cases (males)					
Non-tuberculous					
Good evidence	9	3,403,000	62.2	9.7	30.9
Insufficient evidence	7	3,610,000	66.9	10.4	33.6
Tuberculous					
Pleural effusions only	5	3,450,000	61.4	9.6	29.8
Active pulmonary Tb.	9	3,380,000	60.1	9.4	29.8
Average	30	3,450,000	62.5	9.8	31.0
Starvation Cases (females)					
Non-tuberculous					
Good evidence	8	3,310,000	60.2	9.4	29.3
Insufficient evidence	6	3,060,000	52.7	8.2	27.5
Tuberculous					
Active pulmonary Tb.	9	3,130,000	57.9	9.0	29.2
Average	23	3,180,000	57.3	8.9	28.8
Starvation cases (children)	7	3,520,000	61.2	9.6	29.9
Controls (healthy British males)	12	5,255,000	98.7	15.4	47.2

caused/ infection and ulceration.Cellulitis of one or other extremity was not uncommon. Scabies and impetiginous lesions were widespread. Many bed-ridden patients had bedsores, all of which were infected. They occurred in the usual sites, over the sacrum, behind the shoulders, heels and elbows. They showed no unusual features apart from their severity and their occurrence irrespective of age. The author observed one in a bedridden female aged twenty nine years who had lain in her own excreta for fourteen days. It measured six inches by four inches and was situated over the sacrum which was exposed; smaller subsidiary sores were present over the ischial tuberosities.

On the other hand many emaciated bedridden internees showed no bedsores in spite of having no nursing attention or means of prevention.

Cancrum Oris.

Twelve cases of this condition were observed. It presented no unusual features except the extent to which it could spread and yet be compatible with life. Two severe cases are known to have recovered under combined penicillin and sulphathiazole therapy. All cases seen had marked pyorrhoea and dental caries.

Alimentary Conditions.

Infections of the mouth were extremely common. Pyorrhoea of a severe degree was usual

usual/ and many cases showed whitish grey necrotic debris and ulceration typical of a Vincent's infection of the gum.

Diarrhoea was universal throughout the Camp. The stools (of which scores of fresh specimens could be seen on the hut floors daily) were never observed to contain blood or mucus. They were usually of a creamy consistency, were pale brown in colour and somewhat bulky. Frequently they contained undigested food particles. The diarrhoea varied in severity with the state of nutrition of the patient. In the healthier better nourished internee, with less upset of digestive function, the features were a colicky central abdominal pain associated with the passage of three to four loose stools daily. There was no anorexia, vomiting, abdominal tenderness or rigidity and the condition cleared up in three to four days with dietetic measures. In the more emaciated types the stools were more numerous and watery. Pyrexia was present up to 101' F. There was associated nausea and vomiting, some abdominal tenderness and slight rigidity. In several cases incontinence with marked dehydration occurred and in the more debilitated, emaciated internees death was precipitated.

This outbreak of diarrhoea occurred immediately after the arrival of British troops in the area. At this time fighting troops distributed solid food

food/ to the internees with these disasterous results. The feeding of the internees constituted a major problem in the Camp and in patients evacuated to hospital. Many different types of diet were tried including Bengal Famine Mixture (20 Kgs. sugar; 12 Kgs. dried milk; 15 Kgs. flour and 5 Kgs. salt to 300 Litres of water - - 1 Litre per patient distributed) and Protein Hydrolysate, but it was manifestly impossible to suit the varying conditions and digestive tracts of some twenty to thirty thousand ill people. Indeed, for any internee to adhere to a diet was quite exceptional. Food was the one thing that mattered to them and all types of food were hoarded away by internees.

The dietetic measures used subsequently in hospital are full described by Lipscomb (1945) and Vaughan et Alia (1945).

Whilst there may have been some cases of nutritional diarrhoea due to nicotinic acid deficiency, the vast majority were due to overfeeding with solids. A proportion amounting to 8 per cent. and 15 per cent. in two un-numbered series of cases showed a positive B.Dysenteria (Flexner II) culture of stool. The dietetic origin was further borne out by the complete failure of sulphaguanidine, tannalbin, kaolin and charcoal to control the diarrhoea. All were tried in large doses but with few exceptions no

no/ improvement resulted. Careful dietetic measures in hospital appear to be the only effective remedy. No outbreak of diarrhoea occurred among British Army personnel working in the huts of the Camp but cases were reported among the medical student workers

Mental Conditions.

With a few individual exceptions normal standards of behaviour were absent. For most of the internees life had become a matter of self preservation. Thus self consideration came before consideration of one's relatives and friends. This attitude extended to many of the comparatively fit internees as well, and proved a source of considerable trouble to those working in the camp. At times it was impossible to carry out an orderly evacuation of huts. As soon as bearers arrived in a hut with stretchers, they were swept out of the door by a mass of hysterical internees, all shouting in many languages and clamouring to be evacuated. No consideration was given for the unfortunate internees on the floor who bore the brunt of the stampede. No amount of reasoning and shouting by interpreters could restore order on these occasions; even the threat of force frequently failed necessitating the leaving of the evacuation of the hut till the following day.

Many feeding difficulties at the outset were

were/ due to this lack of sense of communal responsibility. The healthy internees collected food from the kitchens in large containers and were responsible for the distribution in their respective huts. In several cases the distribution went no further than the particular internee's circle of friends or those of his or her nationality. Any that remained was carefully hidden against a future day of shortage. Others in the hut were completely ignored and many who could not fend for themselves were not fed for several days when adequate supervision by reliable internees or British personnel could be ensured. The phobia of future shortage was very real to many internees and even some weeks after liberation they would hoard crusts, pieces of meat and other oddments of food under their pillows.

Coupled with this abnormal behaviour was a marked loss of self respect and loss of sensitivity to surroundings. The surrounding scene of dead bodies, of squalor and filth, of scores of people defaecating in situ seemed to cause no mental reaction whatsoever. This was most noticeable in the children the majority of whom seemed quite oblivious to their surroundings; in those whose physical state was reasonably fit there was no evidence of mental abnormality.

Once evacuated from the Camp into better surroundings, the improvement in morale and behaviour

behaviour/ among the internees was very marked. Self respect and a sense of responsibility returned.

A few cases of acute mental derangement complicating typhus fever were seen. Otherwise no psychoses were encountered.

Infectious Diseases.

The predominating were pulmonary tuberculosis and typhus fever. Neither typhoid fever nor cerebro-spinal fever was seen nor have other observers described cases.

Eight cases of diphtheria were diagnosed on clinical grounds; six of these subsequently showed positive swabs in hospital.

Pulmonary Tuberculosis. This disease was very prevalent and is already a major post-war problem on the continent. Lipscomb (1945) reports 6.6 per cent. positive, 5.3 per cent. probably positive and 7.7 per cent. possibly positive over an unselected series of three hundred and thirty one patients who were fit to be screened. Mollison (1946) reports an incidence of at least 40 per cent. in sixty four cases and is of the opinion that the incidence was higher among those that died. Davis (1946) reports ten thousand cases among the living in the Camp at the time of liberation.

Cases seen by the author showed no unusual features being characterised by wasting, tachycardia,

tachycardia/ cough, thick sputum and abnormal physical signs in the chest.

Diseases among the Children.

Before proceeding to a description of typhus fever in the Camp it would be appropriate briefly to deal with the child internees. Compared with the adults they were in a better physical state They numbered some five hundred and were concentrated in two huts in the women's compound. Largely due to sacrifice by the women in these huts the children showed less malnutrition than the adults. There were several cases of typhus fever among them but no case of other infectious disease was seen. Marasmic infants were common but no obvious clinical rickets was encountered. Many of these children had been born in the Camp maternity hut. This differed in no way from the other huts excepting it was somewhat cleaner, though grossly overcrowded. The medical staff consisted of one doctor without instruments or drugs.

Typhus Fever.

There was no certainty as to when the epidemic started in Belsen Camp but internee doctors gave the date as being the middle of February. Likewise the source of infection is unknown.

It is impossible to state the numbers of internees who had succumbed to typhus prior to liberation of the Camp. At the time of liberation

liberation/ it was estimated there were some three thousand five hundred cases of typhus in the Camp I. By May 14th, the last case had occurred among the internees. There were no cases in Camp II at the time of liberation.

Clinical Features. The cases of typhus in Belsen presented no unusual clinical features. Cases of varying severity were seen but malnutrition was so widespread it was impossible to assess accurately the severity of the typhus fever itself.

The onset was usually sudden, premmonitory symptoms of anorexia, feeling of chill and general malaise lasting but for a few hours to one day. Severe frontal headache, giddiness or severe lumbar backache were the common initial symptoms. Rigors were uncommon. In a few severe cases the onset was marked by acute delirium.

A slight pyrexia lasting for a few hours was an early feature but within two to three days the temperature had risen to 103' to 105' F.

Flushing of the face with marked congestion of the conjunctivae was soon observed, giving the patient a typical dusky complexion with a dull, somewhat stupid expression. A dry cough due to an upper respiratory catarrh or bronchitis was a common symptom in the first few days of the illness.

Physical examination in the first two to three days usually revealed the following;-

Alimentary System. Vomiting was not a feature though anorexia was common. Diarrhoea was present in the majority of cases, probably due to the faulty feeding already referred to on page 39. Occasionally the spleen was palpable but otherwise the abdomen showed no abnormal physical signs. The tongue was always coated and sometimes showed enlargement in the early stages. After the fourth or fifth day it became dark red in colour, dry and smaller than normal.

Cardiovascular System. Tachycardia with hypotension was a constant feature but in view of the widespread tuberculosis and malnutrition it was impossible to attribute this solely to typhus. Nevertheless it was always present in those cases where nutrition was good and there was no obvious evidence of tuberculosis. A soft, blowing systolic murmur at the mitral and pulmonary areas was frequently found.

Central Nervous System. The most striking feature of the cases was the mental change. Stupor was an early feature and this became progressively more marked until at the end of four to five days the patient showed the low muttering delirium of the typhoid state. Where acute delirium marked the onset, restlessness continued throughout the illness. In both types insomnia was a common feature.

Coupled with the mental changes was lassitude leading to marked muscular prostration.

This was an early and prominent feature which became more marked as the case progressed until at the end of four or five days the patient lay in a helpless state almost oblivious to external stimuli.

The Rash. The rash usually appeared on the third to fifth day. It varied in degree and distribution according to the severity of the case. Starting on the sides of the chest and back, it spread to the abdomen and limbs. It was never seen on the face, palms or soles. In a case with a fully developed rash, the latter was always most profuse on the trunk; in the milder cases it was frequently absent altogether from the limbs and its appearance on the trunk was transient.

The rash commenced as a faint mottling "in" rather than "on" the skin. There then appeared faint pinkish macules with no clear cut defined margin. At first they faded on pressure. Later they became dark red and then brownish in colour; at this stage they did not fade on pressure. Being irregular in shape and outline the fully developed case showed a blotchy appearance of the skin. In some of the severe cases the rash became slightly raised and showed petechiae.

Progress of Cases. In uncomplicated cases the temperature fell by crisis or lysis. At this stage a marked improvement usually occurred in the general

general/ condition of the patient. The appetite returned, the tongue became moist and the mental state more alert. General weakness however, continued for some considerable time.

The Weil-Felix Reaction. The author had no facilities for obtaining Weil-Felix reactions. The only reference to these is that of Mollison whose findings were as follows;-

In forty eight cases examined twenty one showed a titre of 150 or more; twenty seven cases were negative or gave a titre of 150 or less. Of twenty six of these tests done in May,1945 twelve were positive and of twenty two done in June or early July,1945 nine were positive. Of nineteen patients who said they had not had typhus ten had negative and nine had positive Weil-Felix reactions. Of nine patients who said they had had typhus five had positive and four had negative Weil-Felix reactions. From these figures Mollison reaches the general conclusion that the majority of patients in Belsen had recently had typhus.

Complications. The following were all observed and when occurring in starved patients usually proved fatal; bronchopneumonia, cardiac failure, bedsores, cancrum oris, gastro-enteritis and otitis media.

5. <u>Measures adopted to deal with the situation.</u>

The immediate problems confronting the British units at Belsen were enormous - the burial of the dead, provision of adequate water and food supply, provision of sanitation and of hospital facilities, evacuation of the sick. All these problems applied in much greater measure to Camp I than Camp II therefore the authorities decided to commence work on Camp I immediately and later to deal with Camp II.

Mass graves where dug by bulldozer and German civilian labour. The former S.S. guards and Hungarians were employed in removing the bodies to these graves. The daily death rate on 30th April, 1945 was five hundred and forty eight. By 17th May, 1945 it had fallen to ninety seven.

Deep trench latrines were erected throughout the camp and a start was made in cleaning up the filth and excrement littering the camp.

Food and clothing were rushed to the camp from army and German sources.

<u>Provision of Hospital Facilities.</u>

It was fortunate that the vast Wehrmacht Barracks were near at hand and practically unoccupied. Each day a square of five blocks was equipped with about six hundred and fifty beds, ready to receive cases the following day. Each of these squares had a central canteen for workers and adequate cooking

cooking/ facilities for all patients. The blocks were staffed by internee doctors and nurses who volunteered for the work, and were placed under the supervision of British doctors and nursing sisters. Further accommodation was provided by the evacuation of the German Military Hospital, a thirty bedded wing of which was earmarked for possible casualties among British personnel working in the camp.

Drugs and dressings appeared to be a major problem but the district around Celle and Hanover was the site of many Wehrmacht Base Medical Stores. Hence in a matter of four to five days a well stocked dispensary was established in the middle of the hospital area. At the end of a fortnight this could adequately cope with the needs of some thirteen thousand patients.

Feeding of Patients in Camp I.

This was carried out from the large central kitchen in the camp. Reference has already been made on page 40 to the difficulties encountered.

Evacuation of Camp I.

The evacuation of the camp began on 21st April,1945.. In view of the large numbers of internees in the camp and the appalling conditions which were rapidly deteriorating, it was decided that speed of evacuation was essential. With this in mind cases were loosely divided into "fit" and "unfit". The "fit" persons were those who were

were/ able to walk and look after themselves. They were evacuated by truck to an area of the barracks which became known as Camp III; it adjoined the hospital area. The "unfit" were those cases who were helpless and bedridden. To begin with an attempt was made to evacuate typhus cases only. The time involved in making a clinical diagnosis resulted in considerable delay in evacuation. Further delay was caused by the internees who adopted endless subterfuges and caused considerable uproar when they found certain inmates being apparently favoured and taken from the huts whilst they were left. Therefore the system of evacuating huts completely was adopted, a start being made where sanitation and general conditions were worst.

The evacuation of the "unfits" was done by ambulance. Each day two teams worked in the camp from 8 a.m. till 5.30 p.m. with a half an hour break at midday. A team consisted of one officer six stretcher bearers, nine drivers and nine ambulances. It was found any greater number of ambulances caused delay on the road leading from Camp I to the hospital area. After trial and error it was found that speediest evacuation could be carried out by teams of the above numbers. About six hundred to seven hundred casualties were evacuated daily. By the 18th May, 1945 when evacuation was completed thirteen thousand eight hundred and

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and/ thirty four casualties had been evacuated from Camp I to the hospital area.

In all fifty five men were employed at one time or other inside the huts, Their work consisted in stripping the patients, wrapping them in blankets, loading them on stretchers and then on to the ambulances. Each patient had a provisional diagnosis marked on the forehead (T = typhus, Tub = tuberculosis, E = enteritis) prior to being loaded on to the ambulance. Some of the British ambulances were later replaced by those of the American Field Service driven by American personnel.

Whilst the work of evacuation was proceeding, certain huts in the camp were converted into a small hospital area. Huts which had been evacuated and disinfested were used and in them the most sick were cared for pending evacuation. This small hospital was staffed by medical students and internee nurses. The work commenced on April 28th, 1945 and did much to help the sick in the camp; it was a great factor in maintaining morale among internees who were still awaiting evacuation.

A photograph of the evacuation of a hut is shown on page 55.

6. Measures adopted to deal with the epidemic of louse-borne typhus fever.

General Measures.

These measures were put into force as soon as the camp was liberated. Warning notices "Danger Typhus Fever" were posted on all roads, at a distance of three miles from the camp. Camp I, where typhus prevailed was already surrounded by a double wire fence. The Hungarian regiment were posted as guards around the wire, with the object of preventing internees from escaping. In spite of this many internees escaped and were daily encountered on roads from the camp, sometimes at considerable distances away. The striped concentration camp uniform was a common sight in the town of Celle some fifteen miles distant. It is not known definitely that all who escaped were sufferers from typhus but the assumption is justified that, if not actually incubating typhus fever, they were heavily infected with lice. Thus two French soldiers who had escaped from Sanbostel Camp, some twenty miles distant from Belsen, reported sick to the Glyn Hughes Hospital. The former German Military Hospital had been thus renamed by the British. Both were found to be suffering from typhus fever which at that time was present in Sanbostel Camp.

A system of passes for entrance to Camp I was introduced. Every person entering the camp

camp/ had to be dusted with 5 per cent. D.D.T.powder. The dusting was done by means of a large hand gun with a nozzle some fifteen inches long. One method of dusting was universally employed throughout the Camp. The subject to be dusted kept his clothes on and the nozzle of the gun was passed up one sleeve next to the skin and two strokes of the gun handle were made. This was then repeated for the other sleeve, each trouser leg from below and above, down the front and back of the neck and under the headgear. The outside of the socks and footwear was liberally dusted. It was found that ten persons could be dusted with one pound of powder. This method of dusting is shown on the next page-p.55.

Any vehicle passing in~~to~~ to the camp for the purpose of conveying internees was liberally dusted inside. This applied particularly to the ambulances used in evacuation. They were swept out at the end of each days work and a fresh dusting was applied.

As soon as a hut in Camp I was evacuated it was dusted. The work was done under the direction of Captain W.A.Davis of the U.S.A. Typhus Commission whose unit commenced work in the camp on 22nd April,1945 and completed its task on 25th May,1945. A ten gun power driven duster was used for this work; for most of the time 5 per cent. D.D.T. powder was used, the 10 per cent strength urgently asked for being delayed in arrival. This unit also carried out the dusting of all

The evacuation of huts in Camp I. See p.51

Method of dusting with D.D.T.powder. See p.54.

all/ "fit" internees as they were evacuated from the camp.

Measures to prevent spread of typhus infection by Internees.

The "unfit"evacuated by ambulance were all stripped and wrapped in blankets before leaving the hut, the ambulance and blankets being previously dusted with 5 per cent D.D.T.. On reaching the barrack area the ambulance immediately reported to the "human laundry". This was a converted stable with some twenty four tables and a liberal supply of hot water from a portable boiler. Here the internees were unloaded from the ambulance; their hair was clipped and they were washed with soap and water. A thorough dusting with D.D.T. was then applied. They were then loaded on to clean stretchers and blankets and driven in non-contaminated ambulances to the hospital blocks. The "human laundry" was staffed by German nurses and orderlies working under British supervision. Photographs of the "human laundry" are to be found on page 57. Of forty nine of these nurses engaged in this work thirty two contracted typhus. None had received typhus vaccine. All wore operating gowns and a few wore masks. One British and one German barber were employed in clipping hair at this centre. Both wore operating gowns but no masks. The British barber had been inoculated against typhus (see page 58) but not the German. Both contracted typhus fever and whilst the

Interior of the "human laundry" - note extreme emaciation of the subject being disinfested.
See page 56.

Unloading of cases outside the "human laundry".
See page 56.

the/ German died, the British barber survived.

<u>Measures to prevent infection of British Army personnel employed in the evacuation of the huts.</u>

It is to be noted that these were all Royal Army Medical Corps personnel who were fully alive to the dangers of infection involved in the work and who could be relied on to take all proper precautions. All excepting one had been vaccinated against typhus fever within four months of entering the camp. The inoculation consisted of three 1 c.c. injections at weekly intervals of Craigie type of vaccine. All wore typhus suits whilst working in the camp. These were put on each morning prior to leaving for the camp and at the same time a dusting with 5 per cent. D.D.T. powder was applied. The suits consisted of a one piece garment complete with hood and boots. They were made of a khaki twill material and tied by tapes at the back. It was soon found that with the fabric boots of the suits being worn on top of the normal footwear the former rapidly became torn. This was overcome by wearing the normal footwear outside the suit and improvising puttees. Battle dress trousers and blouse were worn under the typhus suit. Gauntlets of a khaki twill material bound in position by tapes were worn by all personnel. Masks were never worn. Photographs of the anti-typhus suits are to be found on page 59. At the midday break the typhus suit was removed and dusted with D.D.T.; prior to the

The anti-typhus clothing worn by British personnel - See page 58.

the/ putting on of the suit for the afternoon's work each person was again dusted. Ambulance drivers were not required to actually handle patients; they did not wear protective clothing but were dusted daily.

In the evening each man had a bath and a medical examination to exclude infestation with lice. At the same time his clothes were placed in a steam disinfestor. At no time did any of these men find lice on themselves, nor were any found at a medical inspection.

Measures to prevent infection of Medical Students who were working in Camp I.

All had been inoculated against typhus within one month of entering the Camp area. None wore protective clothing or masks since they commenced work in the Camp after all the huts and internees had been dusted with a 5 or 10 per cent. D.D.T. powder.

7. Incidence of louse-borne typhus among British and German personnel working in the Camp.

Among the British personnel working in the Camp the following contracted typhus;-

a) Eighteen Royal Army Medical Corps personnel, seventeen of whom worked in the huts in intimate contact with the internees. The other case was the barber who was employed in clipping the hair of the internees at the "human laundry".

b) Six medical students all of whom worked in the

the/ camp.

Requests for the case sheets of these cases (including the author's own) have been refused by the War Office but certain features of these cases can be recorded. All were of short duration, none running a temperature beyond the ninth day after onset. The fever varied considerably from case to case, some showing a maximum of 101' F., others 104' F.. All cases took a minimum of two days to reach the maximum pyrexia.

The onset was marked by six to twenty four hours anorexia and vague malaise. This was followed by frontal headache and lumber backache. Of the twenty four cases treated eight developed a severe typhus state. These cases all showed an extensive rash. Other cases showed transient or mild rashes. No deaths occurred and complications arose in one case only. This was a sergeant who developed severe haematuria. One other case developed jaundice some fourteen days after becoming apyrexial from typhus. The features were typical of infective hepatitis and recovery was uninterrupted.

Whilst the exact readings of the Weil-Felix reactions in these twenty four cases are not available to the author, it is known that the readings varied considerably. Several of them showed a low or negative titre. Topping (1944) has proved that negative Weil-Felix reactions are of no

no/ value in excluding typhus fever in subjects vaccinated against the disease. He records seven cases in vaccinated laboratory workers. None had Weil-Felix reactions which reached the heights seen in seven unvaccinated control subjects; in fact three of the seven vaccinated subjects failed to develop a Weil-Felix reaction of significant titre. Similar observations in the case of the experimental animal were first made by Munter (1929). He inoculated rabbits with typhus virus and after a suitable time they developed agglutinins for Proteus OX 19. After several months, when the Weil-Felix had returned to the normal level, the rabbits were re-inoculated, some with Rocky Mountain Spotted Fever and some with typhus virus. Those receiving the homologous strain failed to develope a rise in agglutinins for Proteus OX 19.

Among the German personnel the following contracted typhus:-

a) Of the sixteen S.S. men employed in burying the dead in Camp I twelve were affected. Ten of these died.

b) Of forty nine German nurses employed in the "human laundry" thirty two developed the disease. The exact death rate is unknown but it is known that at least six cases died.

S E C T I O N   III.

DISCUSSION.

A. The aetiology of louse-borne typhus fever

B. Measures of control in an epidemic.

C. Anti-typhus vaccines.

A. THE AETIOLOGY OF LOUSE-BORNE TYPHUS FEVER.

1. Rickettsia Prowazeki.
2. Mode of Infection.
3. Mode of spread of louse-borne typhus fever at Belsen among internee and British personnel.
4. Conditions predisposing to the outbreak of louse-borne typhus fever at Belsen.

1. R.Prowazeki.

The casual organism is now accepted to be R. Prowazeki. In 1909 (a) Nicolle first demonstrated the transmissibility of the disease by inoculating a chimpanzee subcutaneously with blood from a patient. The chimpanzee developed the disease. Again in 1909 (b) Nicolle working with Comte and Conseil transmitted the disease to monkeys by the bites of lice which had fed on an infected chimpanzee. This demonstrated the louse to be a vector of the disease. In 1910 Ricketts and Wilder first described pleomorphic organisms in the bodies of infected lice. In 1916 Prowazek and da Roche Lima studied the organisms and an accurate description was given by the latter who called them Rickettsia Prowazeki. His work was confirmed by Nöller in 1916 and also by Töpfer and Schüssler(1916) The orgamisms are small resembling cocci or bacilli. They stain well with Giemsa's reagents and are gram-negative. They only grow in the presence of living cells such as developing chick embryos or in tissue culture. Monkeys are susceptible to infection as also are guinea-pigs and white mice. The rickettsia multiply exceedingly in the mid-gut of infected lice.

Gavino and Girard (1910) were the first to study the resistance of the virus to heat. In May, 1910 they carried out an experiment on a monkey and

and/ infested the latter with virus containing blood which had been heated to 50' C. for forty minutes. Subsequently using blood at 55' C. for fifteen minutes they failed to infect a monkey. In October, 1910 however, Nicolle, Conor and Conseil found the virus lost its heat after heating at 50' C. for fifteen minutes. All the above experiments were carried out by intraperitoneal inoculation of a monkey with citrated or defibrinated blood. They do not take into account the possible natural immunity of the monkey. In 1911 Anderson and Goldberger carrying out a similar series of experiments concluded that the virus is deprived of its virulence by heating at 55' C. for fifteen minutes.

2. Mode of Infection.

In their experiments of 1909 Nicolle, Comte and Conseil used the body louse, Pediculosis humanis corporis, and succeeded in transmitting the disease from one monkey to two others by these lice. In 1911 Nicolle and Conseil reported further successful experiments in transmission of the disease in monkeys by means of the bite of infected lice. At the same time Anderson and Goldberger presented the first evidence incriminating the head louse Pediculosis humanis capitis. Using Mexican virus they successfully transmitted the disease to monkeys by subcutaneous injections of crushed insect. They suggested the disease could be transmitted by the

the/ bite of the insect.

Nowadays it is believed lice do not infect directly by their bites since the rickettsia do not enter the salivary glands of the insect. They infect indirectly by means of their infected faeces which are deposited on the skin and which enter the body through the bite wound in the skin or through abrasions due to scratching (Rogers and Megaw, 1944).

The infectivity of the buccal and pharyngeal secretions was first studied by Otero in 1906. He smeared the throat of a human subject with a gauze swab impregnated with pharyngeal secretions of a patient in the tenth day of the illness. Seventeen days later the throat of the same subject was again smeared with a swab impregnated with saliva from a patient in the twelfth day of the illness. These inoculations were not followed by any symptoms. That this subject was susceptible is shown by the fact that he subsequently contracted typhus following inoculation with infected blood. Anderson and Goldberger (1912) made one test to ascertain the possibility of infection by this route. They injected a Rhesus monkey subcutaneously with the buccal and pharyngeal secretions of a patient in the sixth day of the illness. The monkey gave no evidence of typhus reaction and was resistant to an immunity test thirty two days later. Anderson and Goldberger state that this evidence hardly justifies definite conclusions, but

but/ in the light of the epidemiology of the disease they consider that the secretions are not infective and droplet infection plays no part in the transmission of the disease.

Poole and Bensted (1943), on the other hand, draw attention to the high incidence of typhus among medical and nursing attendants and attribute this to possibility of direct droplet infection. They also state that there is little doubt that the laboratory infections so common in typhus research workers are often acquired in this way from animals. Loeffler and Mooser (1942) report on six cases of typhus occurring in laboratory workers due to droplet infection from animals whilst preparing vaccine. Nicolle and Sparrow (1932) have shown that the instillation of a drop of virulent emulsion of rickettsia on the nasal mucosa or on the conjunctiva regularly induces in man a general typhus infection. Allowing for droplet infection possibly being of some importance in the spread of the disease, the true epidemic spread however is always associated with louse infestation.

The third and last mode of spread to which reference must be made is that in which infection is due to the inhalation of dried louse faeces. Dried infected louse faeces have a high infectivity; Rogers and Megaw (1944) state that rickettsia can survive for months or even years in the dried faeces of infected lice, and suggest that persons who handle

handle/ clothing of patients are liable to be infected by inhaling the dust coming from garments even after the latter have been stored for long periods.

Blanc et alia (1938) have shown that dried flea excreta infected with murine typhus can transmit infection to man if placed on the nasal mucosa or conjunctiva. They deduce it is possible that louse-borne typhus can also be transmitted by the oral-route.

In 1939 Castaneda succeeded in infecting mice and rabbits with typhus by the intranasal introduction of suspensions of R. Prowazeki into the lungs.

Klose (1942) describes an epidemic among Russian prisoners of war, in which German personnel working inside the disinfestation centre and certain workers who did not go near the disinfestation centre, acquired typhus. All these workers were louse free and had their clothing regularly disinfested. He suggests that the infection was due to the dust spread of louse faeces, the organism entering by inhalation or smear infection. Liebau (1942) describes the infection of a German doctor due to blood smear from infected patients.

Chalke (1946), on the other hand, states that had dust spread been even "remotely possible" in North Africa the uninoculated British forces would have suffered heavily since conditions there were highly favourable for such spread. On the other hand, of forty six cases which were admitted to hospital with

with/ typhus from these forces only two were louse infested or showed evidence of bites and many of the forty six had no history of association with the Arabs amongst whom the disease was prevalent.

3. <u>Mode of spread of louse-borne typhus fever at Belsen among internees and British personnel.</u>

In reviewing the Belsen outbreak with regard to the mode of spread of the disease, it is necessary to note certain governing factors, notably the degree of exposure to infection and the preventive measures adopted by those who developed the disease. Reference has already been made to conditions prevailing among internees at the time of liberation (see page 26). Mass overcrowding was present and no attempt at disinfestation was being made. As a result the population was almost 100 per cent infested. In such conditions, there can be no doubt that the disease was largely spread directly by lice and inhalation of dried faeces and droplet infection played little part in spreading the disease among internees. However, this cannot be said of the British personnel who contracted the disease. Altogether eighteen Royal Army Medical Corps men developed the disease (see page 60). Seventeen of these had worked in the huts in intimate contact with the internees and patients. Elaborate precautions were taken to prevent infestation of these men. They wore suitable anti-typhus clothing (see page 58) but

but/ no masks. They were dusted twice daily with D.D.T. and had a daily bath and medical inspection. All had been inoculated against typhus. None of these were found to be infested nor did any find lice on themselves at any time. It is therefore justifiable to conclude that the mode of infection in these cases was either by droplet infection or by the inhalation or intra-ocular inoculation of dried louse faeces acquired whilst handling the contaminated clothing of patients being stripped in the huts.

The absence of typhus among those who worked in the camp but not in the huts is attributed to the fairly heavy rainfall which occurred at the time. This prevented dust spread out of doors.

It is to be noted that no case of typhus occurred amongst British personnel nursing the patients in the hospital blocks. All had been inoculated against typhus and all were dusted with D.D.T . Before admission to the hospital the patients had been stripped, washed and dusted with D.D.T.. Some had had their hair clipped. Therefore the possibility of infestation directly by lice from the patients or dust infection from contaminated clothing did not exist. The only possible mode of infection to which these workers were exposed was that of droplet infection. The absence of typhus among these workers supports the view that the infection of those who worked in the huts was by inhalation of dried louse

louse/ faeces or by intra-ocular inoculation rather than by droplet infection.

It is not known whether the thirty two German nurses who worked in the "human laundry" and developed typhus became infested or not. The possibility of direct infection by lice cannot be excluded in these cases.

4. Conditions predisposing to the outbreak of louse-borne typhus fever at Belsen.

Three fundamental conditions must exist before an epidemic of typhus can occur. These are:-

a). The virus of the disease must be present.

b). The vector of the disease must exist among the community.

c). The population must be receptive to the disease.

The presence of R.Prowazeki in an area may be due to its pre-existence there or to its importation by patients or by infected lice. Throughout the world there are certain areas where louse-borne typhus is endemic, notably eastern Europe (Poland and Rumania) and Russia. These areas are shown on the map on page 17. Biraud (1943) states that there were no civilian cases of typhus recorded in Germany in 1939. In 1940 six cases were notified and in 1941 three hundred and ninety five cases occurred. All these cases were in eastern Germany, that is, in those areas nearest the endemic region of Poland and Rumania. In 1942 however when one thousand and thirty two cases were recorded by the end of June, the disease appeared

appeared/ for the first time in the north western areas of Germany. Thus at the time of liberation of Belsen sporadic cases of typhus were occurring in the surrounding areas and it may be that the disease was introduced to the camp by such a case. A more likely explanation is that the disease was introduced by some prisoners from the eastern part of Germany. At the time of the outbreak (February to March, 1945) the Russians were advancing over Poland and eastern Germany. Mass movements of population took place and the Germans moved all slave labour and prisoners westwards.

It has been stated on page 27 that the second fundamental condition for an epidemic was amply fulfilled at Belsen. Nearly all internees were infested with lice.

Before considering the existence of a receptive population at Belsen reference to immunity in louse-borne typhus fever must be made. Megaw (1934) and Biraud (1943) state that one attack confers immunity, but this is not lasting and second attacks can occur in milder form some years later. Second attacks have been recorded by Murchison (1873). Mackenzie (1941) notes that partial immunity appears to exist in endemics areas and attributes this possibly to a milder form of typhus which may pass unnoticed by the individual. He states the milder form may be murine typhus. Of the internees present

present/ in Belsen, those from the endemic areas in the east may have had a degree of acquired immunity. This cannot be said of the western Europeans in the camp, since typhus is not endemic in France, Belgium, or Holland. Thus it can be said that the population of Belsen were at least in part receptive to the disease.

In general, an epidemic may be precipitated by an increase in the virulence of the responsible organism or by a diminution in the resistance of a community to the disease. Murchison (1873) first pointed out the association of famine and overcrowding in typhus epidemics. Since then all great epidemics have been accompanied by these two factors. Famine diminishes the resistance of the community and overcrowding facilities the movements of lice. Mackenzie (1941) stresses the importance of famine rather than overcrowding, quoting as an example the Kirghiz villages north of the Caspian Sea where typhus is endemic. Villages are cut off in the winter thus preventing movements of population and resulting overcrowding. Nevertheless in years of famine the disease becomes widely epidemic. He also notes the rapidity with which typhus disappears in a district once a supply of food becomes available. He does not mention however that when the latter becomes available in an epidemic, anti-typhus measures are usually brought into existence at the same time thus

thus/ tending to hasten the end of the outbreak. Belsen affords another example of the association of famine and overcrowding with epidemics of louse-borne typhus fever. Both existed in marked degree in the camp and it is impossible to state which was the more important as a precipitating cause of the outbreak.

B. MEASURES OF CONTROL IN AN EPIDEMIC.

1. Former methods of disinfestation.
2. Anti-louse Powders and Creams.
3. 2-2-bis(parachlorophenyl)1,1,1-trichlorethane (D.D.T.).
4. Results obtained with D.D.T. at Belsen.
5. Toxicity of D.D.T. to man.
6. Effect of D.D.T. on fabrics and materials.

In those parts of the world where louse-borne typhus fever is endemic the control of the disease has always constituted a major problem in peacetime. Its control in time of war is a potential problem to all armies. Hitherto whilst different countries have used methods which vary in detail, the underlying principles have been the same. These principles were enumerated by the 1937 meeting of Experts (Birand 1943) as follows:-

a) The intensification of measures for discovering louse infestation and for delousing.

b) The isolation of the sick (transfer to hospital) and of foci of infection (the establishment of sanitary cordons and the victualling of populations in isolation).

c) The collection and use of convalescents serum (particularly among non vaccinated subjects in contact with the sick).

d) The mass vaccination of populations in infected localities.

1. Former methods of disinfestation.

Of these principles, mass methods of delousing is undoubtedly the most important in dealing with any outbreak of louse-borne typhus fever.

Since Gavino and Giraud (1910) first studied the effects of heat on the louse and on R.Prowazeki many methods of disinfestation by heat have been employed.

Prior to 1940 the methods used by the British army were largely based on the use of heat. Many different types of disinfestor were used, ranging from the elaborate Manlove Alliot and Company model to low pressure steam models. Such equipment was only suitable for use in large static centres. Under field conditions of active service portable steam disinfestors were carried by certain units and a Serbian Barrel could readily be improvised by all.

McKenzie (1941) has described methods of disinfestation used in other countries. In Poland both steam and cyanide were used. In one centre where refugees arrived chiefly by train a tunnel was built into which hydrocyanic acid gas could be liberated. On arrival of the train all passengers were given a blanket and told to strip leaving their garments and all their belongings on the train. Each person was then bathed in hot water with soft soap and paraffin. Meanwhile the train was backed into the tunnel, the engine uncoupled, and cyanide gas liberated in the tunnel. When bathing of the refugees was completed, the train was pushed out of the tunnel and all compartments thoroughly exposed to the air. This completed the process of disinfestation. In Mesopotamia a complete train was used as a disinfestor, superheated steam being passed into the sealed waggons from the locomotive.

In Russia the method of disinfestation

disinfestation/ employed was be means of "Russian Baths". Log huts were built and heaps of stones with a fire turning underneath were erected on the hut floor. Water was thrown on the stones when the latter were sufficiently hot and the steam thus generated disinfested the clothing.

In China disinfestation by hot air was employed, the materials to be disinfested being placed in large brick ovens.

Relating his experience in Russia and Poland Owezarewicz (1942) described the use of various chambers employing dry air, steam or chemicals such as sulphur dioxide, hydrocyanic gas or chloropicrin.

All the above methods have certain obvious disadvantages. The apparatus required is cumbersome and therefore relatively immobile, necessitating that the material for disinfestation be brought to a centre. The smaller types of apparatus which are portable are limited in capacity and therefore mass disinfestation by them is time consuming. Many of the steam types of machine require skilled attendants to maintain necessary temperatures and pressures. If this is not done the apparatus fails to destroy lice. Using the above types of apparatus personnel whose clothing and equipment is to be disinfested have to strip completely. This necessitates adequate changing accommodation and a large supply of blankets or clothing. An important disadvantage of steam

steam/ disinfestation is that whilst it destroys lice and R. Prowazeki it destroys materials made of leather, fur, canvas and webbing or rubber. Similarly hot air above 60'C. not only destroys lice and R. Prowazeki but also leather, fur and certain cloth garments. Below 60'C. it does not destroy R. Prowazeki.

The chief disadvantage of the above methods however is that whilst they can be used for disinfestation of clothing and equipment they cannot be used for disinfestation of lice on the body. The latter necessitate that further measures be taken. This usually consisted of the shaving and clipping of the hair on affected personnel, followed by a thorough wash with some insecticidal solution. One such method was the thorough application of equal parts of olive oil and paraffin to the hair, leaving the patient overnight with the hair wrapped in a towel and next morning giving a wash in soap and water. This method does not destroy the eggs of lice however and it is necessary to remove the latter with a fine tooth comb. Palfrey, Wolbach et alia (1922) found a mixture of lightwood oil and kerosene to be effective. They did not wash the scalp however as they suspected that wetting the deep layers of dandruff in some patients interfered with the penetration of the oil, thus allowing the lice to survive. Many antiseptics have been used at one time or another but all have the

the/ disadvantage that it is impossible to ensure rapid death of lice with strengths of antiseptic which do not damage the patients skin. Thus the most reliable method was the mechanical removal by shaving and bathing. This is obviously a lengthy procedure where large numbers of people are involved. Moreover it gives no protection whatsoever against re-infestation.

2. Anti-louse powders.

To overcome the disadvantage of methods mentioned above repeated attempts have been made by different workers to produce an anti-louse powder. Such a powder must ideally have certain qualities. It should be quickly lethal to lice but must be non-toxic to man. It must be non harmful to fabrics, metal and leather and should be non-staining and non-offensive. It should be stable to sunlight and damp and must be long lasting in its louse killing properly thus preventing re-infestation. Simplicity in its practical use is a necessity.

Before 1940 the powder in use in the British army was a powder consisting of crude unwhizzed napthalene 96 parts, creosote 2 parts, iodoform 2 parts (N.C.I. powder). It quickly destroyed lice but had no powers of preventing re-infestation hence it had to be applied every three days (Craufurd-Benson and Macleod 1946).

In 1939 H.J.Craufurd-Benson and J. Macleod carried out extensive tests on Pediculosis humanis

humanis/corporis with various substances, seeking to produce an anti-louse powder which could be applied by an individual to his own clothing and which would prevent reinfestation. They found naphthalene to be the most effective insecticide for killing body lice quickly but it failed to give any protection against re-infestation. Derris and pyrethrum were found to be toxic to Pediculosis humanis corporis but either alone or in combination with each other they were inferior to other combinations of insecticides. Derris activated by a high boiling tar acid (H.B.T.A.), whilst slow in killing lice was found to be the best preparation which gave protection against re-infestation. The preparation A.L.63 was outstanding as the best preparation that controlled body lice. It destroyed them rapidly; when applied to the clothing of verminous persons it killed 95 per cent of all lice on the garment within twenty four hours and it gave complete protection against re-infestation for five days and partial protection for eight days. When applied to clean garments as a prophylactic measure A.L.63 gave complete protection for an average of seven to eight days and partial protection for approximately sixteen days. Patients living in verminous surroundings were made to wear one shirt continously for a month without washing it. Even under these conditions they were protected from infestation by treatment

treatment/ of the inside of the shirt at eight day intervals with A.L.63. The original formula of A.L.63 was high boiling tar acid 2 per cent, derris root 14.3 per cent, naphthalene 50 per cent, China clay 33.7 per cent. In 1941 when Japan entered the war derris root was no longer obtainable but it was found that South American cube root could be used instead and thus A.L.63 was introduced.

Graphs illustrating the results of Craufurd-Benson and Macleod are shown on pages 84 and 85.

In the Naples typhus epidemic of 1943 the original A.L.63 was solely used by the British army and by the twenty thousand civilians regularly employed by the British army(Chalke(1946)and Craufurd-Benson (1946)). One British soldier was infected; he was a deserter who was heavily infested when caught. As far as is known no case occurred among the civilian employees. This is an indication of the high efficacy of A.L. 63 though in the case of British army personnel, anti-typhus inoculation and enforced hygiene and avoidance of crowded places were important factors in the absence of disease.

In 1941 Busvine and Buxton recommended the use of one of the following as an insecticide for head lice:-

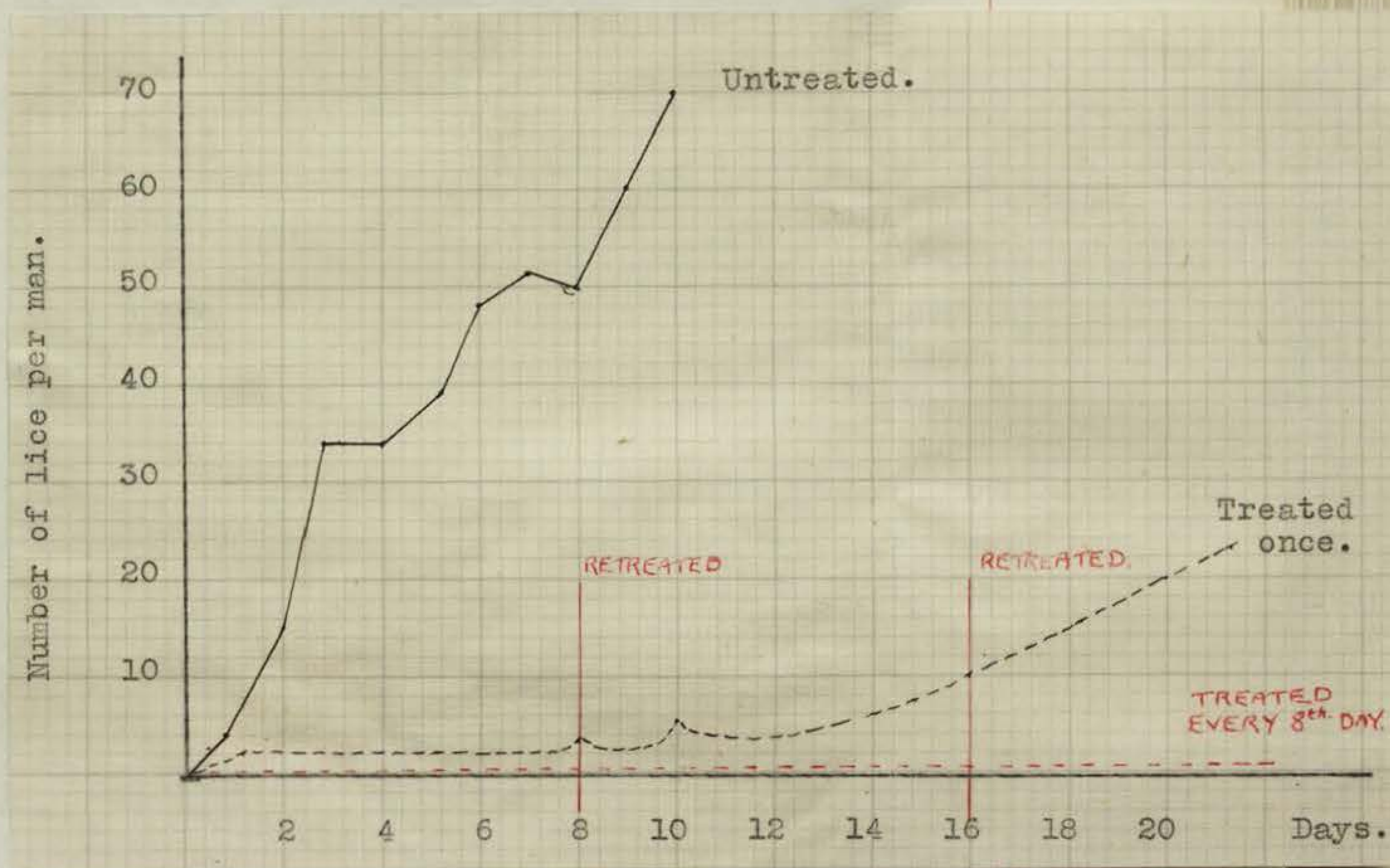
a) 25 per cent technical lauryl pheocyanate in a white oil.

b) 50 per cent lethane 384 special.

c) Derris cream.

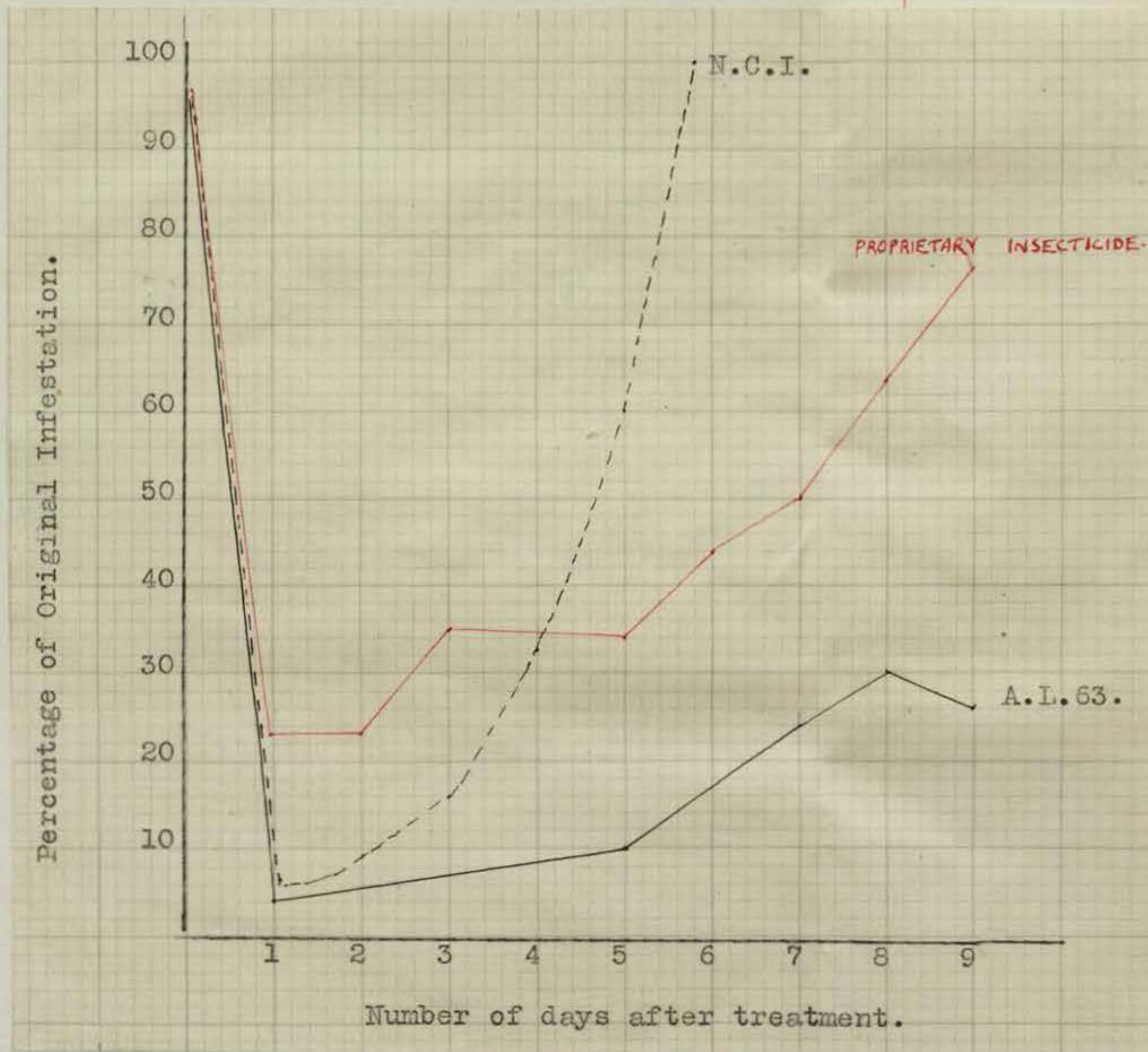
Protection against infestation of clean army shirts under verminous conditions - treated with A.L.63.

(from Craufurd-Benson, H.J., and Macleod, J. (1946). J.Hygiene, 44,294.).



Duration of protection after treatment of verminous persons.

(from Craufurd Benson, H.J., and Macleod, J.(1946). J.Hygiene, 44, 294.).



They found that all three prevented re-infestation for eight to nine days provided the hair is not washed or combed. They admit certain disadvantages especially the liability of thiocyanates and derris emulsions to cause dermatitis. This appears to be particularly liable if they are applied near the scrotum. In addition there is the usual disadvantage of appearance and unpleasantness of oily preparations on the skin.

The table below shows the findings of Busvine and Buxton (1941).

Results of Trials of Head-Louse Insecticides.

Experimental Subjects	Insecticide	No. of Cases	Failures (%)
Recruits to Service "A"	25% lauryl thiocyanate	55	1.8
Mediterranean evacuees	" " "	45	8.9
Recruits to Service "B"	" " "	51	7.8
" " " "	10% " "	18	39.0
" " " "	4% " "	20	60.0
" " " "A"	50% lethane special	26	7.8
Mediterranean evacuees	" " "	13	15.4
" "	Derris cream (1% rotenone)	12	8.3
Recruits to Service "A"	" " "	35	0
" " " "	Thin derris cream (1% rotenone)	187	1.1
" " " "	Thin derris cream (0.5% rotenone)	84	7.1

The powder used by the United States army in the early part of the war was M.Y.L., which contains pyrethum. In the extensive controlled series

series/ of experiments on human volunteers Davis and Wheeler (1944) found it to kill lice on clothing and to continue to kill new lice for at least ten days after application. They found that new larval lice emerged from the eggs but were killed showing that the efficacy of the powder was not due to any ovicidal action but due to the killing of the lice themselves. Craufurd-Benson (1946) and Chalke (1946) describe its use in the Naples typhus epidemic. In the early stage of the epidemic prior to January 1st 90 per cent of the powder used was M.Y.L. and this led to the checking and partial control of the epidemic, a significant decrease in case incidence resulting. The 10 per cent D.D.T. powder which was introduced after January 1st contributed to the final ending of the epidemic.

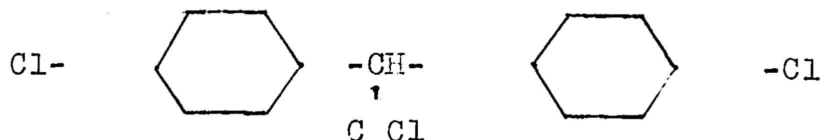
3. <u>2-2- bis (parachlorophenyl) 1,1,1-trichlorethane (D.D.T.).</u>

Before discussing the results obtained with D.D.T. powder at Belsen it is of interest to consider briefly the development of this substance as an insecticide.

Heilbron (1944) states it was first synthesised by Muller, one of the chemists in J.R.Geigy of Basle, who first recognised its insecticidal properties and took out patents protecting its use as an insecticide in 1940.

The following brief essentials in its chemical properties are taken from Langer Martin

Martin and Muller (1944). It is a synthetic organic chemical 2-2- bis (parachlorophenyl) 1,1,1 - trichlorethane the formula being



For convenience the designation D.D.T. has been adopted being derived from the generic name dichlor-diphenyl-trichlorethane. It is a white crystalline substance with a faint, pleasant smell and is exceedingly non-volatile at ordinary temperatures. It is soluble in most organic solvents and the solubility is greatest in the less highly refined oils. The solubility in water is very low. It is stable in the presence of light, ultra-violet light, water vapour and boiling water.

Extensive trials to determine the effect of D.D.T. dust on Pediculosis humanis corporis, Pediculosis humanis capitis and phthirus pubis, were carried out in the United States of America by Bushland and others in 1943. A cloth sleeve was slipped over the arm or leg of a subject, lice and powder introduced and the ends fixed above and below with tape. Results were examined in twenty four or forty eight hours and if all lice were dead more were introduced until the powder began to lose its insecticidal action. They concluded that the

the/ approved percentage of powder (which is not specified) will afford almost complete protection against infestation for three weeks and give effective control for a longer period. They found the powder had no ovicidal properties but the duration of effectiveness extends beyond the normal range for incubation of louse eggs, thus destroying the newly hatched insect. They further tested its effectiveness when impregnated in garments and found it to be effective in preventing infestation for an even longer time when impregnation was done by dipping the garments in solutions of D.D.T.. Moreover such garments retained their protective properties after several launderings.

The author had no opportunity of carrying out controlled cell tests on lice at Belsen but the following facts were observed.

With 5 per cent D.D.T. powder, living but moribund lice were found on patients about one hour after dusting. With 10 per cent powder no live lice were ever found thirty minutes after dusting.

D.D.T. was first used on a large scale in the Naples epidemic of louse-borne typhus fever. It would appear to have been used too late in the epidemic to assess its value properly. Its use on a large scale was not introduced till early in January, 1944 when the epidemic was already subsiding due to energetic case searching, hygiene measures and mass dustings with A.L.63 and M.Y.L.. Nevertheless it played a large

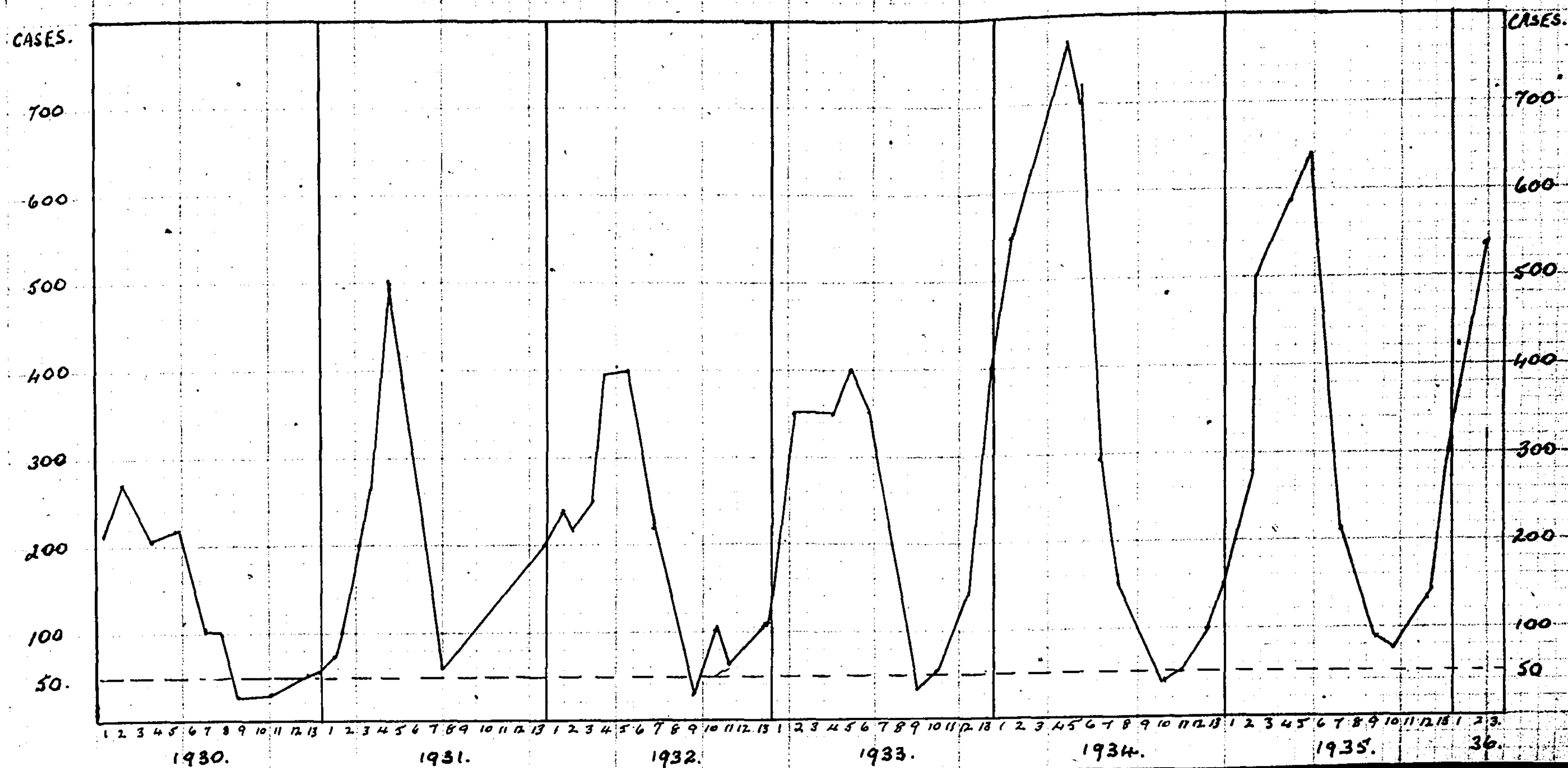
large/ part in terminating the outbreak.

4. <u>Results obtained with D.D.T. at Belsen.</u>

The Belsen outbreak of typhus fever affords the first example of an epidemic brought under control solely by the use of D.D.T. and case isolation. To begin with a 5 per cent strength powder was used and later on, 10 per cent strength. Its method of use has already been described on page 54 . Dustings were commenced on April 21st, 1945 and by May 1st, 1945 some sixty three thousand had been completed. The last case of typhus fever occurred among the internees on May 14th hence allowing for an incubation period of twelve days the epidemic had been brought to a spectacular termination. Other factors which may have caused this must be considered however, notably the abolition of malnutrition and overcrowding. McKenzie (1941) notes the rapidity with which epidemic typhus disappears once a supply of food becomes available in the area. This factor cannot have influenced the course of events in Belsen since malnutrition and inability to assimilate food constituted a major problem long after the epidemic of typhus had subsided. Similarly overcrowding cannot have been a factor of influence since this existed throughout all areas of the Camp until repatriation of internees commenced on May 17th, three days after the outbreak ended, and continued to exist in lesser degree for a further month. It may

may/ be argued that since the majority of internees came from eastern Europe and other concentration camps those who survived Belsen epidemic had an acquired immunity to the disease while those who had no immunity died, hence, the outbreak subsided spontaneously. This argument cannot be upheld when it is remembered that the inmates of Camp II were a cross section of nationalities similar to Camp I and at the time of liberation there was no case of typhus in Camp II. Moreover the hospital area to which the typhus cases of Camp I were evacuated adjoined Camp II and in spite of barbed wire fences and warning notices a certain amount of illicit movement of internees between Camp II and the hospital area occurred. Nevertheless few cases of typhus developed in Camp II a fact which can be solely attributed to D.D.T. powder.

There remains the argument that typhus epidemics tend to abate in the hot weather and the Belsen epidemic ended for this reason. A study of the chart shown at the top of the next page, page 92 shows that in May epidemics in Poland are just past the peak but do not end until June or July. None end abruptly in a fortnight as did the Belsen outbreak.



Typhus cases reported in Poland by four-week periods from 1930-1936.(From League of Nations Epidiological Report, 1936.)

Of the author's unit sixty six men were employed in the huts of Camp I from the outset. A further eight were employed in unloading stretchers at the "human laundry" ; twenty four ambulance drivers also aided in the loading and unloading of stretchers in addition to their usual duties. No evidence of louse infestation was ever found on these men all of whom were dusted daily with D.D.T. powder. In addition the fifty five men employed in evacuating the huts wore protective clothing as described on page 58. The remaining eleven men employed in the camp

camp/on feeding duties where contact with the internees was not so intimate but nevertheless the possibility of infestation was considerable. This also applied to the eight men working at the "human laundry".

Thus it can be stated that the anti-typhus measures and methods of preventing infestation at Belsen were highly effective. These measures were four in number:-

a) The dusting of all patients, internees and workers with D.D.T. powder.

b) The bathing and isolation in hospital of typhus cases.

c) The use of anti-typhus clothing by those in most intimate contact with infested cases.

d) The cordoning off of the area.

No mass bathing of internees was done. No mass vaccination was carried out. Convalescent serum was not used.

It is to be noted that the task of discovering louse infestation at Belsen did not arise. It was rightly assumed that all internees were infested. Accordingly all were dusted.

The task of cordoning off the area was equally simple. Barbed wire and guards were already there and no great efforts were necessary to prevent movements of internees. Nevertheless many of the latter did escape in the confusion of the early days of

of/ liberation and it is probably due to the wide-spread use of D.D.T. powder throughout refugee camps and continental trains that further epidemics have not occurred in western Europe.

5. Toxicity of D.D.T. powder to man.

Being in powder form the D.D.T. used could affect the skin and eyes by contact, the air passages by inhalation and it is possible a certain amount of the powder could be swallowed in a dust laden atmosphere.

Effect on the skin.

Of the fifty five men who worked inside the huts twenty six were employed at a time and submitted to two dustings daily over the period 21st April, to 18th May,1945. These men were closely observed by the author and none showed the presence of any skin irritation or reaction. The author knows of no case of skin reaction among the many other unit personnel who were dusted only on one or two occasions.

Effect on the air passages and eyes.

At the entrance to Camp I three men were employed for a period of three weeks in dusting official visitors and workers entering and leaving the camp. This was done in a small room and as a result these men worked for most of the day in an atmosphere laden with D.D.T. dust. At no time did any of the men develop signs of respiratory affection or symptoms to suggest toxic absorption. Similar

similar/ conditions existed in the "human laundry". No case of respiratory illness or other complaint resulted among the German and British personnel engaged in the work there.

This clinical evidence of the non-toxicity of D.D.T. powder when inhaled confirms the extensive investigations of Neal and his co-workers (1944). They investigated the effects of D.D.T. in inert powder up to 10 per cent strength. They exposed men and experimental animals to the powder daily in closed chambers for periods up to weeks in duration. They found no harmful effects resulted and attribute it to a) the relative insolubility of D.D.T. preventing absorption. b) the large size of the D.D.T. dust particle which does not reach the alveolar space, a large proportion of the dust being retained in the uppermost regions of the respiratory tract.

None of the workers in Belsen exposed to dust laden atmospheres developed abnormal conditions of the eyes although none wore goggles. Wasicky and Unti (1944) have placed ointments and colloidal solutions up to 5 per cent strength D.D.T. on the conjunctivae and observed no ill effects. Cameron (1945) reports no harmful effects from placing D.D.T. powder in the eye.

<u>Effect when ingested.</u>

From those who worked in the dust laden atmospheres it would appear there is no danger

danger/ of absorption of D.D.T.powder (used in 5 to 10 per cent strength) by the alimentary tract. Experimental work with D.D.T. dissolved in oils has proved the danger of absorption of such a solution; this work has been carried out by Smith and Stohlman (1944), and Cameron (1945). Case (1945) reports the following toxic effects:- an increased erythrocyte destruction and diminution of polymorphonuclear leucocytes accompanied by the appearance of immature white cells; aching of the limbs, diminution of reflexes and a curious apprehensive mental state. Impairment of hearing and transient yellow vision have also been recorded. A fatal case of poisoning in a child who drank about one ounce of a 5 per cent solution of D.D.T. in kerosene is recorded by Hill and Robinson (1945). Fine tremors preceded the onset of coma which occurred in one and an half hours . Death was due to pulmonary oedema probably from paralysis of the respiratory centre.

The experimental work on the absorption of dry powder by animals is conflicting and inconclusive (Woodward,Nelson and Calvery (1944)).

6. <u>The effect of D.D.T.powder on fabrics and materials.</u>

There was no evidence of damage to clothing in those men who were dusted twice daily and who wore the same clothes for periods up to ten days. The insides of the ambulances used at Belsen were repeatedly dusted but no harmful effect on the leather or metal work was observed.

C. ANTI-TYPHUS VACCINES.

I. Types of Vaccines.
   a) The live virus vaccines.
   b) The killed virus vaccines.

2. Observations on personnel immunised with Craigie type vaccine at Belsen.

1. Types of Vaccines.

Anti-typhus vaccines are of two main types. These are a) The live virus vaccines b) The killed virus vaccines. In each of these methods either the murine typhus rickettsia or the rickettsia of louse-borne typhus can be used.

a). The live virus vaccines.

Attempts to use a live virus vaccine were first made by Nicolle (1935). Using louse-borne strains of virus he produced immunity in volunteers. His source of virus was the blood serum of the infected monkeys and the brains of infected guinea-pigs. Since there is no method of estimating the concentration of virus prior to injection and since the concentration varies with different animals there is grave danger of produc- a severe attack of louse-borne typhus fever.

When the murine type of disease was discovered the production of live vaccines using this strain of virus was investigated. Nicolle and Laigret (1935) using such a strain of virus, prepared vaccines from the brains of infected guinea-pigs. They attenuated the virulence of the virus by suspension in olive oil. Once again difficulty in titration was experienced and thirteen cases of vaccinal typhus out of a total of thirty two thousand four hundred and eighty nine vaccinations were observed. The incidence among Europeans was 0.45 per cent and among Tunisians 0.016 per cent. Later, using a vaccine prepared from

from/ mice brains Laigret and Durand (1939) were able to determine the quantity of active virus in a dose of vaccine and reported successful results in North Africa, where no case of vaccinal typhus occurred in two hundred thousand four hundred and eighty eight vaccinations.

Blanc and his co-workers (1938) prepared a vaccine from the tunica vaginalis of infected guinea-pigs. Attentuation of the virus was achieved by diluting two thousand times and adding five percent by volume of ox bile. The disadvantage of this method was the necessity of inoculating guinea-pigs and preparing the vaccine shortly before use. To overcome this Blanc and Baltazard (1938) employed the excreta of typhus infected fleas as a source of virus. Ox bile was used as the suspending medium. Since the virus remains usable for two years in such excreta the difficulty of preparing the virus immediately before use was overcome. Chalke (1946) reports an incidence of 5 or 6 per cent of vaccinal typhus in North African natives following the mass use of this vaccine after 1941. He further states that sixty per cent of vaccinated persons acquired a "dureable and solid" immunity.

b) Killed Vaccines.

The first efforts to immunise against typhus fever were made by da Roche Lima (1918). He tried the effects of a phenolised suspension of body lice

lice/on guinea-pigs. The results were inconclusive but some degree of immunity resulted in certain cases. Not until 1930 was immunisation on a large scale in humans attempted. This was done by Weigl who prepared a vaccine by the intra-rectal injections of lice with a suspension of R.Prowazeki. After some eight days the intestines are detached from the lice by microdissection; the intestines are then ground and emulsfied in a solution of saline containing 0.5 per cent carbolic acid. That this vaccine is effective has been amply proved by subsequent investigators. Mosing (1938) states that of one hundred and twenty thousand persons vaccinated in Poland only 0.09 per cent developed typhus. Radlo (1937) observes that in the Jaworow district of Poland the annual incidence of typhus fell from two hundred to twelve following the use of Weigl's vaccine on thirteen thousand nine hundred and eighty inhabitants. Of thirteen thousand and seventy six persons inoculated by Mariani (1938) in Ethiopia only eight cases of typhus were recorded; one of these died. He noted febrile reactions in 5 per cent of people following vaccination. These figures prove that Weigl's vaccine is effective and harmless. However, considerable difficulty is involved in its production. A number of highly skilled staff are required; also large numbers of immune persons on whom the lice can be fed and since it requires

requires/ roughly one hundred lice to provide sufficient vaccine for one person, production is limited.

Castaneda in 1939 produced large numbers of rickettsia by the intranasal inoculations of rats and mice with infectious material from a strain of endemic typhus. The animals developed a rickettsial pneumonia, the lungs showing large numbers of organisms post mortem. Castaneda found that formolized suspensions of these rickettsial would protect guinea-pigs and human volunteers against infectious doses of the same strain of rickettsia.

In 1940 Durand and Giroud, following up the work of Castaneda produced a formorlised vaccine from the lungs of mice injected intranasally with R.Prowazeki. In 1941 they produced a similar vaccine following the intranasal inoculation of rabbits and in 1943 Horrenberger and Renoux used the lungs of sheep. These methods resulted in the successful production of large quantities of vaccine. Biraud (1941) states that this vaccine proved highly satisfactory in Rumania. In respect of its use in North Africa Chalke gives the following figures:- of twenty nine Algerian doctors who contracted typhus eleven had been vaccinated and survived. Thirteen of the eighteen unvaccinated died. Altogether some seventy one thousand people were vaccinated; many contracted typhus but none died.

The technique of preparation of these "lung"

"lung" vaccines is not without risk however. Several instances of laboratory workers acquiring typhus by the sneezing of animals have been recorded. Loeffler and Mooser (1942) record six such cases.

In 1938 Cox succeeded in producing considerable quantities of rickettsias by inoculating the yolk sac of the developing chick embryo. The method was applied by Cox to the rickettsias of Rocky Mountain spotted fever, endemic typhus, European (epidemic) typhus, boutonneuse fever and Brazilian spotted fever. Rickettsias of all these excepting epidemic typhus were consistently found and were readily maintained in serial passage. The difficulty in respect of epidemic strains was later overcome and Cox and Bell (1939 and 1940) reported the successful protection of guinea-pigs by vaccines prepared from infected tissues of developing chick embryos. The method of preparing the vaccine was briefly as follows:- Fertile eggs were incubated for six to seven days. The inoculum was then injected into the yolk sac through a small hole in the air sac end of the egg. The eggs were then incubated until death of the embryo occurs. This was usually after an interval of five to seven days. The tissues were then removed, washed in saline, pooled and ground with alumnum. The mixture was made up to a 10 per cent suspension in saline containing formalin.

Craigie (1942) developed a method of

of/ purification of the yolk sac culture of rickettsias by ether treatment, which resulted in a considerable concentration and separation of the rickettsias from unwanted egg-yolk. The vaccine produced by Craigie was composed of pooled cultures of three rickettsial strains - a murine strain, a recently recovered strain from the Madrid epidemic of 1941 and the old classical Breinl strain first recovered in Poland in 1919 to 1921. This vaccine was the type used to inoculate the British army personnel who worked at Belsen.

In a later publication (1945) Craigie states that the results obtained in preparing a vaccine by the above method may be variable due to the complex physical system created when crude yolk sac preparations of rickettsias are shaken with ethyl ether. He suggests a new technique for preparing the vaccine based on control of the hydrogen ion concentration of the suspension by the addition of acetate buffer. Later he further modified this technique and now the crude yolk sac preparations of rickettsias are processed at p H 7.0.(Craigie 1945)(Med.Res.Conc.Spec.Rpt. Ser.255).

The first field results obtained with Cox's vaccine are reported by Stuart Harris (1945). In 1943 prior to the introduction of immunisation in the British army in Africa thirteen deaths occurred out of forty one cases of typhus fever (32 per cent). In

In the American army however, where all were immunised with Cox's vaccine and where other anti-typhus precautions were identical and risks of infection were similar there were twenty cases of typhus; no deaths occurred. Following the introduction of vaccination in the British forces in the Middle East at the end of 1943 the typhus incidence and death rate was much less in 1944, even allowing for a smaller civilian epidemic that year. In the Naples epidemic only two British and two American soldiers acquired the disease. None of them died. These figures are shown in the table below:-

Typhus Fever in the British Army.

Area	Period	No.of Cases	Deaths.
(a) Prior to immunization.			
Middle East	January to June 1943	134	44(33%)
	July to September "	57 High proportion of murine cases	1(2%)
North Africa	January to April "	41	13(32%)
(b) After immunization with typhus vaccine.			
Naples	January to March 1944	2	1
Middle East	January to June 1944	19	2(10.5%)

(from Stuart-Harris, C.H.(1945).Proc.R.Soc.Med., 38,511).

In 1943 a series of experiments on human subjects was carried out by E.Ding, a German doctor on military service. He inoculated six groups, each of about two hundred persons, with different killed vaccines and established two control groups of similar numbers. Some six to eight weeks later all had typhus which must have resulted from experimental

experimental/ inoculation. The mortality in the control groups was 33.3 per cent and 20 per cent; in those inoculated with the vaccines of Durand and Giraud, Weigl and Cox there were no deaths though cases did occur. He concludes that rabbit and dog lung vaccines, Cox's vaccine and Weigl's vaccine are equally satisfactory.

Topping (1944) records laboratory infection with murine and epidemic strains in fourteen workers seven of whom were vaccinated with yolk sac type of vaccine. None of either vaccinated or unvaccinated groups died; but in the former the disease was much less severe in its clinical manifestations. Berke (1946) reports mild cases but no deaths among three thousand one hundred and twenty two persons inoculated with Cox's vaccine in Afghanstan in 1943. The outbreak of typhus was not serious but deaths occurred among the uninoculated.

2. Observations on personnel immunised with Craigie type vaccine at Belsen.

The vast majority of troops in England were vaccinated against typhus in the early months of 1944, prior to the invasion of the Continent. The authorities repeatedly stressed the importance of inoculation, throughout the campaign and at Belsen there were few British troops who were not thus protected. In the case of the unit to which the author belonged all men had been inoculated, some four months prior to entering the camp, others fifteen months beforehand. Of

Of/ the eighteen men who acquired typhus fever seventeen had been inoculated within four months of entering the camp the other one fifteen months previously. No fatal case occurred. The inoculation consisted of three 1 c.c. weekly injections of Craigie type vaccine followed by a "booster" dose three months later.

The medical students who worked at Belsen had all been inoculated with three weekly injections of 1 c.c. either Cox or Craigie vaccine; this had been carried out within one month prior to their arrival in the camp area. Six of these students developed typhus fever; no deaths occurred.

Of sixteen S.S. men who were employed in burying the dead ten died of typhus and two survived the disease. Among forty nine German nurses employed in the "human laundry" two cases occurred. The exact death rate is unknown though it is known at least six cases died. None of the German personnel had been vaccinated against typhus.

Table showing incidence and death rate of typhus fever in vaccinated and unvaccinated groups.

	Nos.	No. of Cases.	Deaths
British Army Personnel.	55 vaccinated	18 (32.7%)	Nil
Medical Students	96 "	6 (6.2%)	Nil
German Army Nurses	49 un-vacc.	32 (65.3%)	at least 6 (19%)
S.S. Personnel	16 "	12 (75%)	10 (83.3%)

In assessing the value of protective

protective/ inoculation it is essential to consider other factors, notably the degree of exposure to infection and the time of vaccination.

From the description given on page 60 it will be appreciated that the cases which occurred among British personnel were those who had worked in the huts of the camp and had therefore been in most intimate contact with typhus infected internees. On the other hand, they took the most stringent precautions against infection in the form of dusting with D.D.T. powder; the wearing of anti-louse clothing and attention to personal cleanliness (see page 58). Similar precautions were taken by the German nurses except that they wore nursing gowns instead of standard anti-louse clothing. On the other hand, their duties did not include the stripping of clothing from patients as did those who worked in the huts. The medical students wore no anti-louse clothing but otherwise the precautions taken by them were identical. However, they did not commence their work in the camp till some seven days after the other workers. In that interval the louse population had decreased considerably following the extensive dusting of huts and internees with D.D.T. powder.

Therefore it can be stated that the risk of infection was approximately the same in the case of these three groups of workers.

In contrast the S.S. men had no protection

protection/ except their own everyday clothing. They were employed in collecting and burying the dead by hand thus they had to undergo considerable risk of infection.

In the case of British ambulance drivers and American Field Service drivers the risk was less. They did not actually enter the huts though they assisted in the loading and unloading of patients who had been stripped but were unwashed. No case of typhus occurred among these drivers. Davis (1946) suggests that the freedom of American workers in contrast to British was due to the former being inoculated with Cox's type of vaccine. This observation cannot be upheld since no American personnel were employed in duties other than ambulance driving as mentioned above. The true comparison would not include British personnel working in huts but only British ambulance drivers who were exposed to the same risks and took the same precautions as the American Field Service drivers. In that light no differentiation can be made between the Cox and Craigie type of vaccine, since no case of typhus occurred among either group of drivers.

Among remaining British personnel working in the area no typhus occurred. These personnel were employed in the hospital area of Camp II and in administrative duties, where exposure to infection was considerably less than in the other groups mentioned.

The dangers to which workers in a typhus epidemic are exposed is well known and is greatly stressed by McKenzie (1941), Biraud (1941) Megaw and Rogers (1944) and other authorities. In spite of strict precautions the incidence of typhus is high among such personnel and the mortality is high.

S E C T I O N 1 V.

CONCLUSIONS.

SUMMARY.

CONCLUSIONS.

In Belsen concentration camp there existed a community which was potentially, at least, in part receptive to louse-borne typhus fever. Those internees who came from eastern Europe, Russia and the Balkans may have had an acquired immunity in virtue of a previous attack of the disease or because of having lived in an endemic area as it is suggested by McKenzie (1941). This however cannot be said of the many internees who came from western Europe and Scandinavia where neither endemic nor epidemic typhus exists. The origin of the Belsen outbreak is uncertain. It may have occurred as a result of the sporadic cases which appeared in Germany and spread westwards as the war progressed. It is more likely that infection was brought into the camp from the endemic areas of eastern Europe as a result of the mass movements of population which occurred at the time of the outbreak. The precipitating causes of the outbreak were the marked famine conditions, over crowding and complete inadequacy of sanitation prevailing in the camp.

The outbreak was brought to an abrupt end by the hospitalisation of cases, the widespread use of D.D.T. powder and the cordoning off of the affected area. No mass bathing other than that of actual cases was carried out. This was the first epidemic in which D.D.T. was the sole insecticide used and the end of the outbreak came abruptly after its introduction. Other factors which could contribute to the ending

ending/ of an epidemic are the abolition of malnutrition and famine, a high mortality so that only immune persons survive and the arrival of that time of year at which epidemics tend to abate spontaneously. These factors however were of no significance in the sudden ending of the Belsen outbreak. The efficacy of D.D.T. powder is further proved by the fact that no infestation occurred among ninety eight British army personnel working in intimate contact with louse infested internees and typhus cases. Fifty five of these men wore protective clothing and were dusted with D.D.T.powder twice daily. The other forty three were dusted twice daily but wore no protective clothing. When used as an insecticide in powder form of 5 to 10 per cent strength it was found that D.D.T. powder is non-toxic to man. Moreover it is non-harmful to clothing, canvas fabrics, leather and metal. Its use is extremely simple, being pumped from a small powder gun and is a great advance on the older methods of disinfestation, in that it is more easily and quickly applied when large numbers of people are involved. In addition it is much more effective and certain both as a means of killing lice and of preventing re-infestation. The method of dusting recommended is as follows. The subject keeps his clothes on and the nozzle of the gun is passed up one sleeve next to the skin; two strokes of the gun handle are then made. This process is then repeated for the other sleeve, each trouser

trouser/ leg from below and from above, down the front and back of the neck and into the inside of any headgear. The outside of the socks and footwear are then liberally dusted.

The results obtained with D.D.T. powder at Belsen confirm the experimental findings and practical experiences of other workers, proving it to be a highly effective louse killing agent and harmless to man when used as such in powder form.

In spite of D.D.T, powder, protective clothing (excepting goggles and mask) and protective vaccination however, workers who are in intimate contact with infested typhus cases are liable to acquire the disease. The mode of infection in such cases occurring at Belsen was by inhalation of dried louse faeces or by the latter entering the eyes. Since eighteen out of fifty five workers were so infected the danger of such a mode of infection is of considerable practical importance. To prevent it the wearing of a dust proof mask and goggles is essential.

There were no cases of the disease among British personnel who nursed typhus cases in the hospital area. This is an unusual event in the light of former experience recorded by other authors;it can be attributed in a certain degree to protective inoculation with the Cox or Craigie type of vaccine but in a greater measure to the efficacy of thorough washing with soap and water followed by dusting with 5 or 10 per

per/ cent D.D.T. powder as a means of disinfestation of typhus cases.

Concerning the use of anti-typhus vaccines there are two main objections to the live virus type. The first of these is that there is no reliable method of estimating the necessary dosage hence vaccinal typhus occurs in a proportion of vaccinated persons. Secondly there is the danger to the community of starting a widespread epidemic if the inoculated person is bitten by vectors whilst the virus is circulating in his or her blood stream. For these reasons the live virus vaccines have largely been superseded in practice by killed virus types. Of the various methods which have been employed in preparing the latter, those of Durand and Giroud, Cox and Craigie have been most widely used in recent years. All British personnel at Belsen had been inoculated with the Craigie type of vaccine. It did not fully protect them in that a total of twenty four cases developed louse-borne typhus fever. All these cases had been inoculated within four months of entering the camp, excepting one who had been inoculated fifteen months beforehand. Those effected were the personnel who had been in most intimate contact with infested internees. There were no deaths among them but the mortality among forty four unvaccinated German cases was at least sixteen.

In the vaccinated the course of the disease

disease was shorter than usual, none running a fever beyond the ninth day. It tended to be less severe in nature only eight cases developing the typhus state and showing an extensive rash; the others had a milder form of disease.

Of two groups of workers in which the risk of infection was approximately equal the one group, forty nine unvaccinated German nurses showed thirty two cases of typhus; the other consisting of fifty five vaccinated British army personnel showed eighteen cases. This suggests that Craigie's vaccine does afford some protection against infection with typhus fever. The mortality figures and the clinical course of the disease in the vaccinated definitely prove that Craigie's type of vaccine affords a high degree of protection against fatal results.

SUMMARY.

On 15th April,1945 the concentration camp at Belsen, near Celle in North West Germany was liberated by the British army. Some fifty eight thousand living internees were found in the camp; ten thousand unburied bodies lay around the huts and grounds. The living had had no food or water for about seven days, after a long period of starvation. Gross overcrowding was found in every hut in the camp and the non-existence of hygiene and sanitation led to scenes of squalor and filth which almost beggar description

Disease was rife in the camp and a description of the more prevalent types is given. The syndrome of starvation was most widespread there being few internees who did not exhibit it to some degree. The incidence of pulmonary tuberculosis has been estimated as high as 40 per cent. Diarrhoea became widespread after liberation due to the internees being given an unsuitable diet by the liberating forces. Some three thousand five hundred cases of louse-borne typhus fever were found. Clinically they presented no unusual features apart from the co-existence of other syndromes mentioned above. The origin of the infection is unknown but was probably due to the mass movement of population and slave labour from the endemic areas of eastern Europe. Once infection had entered the camp the outbreak was precipitated by the famine and overcrowded conditions prevailing.

A detailed description of the camp area is given. Nearby was a large Wehrmacht barracks which was converted into a hospital area and transit camp. But for the existence of these buildings the problem of Belsen may well have been insurmountable.

The measures adopted to cope with the situation are also described, more particularly in respect of the outbreak of typhus. Certain deductions and conclusions are made on the control of the latter. The sudden ending of the outbreak is attributed

attributed/ solely to the universal dusting of internees with a 5 to 10 per cent strength of D.D.T.powder in an inert powder and to the isolation of typhus cases. No mass bathing of internees was carried out; typhus cases however were thoroughly washed and dusted with D.D.T. powder before admission to hospital. This is the first epidemic in which dusting with D.D.T. powder and washing with soap and water were the sole means of disinfestation employed. No toxic effect from the use of D.D.T. powder was observed in British workers in the camp and it is considered that used as an insecticide in powder form the substance is harmless to man and materials such as clothing, fabric, leather and metal. Moreover its use is extremely simple and is a considerable advance on the older methods of disinfestation an account of which is given in the Thesis. A description of the method of dusting with D.D.T. powder is detailed.

In spite of elaborate precautions against typhus which included the wearing of anti-typhus [illegible] clothing (excepting goggles and masks) and dusting with 5 to 10 per cent D.D.T. powder eighteen members of the author's unit developed typhus fever. They had all been in intimate contact with infested typhus cases. None became infested at any time and it is considered that infection was due to the inhalation of dried louse faeces or to the intraocular entry of the virus from the latter.

An account of various vaccines which have been employed in preventing typhus is given and their merits and disadvantages considered. Experiences with Craigie type of vaccine at Belsen are recorded. In assessing by field experience the value of vaccine as a means of preventing infection it is stressed that other factors must be taken into consideration. Such factors are the risks of infection to which subjects are exposed and any other anti-typhus measures adopted by these subjects. In a group of fifty five vaccinated British workers at Belsen eighteen acquired typhus. Of forty nine unvaccinated German workers in which the risk of infection and precautions adopted were similar thirty two contracted the disease. This suggests that the Craigie type of vaccine with which the British personnel were vaccinated is of value in preventing the disease. The protective value in the developed case is assessed from the mortality figures in two groups of cases. Of a total of twenty four cases in vaccinated subjects none died. Of forty four unvaccinated cases at least sixteen died. Moreover in sixteen of the vaccinated the disease was mild in nature. These figures prove the high protective value of Craigie's type of vaccine in preventing fatal results.

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