

## Section of Epidemiology and State Medicine.

May 23, 1913.

Dr. W. H. HAMER, President of the Section, in the Chair.

---

### **Anthrax in the Woollen Industry, with Special Reference to Bradford.**

By F. W. EURICH, M.D.

WHILE fully recognizing the honour you have done me in asking me to read a paper on "Anthrax" before your Section, I hesitated to accept the invitation, as my own interest in the anthrax problem has been confined to certain local issues, and because the whole problem has been so exhaustively dealt with by Dr. Legge not so very many years ago. The investigations, moreover, which are being carried on in Bradford are not yet completed. However, as your Secretaries agreed to accept the risk, it would have seemed uncivil to decline.

New industries, it is well known, often introduce new diseases. With the introduction of alpaca, mohair and the various Eastern wools into the factories of the Bradford district in the first half of the last century there appeared among the operatives forms of bronchitis, pneumonia, and so-called blood-poisoning of a peculiar deadly nature. The workpeople were quick to associate these outbreaks with the manipulation of this foreign material, but the medical profession was, as a body, slow to recognize in them specific features. A notable exception was Dr. J. H. Bell. Long before bacteriological investigations proved the specific nature of these cases he resolutely defended this view. On one occasion he even risked legal proceedings by inserting in a death certificate that the disease had been contracted owing to the employers' neglect in taking adequate precautions. He was, however, by no means clear what these adequate precautions

were. His discovery in 1879 that wool-sorter's disease is a form of anthrax was the outcome of a suggestion thrown out by his friend Dr. Eddison, of Leeds, then fresh from the bacteriological laboratories of the Continent. Some years later a conference of representatives of employers, workpeople, health committee, and the medical profession took place, and certain regulations, known as the Bradford Rules, were drawn up. These earlier regulations were carried into effect voluntarily, and formed the basis for subsequent regulations made, and at various times amended, by the Home Office. These precautionary measures—the general tenor of them will be considered later—had a



FIG. 1.

Breaking the iron hoops that bind many bales. In the background are two men busy opening fleeces; the funnel-shaped receptacle under the table, for the dust, is connected with an extracting fan.

prompt and beneficial effect. The number of cases, especially those of the pulmonary variety, has been greatly reduced; but this reduction has occurred almost solely among those workpeople whose duty it is to handle the raw material before it has been washed. Even among this class of operatives cases still occur, and no subsequent amplification of the original rules appears to have had any pronounced effect upon the rate of incidence or upon the mortality from this disease.

It was evident that some important factor in the production of anthrax had not received due attention. What this element in the



FIG. 2.

Opening the fleeces upon an "opening board"—i.e., upon a wire grid through which the dust is drawn by means of a fan.



FIG. 3.

Sorted wool being placed upon a lattice and pushed along it into a wiley machine. Note the intimate (and unnecessary) contact of the man with the material, as is also the case in the next figure.

JU—5a

causation of anthrax might be, and what further means of prevention could be adopted, were the main problems. To solve these, the Anthrax Investigation Board was formed.

Before giving you some of the results of these investigations, let me sketch, very briefly, the various processes through which alpaca, mohair—i.e., the hair of the angora-goat—and wool generally pass prior to being spun. The raw material arrives in bales, often, though not invariably, press-packed and bound with hoops of iron. When the bale has been opened the fleeces, which are rolled up and often



FIG. 4.

A workman is shown with a pile of wool at his feet, from which he is feeding a washbowl, spreading the material upon the feeding lattice.

tied with knots, are taken out singly, opened out, thrown into large baskets, and passed on to the sorter. It is the sorter's duty to separate the various qualities of wool of which a fleece is composed, and to pick out foreign substances, such as locks, bits of rag and string, so often found within a fleece. The wool may then be taken direct to the wash-bowl, or it may first be passed through a "willey"—a machine in which the material is roughly torn and shaken out, in order to extract the coarser kinds of sand and dirt. The extent to which wool

may be washed will depend upon the use that is to be made of it. According to this, and also according to the nature of the material, the temperature of the water and the quantity of the alkali mixed with it will vary. In most cases the temperature of the bath is about 130° F. The wool remains in the wash-bowls about ten to twenty minutes, is passed into a drying machine, is often willeed a second time, and in a more searching manner, and then passes to the carding engines. These machines consist of a series of rollers, set with teeth and arranged in such a way that the wool as it passes between each set of rollers has

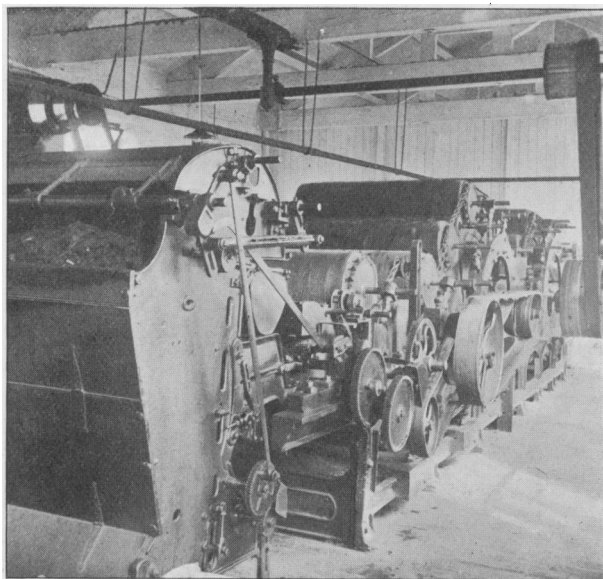


FIG. 5.

A carding engine. The wool is seen in the feeding receptacle on the left (filled by hand), and can be traced upon the rollers farther on as it passes between them. The rollers revolve at various speeds. Note the absence of any cover and of any extracting fan.

its fibres opened out and arranged in parallel bundles, with the result that it issues from the machine in the form of a loose rope called a "sliver." As a good deal of the natural fat of the wool is removed in the process of washing, a little oil is added to the wool as it passes through the carding-engine. A similar effect to that obtained by means of carding is got by passing the wool through what is called a preparing box; in this, too, the wool passes between rollers, and is

teased by sharpened points, but with this difference, that these points are not upon the rollers but travel quietly in the horizontal plane. It follows that this process of "preparing" is less violent than that of carding, and that almost no dust is thrown up into the air. The wool may then be combed in various ways. By it the wool fibres are straightened out, and the shorter fibres are separated from the long. The combed product is called the "top." Such fibres as are altogether too short to be combed are separated out by the machine, and constitute

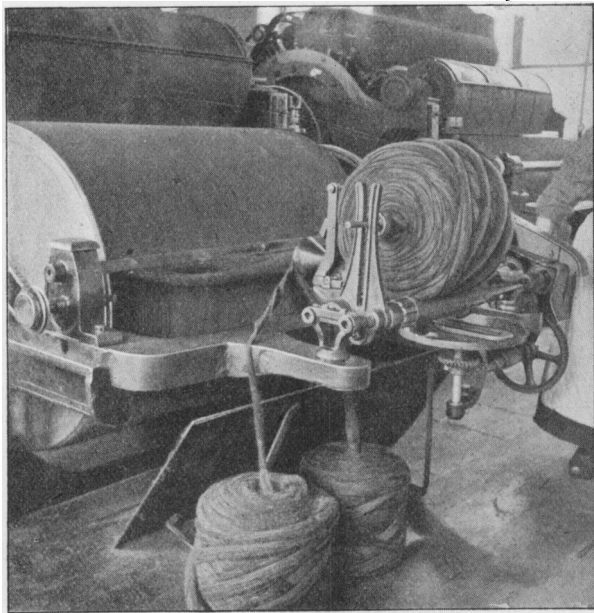


FIG. 6.

Showing the opposite end of the same carding engine, the wool issuing in the form of a loose rope or "sliver," and being wound up into a ball.

what is called the "noil." In all these processes, the washing alone excepted, a certain amount of dust is given off. The regulations provide that during the processes of opening and sorting the dust shall be drawn away from the workers by means of down-draughts created by extracting fans beneath the opening screens and the sorting boards; but there are no regulations for enforcing similar precautions in stages following upon the washing.

Let us now turn to the cases. I have full records of 110; of

these nineteen belonged to the internal variety; they all died. Ninety-one were of the external type; of these thirteen ended fatally. The sites of the pustules are indicated in the following table:—

TABLE I.—SITES OF PUSTULES.

*The figures in parentheses give the number of fatal cases.*

Crown of head	...	...	...	...	...	1
Forehead	...	...	...	...	...	9
Temple	...	...	...	...	...	2
Nose	...	...	...	...	...	1
Cheek	...	...	...	...	...	13 (1)
Ear	...	...	...	...	...	2
Inside nostril	...	...	...	...	...	1
Behind ear	...	...	...	...	...	2
Corner of mouth	...	...	...	...	...	2
Eyelid	...	...	...	...	...	1
Chin	...	...	...	...	...	2
Lip	...	...	...	...	...	1
Neck	...	...	...	...	...	28 (7)
Upper arm	...	...	...	...	...	1 (1)
Elbow	...	...	...	...	...	1
Forearm	...	...	...	...	...	10
Wrist	...	...	...	...	...	7 (3)
Back of hand	...	...	...	...	...	2
Finger	...	...	...	...	...	2
Knee	...	...	...	...	...	1
Buttock	...	...	...	...	...	1
Ankle	...	...	...	...	...	1 (1)
						91 (13)

The frequency with which the pustule occurs on the face, neck, and upper limbs is again brought out by this table. The relation of the severity of the case to the site of the pustule (the fatal cases alone are specially noted in the table) is interesting. Some of the figures are, of course, too small to be of much value, but it is worthy of note that the severest cases occur not only where there is a greater looseness of the cellular tissues, but in parts which admit of the freest movement. Compare, for instance, the relatively high mortality accompanying pustules on the wrist and the mild course generally run when the forearm is the seat of the mischief. The only case of malignant pustule on the ankle which I have seen ended fatally. I am convinced that to insure absolute rest to the part affected is an indispensable part of the treatment.

In the first three years the opsonic index was estimated in almost every case of malignant pustule—generally every day till the patient either died or was out of danger. The index is low during the active stages of the disease, and rises to normal or above normal after the pustule has been excised, or when spontaneous recovery takes place.

In one case the opsonic index rose after excision of the pustule, but quickly fell again, although the patient made no complaint; the dressings were removed, and it was found that a second infection had taken place at the site of operation; this, too, was excised, and the patient made an uneventful recovery. I have had no opportunity of testing the diagnostic value of the opsonic index in cases of internal anthrax, as I have never been called to see one before the infection had become generalized. It should be a useful aid to diagnosis in early cases, for I have several times been able to see the primary focus in a bronchus, twice in the tissues between the root of the tongue and a tonsil, and once in the stomach. Merely a microscopical examination of the serum or of the blood is, of course, insufficient for diagnosis; cultural methods should be employed in all cases. But failure to cultivate the bacillus does not preclude the possibility that the case is one of anthrax. Decomposition of the material, or the bactericidal property of the serum, may explain the failure. To reduce these fallacies to a minimum it is advisable, when such material has to be sent any distance, that some of it should be dried on to sterilized silk threads, or on to glass rods, and packed into test-tubes containing a few grains of chloride of calcium.

As to the treatment I need say little. Our surgeons practise excision of the pustule whenever that is possible, and this is almost invariably combined with the injection of Sclavo's serum. During the last three years, following Professor Sclavo's advice, I have advocated its use in doses of 80 c.c. given intravenously, followed in twenty-four hours by a dose of 60 c.c. if the case be a severe one. Should this treatment be refused by any patient—but I know of no case in which this has happened—I would recommend the trial of a vaccine. It is difficult to estimate the efficacy of any line of treatment, or to say how far it was affected by delay on the part of the patient in seeking medical advice, or by failure on the part of the doctor to recognize the nature of the disease. In this respect the fatal cases are very interesting. Of the nineteen cases of internal anthrax four had had no medical attention whatever, and eight were already moribund when skilled advice was sought. In not one of the remaining seven cases was the true nature of the illness suspected until the patient had passed into the state of collapse; indeed, in two instances it was the unexpected sudden death of the patient which first roused suspicion. Turning to the thirteen fatal cases of malignant pustule, I find that one patient had not sought skilled advice; in one case anthrax was not diagnosed till the



eighth day of the disease; in three instances advice was not sought till the fourth day, and in five not till the third. In only three cases was it sought within the first twenty-four or thirty-six hours, and of these, two were cases of erysipelatous anthrax, while in the third case death was probably accelerated by cirrhosis of the liver. A comparison of these with the cases that ended in recovery is very instructive. I have notes as to the dates of the first medical attendance and correct diagnoses in seventy cases. The accompanying table (*see* Table II) shows how with

TABLE II.—SHOWING RELATION OF SEVERITY OF CASE TO DATE OF FIRST MEDICAL ATTENDANCE. ONLY CASES THAT RECOVERED ARE CONSIDERED.

Day of disease	Spontaneous cure		Mild	Moderate	Severe
First ...	—	...	—	6	—
Second ...	—	...	3	8	5
Third ...	1	...	7	15	3
Fourth ...	2	...	9	3	—
Fifth ...	—	...	—	2	—
Sixth ...	2	...	1	—	—
Seventh ...	1	...	—	—	—
Thirteenth ...	2	...	—	—	—

the lengthening interval between the first appearance of symptoms and the date of medical attendance the number of the moderately severe and of the severe cases increases. After the third day, however, the mild cases, and those which were undergoing spontaneous cure, gain the upper hand, while severe cases cease to occur; finally only cases undergoing spontaneous cure come under observation.

The total number of cases of anthrax, the outcome of contact with wool and hair in the Bradford district during the last ten years, has been 133. Some years ago Dr. Legge calculated that on the number of workpeople exposed to risk the comparative figure of attack was 1·3 per cent. This calculation was based upon the total number of people engaged in the sorting and combing of scheduled—i.e., of black-listed—wools, but did not take into account that the number of hands engaged in the various processes, respectively, to which the raw material is subjected up to and including the combing, is not the same. Nor can the risk of infection attaching to the various occupations be the same. It may be a coincidence, for the figures are small, but out of four card-grinders employed by a certain firm two contracted anthrax in the course of eighteen months. It is also interesting to note in this respect that out of a total of 106 patients, whose length of employment was determined, forty-nine had been exposed to risk for only twelve

months or less. Workers of low-class wools are naturally, perhaps, a somewhat shifting population; they pick up such work as offers and readily abandon it again. But so far as my inquiries have gone, the average length of employment in the different departments will not explain these figures. They *may* be accounted for on the supposition that a certain degree of immunity is in time acquired. I have noted, for instance, several cases who left their employment after a few years' service, but, returning after an interval of some months, contracted the disease. Such relative immunity might be conferred by the introduction of germs of low virulence, such as may undoubtedly be found in wool. I have examined the blood of a number of long-service hands, but failed to discover any difference either in the opsonizing power or in the bactericidal property of the sera. The occupation of the 110 patients is given in the following table:—

TABLE III.—SHOWING OCCUPATION OF CASES OF ANTHRAX.

*The figures in parentheses give the number of fatal cases.*

Warehousemen	...	...	...	...	...	4	(1)
Wool-sorters	...	...	...	...	...	22	(5)
Wool-pullers	...	...	...	...	...	2	(2)
Wool-runners	...	...	...	...	...	3	(1)
Washbowl-feeders and wool-washers	...	...	...	...	...	13	(5)
Wool-dryer	...	...	...	...	...	1	(1)
Willeyers	...	...	...	...	...	11	(2)
Carders	...	...	...	...	...	20	(5)
Card-grinder	...	...	...	...	...	6	(2)
Box-minders	...	...	...	...	...	3	(2)
Finishers	...	...	...	...	...	2	
Combers	...	...	...	...	...	10	(3)
Picker-up	...	...	...	...	...	1	
Packer of tops	...	...	...	...	...	4	(2)
Shoddy willeyer	...	...	...	...	...	2	
Spinners	...	...	...	...	...	4	(1)
Mechanics	...	...	...	...	...	2	

from which it will be seen that sixty-six cases occurred among work-people who would come in contact with the wool or hair after it had been washed. Now the dust which can be shaken from wool before it is washed consists to a large extent of soil mixed with a little fluff; but in the later processes a fine dust of broken fibres predominates. If we are to associate the anthrax spores in wool with the presence of dust from the soil, then it is difficult to understand the frequency with which anthrax is contracted in the later stages of the combing process; it would be difficult to understand why, e.g., this sample of white, East

Indian wool, washed so beautifully clean, should still be full of the spores of anthrax, as it is. Nor does washing, though it necessarily removes many of the spores of anthrax, remove so many of them, relatively, as it does of other dust organisms. The obvious explanation of this is to be found in the adhesive property of blood. If blood-stains upon wool or hair are not too old, then the hæmoglobin is readily extracted by the alkali in the washbowl, but albuminous constituents may remain, and will glue the spores to the wool-fibres. When the blood-stains are old, then even thorough scouring will not delete them; hence even the best washed materials may retain, in part at least, their power to infect. Practically all the difficulties of the anthrax problem centre around this matter of the contamination of wool and hair with infected blood. The wool-combing regulations, as in force to-day, aim (1) at the exclusion from manipulation of obviously dangerous fleeces, and (2) at protecting the worker from the dust during the opening of bales, and during sorting and willowing. They apply to certain black-listed materials only—to raw material grown in countries in which anthrax is known or suspected to be rife, and in which, for one reason and another—such as administrative incapacity, carelessness, &c.—no adequate precautions are being taken to prevent the inclusion of tainted fleeces. Hand in hand with such lack of precautionary methods and of supervision will go the perpetration of “false packing”—i.e., of the inclusion within a fleece of so-called “locks” and “pieces,” by which are meant short strands of wool of inferior quality, not infrequently the sweepings of the knacker’s yard, mixed, may be, with rags and bits of string. The extent to which false packing occurs can be seen from the following figures: 961,116 lb. of Baghdad fleece wools yielded 747 lb. of blood-stained “locks,” 380½ lb. of blood-stained “pieces,” and only 18½ lb. of blood-stained fleece; 260,843 lb. of Bussorah fleece wools yielded 26¾ lb. of blood-stained “locks,” 424 lb. of blood-stained “pieces,” and only 6½ lb. of blood-stained fleece. Of course, not all these samples have been tested for anthrax, but the percentage of positive results is considerably higher in locks and pieces. As many of the samples tested had been for various reasons specially selected, a comparison of the percentages might not be altogether a fair one. The importance of the rôle played by locks and pieces may be made clear by means of the following calculation; the average frequency with which anthrax spores have been detected in blood-stained Persian wool of every description during the past four years is 4·3 per cent. If I now make a calculation which will favour locks and pieces to the

utmost—i.e., if I assume that every blood-stained fleece is infected, and of the locks and pieces only 4·3 per cent.—even then Bussorah locks and pieces are four times, and Baghdad locks and pieces 2·7 times, as dangerous as the fleeces.

The prevention of “false packing,” then, would greatly diminish the risk of contracting anthrax from fleece wool; but how can we expect to find the necessary conscientiousness in Asia Minor or Persia, where human lives are valued so lightly?

The risk in fleece wool would be reduced still further if dangerous fleeces also could be excluded from manipulation. The Regulations provide for this in requiring that the so-called “fallen” and “damaged” fleeces be sought for by men skilled in detecting them, and are to be specially treated. Possibly as the result of a misunderstanding these terms “fallen” and “damaged” appear to be used in the Regulations in a different sense to which they are employed in actual practice. In the wool industry a fleece is considered to be a fallen one when of a peculiar dead lack-lustre appearance—an appearance due to prolonged exposure after the death of the animal. But the longer this exposure the more advanced will be the decomposition of the carcase; and as the bacillus of anthrax perishes as putrefaction advances, a “fallen” fleece will be less dangerous the more characteristic its appearances are. Similarly, a “damaged” fleece is not a blood-stained fleece, but one that has been damaged by contact with sea-water. Such a wetting will prove dangerous only if the fleece be already anthrax-laden; under the influence of warmth and moisture multiplication of the virus takes place, but from experiments I have made it would seem that the multiplying germs do not pass any great distance—scarcely more than a centimetre into the surrounding wool. Such a restriction to the distribution of the bacilli is possible only when a fleece becomes sea-damaged when in the bale, or otherwise tightly packed. Under other conditions the story is a very different one. Now one of the provisions for laying the dust arising during the opening and sorting, as demanded in certain cases of the Regulations, is steeping. Wool that has been steeped is, however, put so promptly through the processes of washing and drying, that germination of the spores and multiplication has scarcely time to proceed. But one objection to damping the wool is that the detection of blood-stains is rendered difficult. However, this difficulty might be overcome when mohair or white wool is being dealt with. But when wool is steeped loosely and becomes thoroughly drenched, blood-clots are softened, portions of them break away and may attach

themselves to, and so possibly infect, fleeces which had till then been sound. The same will happen when wool is washed unsorted; as the wool leaves the washbowls fragments of clot are caught up, and are once more fixed to the wool in the process of drying. Thus the danger-signal becomes obscured, while the risk of infection, though somewhat lessened, still remains a very real one.

What happens in a wool-combing establishment can happen elsewhere whenever infected wool is steeped or washed. Not all foreign wools reach this country in their natural state. They may have been treated in one of two ways: (1) Some wools, notably many East Indian wools, have been washed—i.e., either tub-washed or river-washed in the country of origin. If the washing be done in running water contamination of healthy fleeces will be much less likely to take place than when the wool is tub-washed. Some of the more dangerous material (mohair) is imported from the Cape, and this fact has recently been commented upon in the Cape Parliament. Whatever steps to lessen the evil may in the future be taken there, it is to be hoped that washing of the material will not be resorted to. (2) The wool may be of the kind termed “skin-wool”—i.e., wool obtained from the hides. In so far as the fellmonger’s process is a wet one will the objections mentioned hold good: the traces of blood become obliterated, and the virus becomes diffused. Such is the case with East Indian skin-wool, and with skin-mohairs. But not all skin-wools are of this kind. I find that a dry process is in vogue in Persia. Hence in Persian skin-wools the clots are large, heavy, and readily detected, while in East Indian skin-wool and skin-mohair the stains are faint. In Persian skin-wool, therefore, the presence of blood-clots may fairly be taken as an indication of possible danger, while their absence in the others cannot be taken to promise safety. I can see no other explanation for the fact that I have hitherto failed to cultivate anthrax bacilli from Persian wool other than blood-stained, whereas I obtained them in nearly 20 per cent. of a series of samples of East Indian wool, of which samples only two were blood stained.

Here I may be permitted to digress. It is stated that in the case of China horsehair anthrax bacilli may be cultivated with ease from the dust of most samples, and that hair matted with clots is not often found. As mane-hair is shown to be more dangerous than tail-hair, it has been suggested, in explanation, that the long manes of the horses sweep the ground as the animals are grazing, and pick up the spores with the dust. I have recently been afforded the opportunity of examining eight small

samples of dust shaken from bundles of Chinese horsehair; in six of them I found evidence, both chemical and spectroscopic, of the presence of blood, and from four out of these six I succeeded in cultivating anthrax bacilli.

River-washed wools, then, and skin-wools obtained by wet methods, have this in common, that traces of blood are obliterated and that anthrax spores are liberated; but there is this difference: Washing is a short process, many spores pass into the stream, and the wool is quickly dried; the hides, on the other hand, are steeped for twenty-four hours in tanks, where every condition is favourable to the multiplication of the germs. Skin-wool so obtained may therefore be more dangerous than river-washed material.

Here, then, lies the difficulty in the administrative control of anthrax, so far as the wool industry is concerned. In the case of material which has not come in contact with water, and which is of sufficiently good quality to repay the cost of looking over or of sorting, the systematic search for blood-clots appears to me to be indicated. So large a quantity of scheduled material is manipulated daily—some firms will deal in a single day with fifty bales and more, each weighing 3 cwt.—that it is very desirable to reduce as far as possible the bulk of the material requiring special treatment. The detection of blood in wool and hair is easy if the material be white or of a light shade of yellow. Greater experience is required to discern it on naturally coloured wools. Here the sense of touch should prove a safe guide. Dried blood imparts a peculiar harsh touch to the fingers, unlike other substances, such as tar, salve, and excrement, from which the eye alone might find difficulty in distinguishing it. It is remarkable how little risk seems to be run by those who handle blood-stained pieces *knowing the danger*. I can recall no case of anthrax among those who have been most successful in recognizing them. The amount of blood-stained material found is often considerable. I know of a firm which has in eighteen months put aside 2,000 lb. of such. To destroy it might entail a considerable loss, and a commission comber would be particularly loth to put away material the property of another. What is to be done with it? and what can be done to render innocuous wool and hair which may show no outward indication of being dangerous?

The Anthrax Board has made many series of experiments to find some method of disinfection which will ensure the destruction of anthrax spores, which will do so without damaging the wool-fibre, and which shall be commercially possible.

Ordinary press-packed wool is, when in the bale, not amenable to disinfection. The unopened fleece, too, is not very permeable. Chemical disinfectants, such as formaldehyde, cyllin, or kerol, do not penetrate blood-clots in reasonable time, for they harden the outer portions. Much was hoped for from Seymour-Jones's method. Dr. Ponder had reported very favourably upon its power of penetrating artificially infected clots. The solution consists of formic acid and corrosive sublimate; the acid enters the clot in advance of the salt and facilitates penetration by its action upon albumens. But in actual practice the method fails, as the lime and other earthy salts present among the wool quickly neutralize the acid. The same disability attaches to Professor Schattenfroh's method, which consists of an 8 per cent. solution of common salt in 1 per cent. hydrochloric acid. This solution will certainly kill anthrax spores in twelve to twenty-four hours; but so sensitive is the mixture that the use of tap-water in place of distilled water renders it inert. The method is obviously inapplicable. Though formaldehyde (1 in 20), cyllin (2 per cent.), and kerol (2 per cent.) find too great an obstacle in clots, they are of use when the spores are unprotected, as in the case in washed wools, and in skin-wools and hair prepared by the wet method.

Considerable attention has, of course, been paid by us to steam disinfection. In order that the results of the tests might be strictly comparable, we used infected mohair clots only, the clots in Persian wools being generally larger and more dense; and as all the clots were obtained from the same bale, it is reasonable to assume that the vitality of the spores in the various clots was approximately the same. In one series of tests a current of live steam was used. A tank, through the bottom of which the steam was allowed to enter, was packed loosely, but as uniformly as possible, with thirty or forty Persian fleeces. An infected clot was wrapped up in a fleece and deposited in the centre of the pile. Fifteen minutes' exposure to the steam sufficed to sterilize the clot. Tests on somewhat similar lines were also carried out with mohair in a loose state, with like results, so long as the steam had free access. A series of experiments was also made with a Defries's "Equifex" Disinfector, the steam being under a pressure of 5 lb., with a temperature of 232° F., and the time of exposure varying from ten to forty-five minutes. Clots packed in single fleeces were easily disinfected in fifteen minutes. When the infected fleece was packed between eighteen or nineteen others, disinfection was generally accomplished in fifteen to thirty minutes; but a slight addition to the impediments to be overcome—such as turning in the ends of the

fleece containing the infected clot, or the presence of several hard water-damaged fleeces among the pile—would prevent complete sterilization. On one occasion anthrax bacilli could still be cultivated, though very sparingly, after forty-five minutes' exposure.

The results have thus been inconstant. Had the heavier and harder Persian clots been used the results would, in all probability, have been still less satisfactory. The effect on the raw material would alone condemn this method. The lustre of mohair is diminished; white wool and mohair are turned yellow, and though the average strength of individual fibres is not materially affected, their elasticity is greatly impaired. The material also becomes more harsh, and on being combed produces more noil than does a control sample. In other words, the loss inflicted is a double one; not only is the quality affected but there is also a loss on the combing and a greater amount of waste. Though disinfection by steam is not practicable in bulk, there is no reason why it should not be used for the sterilization of blood-clots removed in the sorting; their daily quantity is small, little time is taken up by the process, and the amount of blood-stained wool so treated would be relatively so small that when sterilized it could be mixed once more with the rest of the wool without affecting the combing or spinning qualities of the whole.

Steam disinfection, particularly when steam under pressure is made use of, has one other drawback: blood-clots become still more firmly fixed and the blood pigment undergoes changes, probably in the direction of hæmatoporphyrin, which make its removal very difficult. In the case of the darker, naturally coloured wools this difficulty may not matter greatly, but in that of white wools it would be a very disturbing element. As time is of no great moment when clots alone are to be treated, it may prove worth while to steep these in warm water over night. They will be softened partly by the water itself and partly by the action of the numerous liquefying bacteria which abound in all wools. When softened in this way the clots must not be steamed, else the wool is rendered quite useless; but disinfectants will now penetrate easily and do not appear so readily to harden the albumen of these clots.

When the time is ripe for the much-needed revision of the wool-sorting and combing regulations many of the alterations will no doubt be based upon the knowledge and experience gained by the Anthrax Board during the last six years. But there is one reform the necessity for which must be obvious to anyone with an observing eye and an open mind who visits these factories. Many workers have at present



to handle the wool to a quite unnecessary extent. There is the wash-bowl-feeder, stooping down over the pile of wool at his feet as he is about to lift it on to the feeding-lattice with his face nearly buried in the wool, and there is the card-feeder exposing himself to risk in a similar way. I have seen men enter the chamber into which the willed wool has been blown and gathering up armfuls of the wool, throw it into large sheets nearly on a level with their mouths—their head, face, and neck becoming covered with wisps of wool in the process. Surely it cannot transcend the ingenuity of man to devise some method of mechanical convection from one machine to another.

For well-nigh forty years has this problem, the prevention of industrial anthrax, exercised us in Bradford. No one can say that it is satisfactorily solved to-day. But when the solution that has eluded us so long shall at length have been found, it will have been not the work of one man, but the result of the co-operation of the experts in the trade.

#### DISCUSSION.

The PRESIDENT (Dr. W. H. Hamer) said the Section would wish to thank Dr. Eurich for a very interesting paper; he had helped those who did not know the conditions under which wool was manipulated in Bradford to understand more fully why it was that the ravages of anthrax there were of a different nature from those observed in other cities. In the days when there were no medical inspectors at the Home Office it fell to the lot of the medical officers of the London County Council to make investigations with regard to anthrax, and many years ago he collected the records of 119 cases of the disease which had occurred in London. He had been comparing the sites of pustulation in those cases with the sites in the cases observed by Dr. Eurich. The sites in external anthrax corresponded closely in the two sets of cases; but in the internal form of the disease there was a difference in the percentages, for whereas the author had nineteen internal cases out of 110, in the London series there were only two such out of 119. He had always wondered how it was there was such a difference between the two cities in that respect, but the lantern slides now shown enabled one to see and appreciate more fully the reason; the infected material was dealt with in a different way. He always felt depressed when he heard papers on anthrax, because it seemed to him extraordinary that a piece of preventive medicine work which should be so simple of accomplishment had never yet been satisfactorily carried out. Dr. Eurich had clearly shown that the mischief was wrought by a

comparatively small quantity of material, and that had been the experience of all who had worked at the subject of anthrax. Dr. Russell, when he investigated the outbreak in a horsehair factory in Glasgow, pointed out that it was a small quantity of material which was dangerous in this respect, and the same point was made when Dr. Spear, for the Local Government Board, investigated a series of cases which occurred from manipulating China hides in Bermondsey in the eighties. A number of cases occurred in London in the nineties, due to the manipulation of goat-skins from a particular source. Bearing these facts in mind, it seemed extraordinary that nothing more effective in the way of prevention of the disease should yet have been accomplished. M. Chauveau read a paper before the Seventh International Congress of Hygiene in 1891, in which he pointed this fact out, and he argued that it was only by convincing those concerned with the disposal of raw material to which suspicion attached, that to destroy it was the only course open to them in order to safeguard their own interests, that it would be possible to exercise an efficacious check upon the disease. He (Dr. Hamer) thought members might well take that expression of opinion to heart, and he hoped that papers like the present one might have the effect of influencing opinion in this connexion.

Dr. T. M. LEGGE said he also felt grateful to Dr. Eurich for the practical nature of his paper, and for the helpful suggestions he had made for the inevitable revision of the Home Office Regulations to which he had alluded. He agreed with the President that it seemed extraordinary that a disease which caused only sixty or seventy cases per year in factories and docks, of which about fifteen were fatal, should cause so much anxiety, and should in Bradford be considered as a scourge. But he thought there seemed to be in the anthrax bacillus something almost occult. For instance, it was extraordinary that pulmonary anthrax should practically be limited to the wool industry. He did not agree that it was due to the different nature of the processes; there was the same amount of dust in a hide-skin warehouse in Tooley Street as in a Bradford sorting house. Dr. Russell's classical cases in Glasgow in 1878 were cases of internal anthrax from horsehair, but since then he could not recall more than one or two cases of pulmonary anthrax in horsehair workers in this country, though there had been cases abroad. It was not that such cases were not being looked for, because at Guy's Hospital a case of internal anthrax would not be overlooked. The work of the Anthrax Investigation Board was one of the most signal things in industrial progress in this country. That a body of manufacturers should band themselves together, as they had done in Bradford, to try and get rid of the evil, was a most praiseworthy thing, and it was the kind of effort which he would like to see adopted in other districts, so as to minimize the incidence of industrial diseases. In Bradford the determination had been to work on scientific lines. He was present at the first meeting of the Board, and since then the work they had done had quite changed current views about the spread of anthrax.

Dr. Eurich had alluded to the importance of the blood-clot, and the conception of that as the great danger, and hence the need for its removal. This was found to be a much greater danger than the dust. Dr. Eurich's work in the examination of a great many samples of dust from the worsted factories, from which he rarely cultivated anthrax, caused him to turn his attention to the examination of the clots, and in some of them he found from 10 to 20 per cent. infected. A thing which had puzzled him was the following: Seeing that it was the workers' fingers which always came into contact with the wool, it was astonishing that he should have had only one report of a case in which the finger was affected. Did Dr. Eurich think the explanation lay in the frequent washing of the hands? Or was it because there were no hair-follicles on the palms of the hands, and therefore no chance of spores lodging there? Further, did Dr. Eurich think that if a spore lodged in a hair-follicle, or a sweat-gland, and worked its way down a little, a pustule might develop without an abrasion at the site? His own view had been that an abrasion was a necessary condition precedent to such development. Reference was made in the paper to Scavo's serum, and he would like to hear whether the author had information as to other serums. Sobernheim's serum he knew was being used for treatment in Germany; it was a serum from sheep, whereas Scavo's was from the ass. The dose of the German preparation was much less than Scavo's. He had read of a serum being used on a large scale in the Argentine Republic, and the dose of that was even smaller than that of Sobernheim's. Dr. Eurich stated that if an operative who was infected refused the serum, he should be offered a vaccine. Had the author thought of the idea of using the serum as a prophylactic inoculation? Perhaps a much smaller dose than for treatment would suffice for this. This suggests itself in the case of the workers at the factories known to be handling specially dangerous wools. Possibly the operatives might express their dislike of this, but if it were very carefully and tactfully explained to them, their objections could be overcome, just as Dr. Eurich had taught them to give a proper danger value to the blood-clots, a matter which five years ago would not have been thought of. He knew that such prophylactic inoculation had been done, certainly once, in India. Dr. Lingard, in a severe outbreak in a jail in which prisoners were manipulating wool, had nine cases of what he called "anthracæmia," probably meaning pulmonary or erysipelatous anthrax, because he differentiated those cases from malignant pustule. After there had been three fatal cases he used a serum which he prepared for animals in his own laboratory. Of the nine cases which he commenced to treat in that way five recovered, four died, and in the latter the life was a good deal prolonged by the treatment. The important point was that there were sixty men who had to clean out and disinfect the wool-sheds subsequent to the outbreak, in which work, of course, they ran great peril. As a prophylactic, Lingard inoculated 5 c.c. of his serum into each worker, and one case only suffered from anthrax, and that only in mild degree. There seemed to be possibilities for good in it. In conversation, Professor Scavo agreed that

prophylactic inoculation might serve the purpose. What Dr. Eurich said, and what had been generally noticed, on the question of dust, made one think the question had been somewhat neglected. Exact dust determinations had recently been made for the Home Office, stating the results as milligrammes per 10 c.m. of air, by Mr. Duckering, H.M. Inspector of Factories at Birmingham, who had had much experience in the metal-grinding, painting, and pottery industries. He had informed him (the results had not yet been published) that the amount of dust in wool warehouses was much greater than in any of the factories in the industries he had previously inquired into. And it was surprising how much vegetable matter, as well as mineral matter, there was in the wools. But the mineral matter in wool factories, when examined microscopically, was found not to consist of spicular and angular fragments, but of more or less rounded particles, thus presenting a contrast to metal-grinding dust. And so far as he was aware, the workers in wool factories did not complain particularly of affections of the lungs.

Dr. COLLIS said he did not pretend to much knowledge on anthrax, for all the time which was at the disposal of the Department had been devoted by Dr. Legge to the anthrax question. That the disease was of interest to others besides those concerned with occupation disorders was once brought home vividly to him. A friend of his, whose father was connected with the horse-hair trade, and who was therefore familiar with the appearance of an anthrax pustule, was dressing for a surgeon at hospital when a man came with a curious sore on the face, and the surgeon sent him to the house surgeon in the next room to excise it. But the dresser thought that, notwithstanding the black centre, it did not look quite like an anthrax sore, so he slipped back and made one or two inquiries of the patient, who proved to be the father of a baby who had recently been vaccinated, and the operation was successfully abandoned. He had thoroughly enjoyed hearing the paper and seeing the instructive photographs.

Dr. CROOKSHANK asked whether much was known about anthrax as it occurred in its natural state amongst animals in South Africa and South America and other countries. He noticed that most of the workers shown in the photographs were obviously men in the habit of shaving, and wondered whether the liability to inflict cuts on themselves when shaving increased the risk of getting the disease.

Mr. MAJOR GREENWOOD, jun., said he was interested in the question of cutaneous irritation precedent to contracting the disease. Dr. Legge raised the question as to the possibility of infection through the unbroken skin. Was there a different degree of irritation in the various phases of the process of manufacture, and, if so, did such difference have any relation to the case-rate.

Dr. EURICH, in reply, said, with regard to the comparison of the internal cases of the disease at Bradford with those occurring elsewhere, it was a question whether the difference was due to these internal cases not having been recognized elsewhere. In tanneries, for instance, one could understand pulmonary cases being rare, because hides were dealt with in the wet state, and there was not much dust. In the felt industry in Lancashire, during the last eight or nine years there had been twenty-one or twenty-two cases of anthrax, and, in spite of the fact that much more dust was associated with the felt industry, not one case of internal anthrax had been reported in connexion with that industry. That industry also dealt in East India wool, and he did not know why Bradford and district should have internal cases of anthrax while the felt industry had none. He agreed as to the rarity of anthrax pustules on the fingers; he had seen it there only twice, which was a very small proportion of the total number of cases. His view was that scratches and pimples did not play such an important part in the development of anthrax as his predecessors believed. Anthrax had been experimentally produced by rubbing infected material on to the skin; and he had been struck by the frequency with which the site attacked proved to be a surface where friction operated, such as where the hat fitted on the forehead, the neck, and the wrist. But those were also common sites of pimples. Still, one or two cases were traceable to injury. One case was traceable to a prick from a thorn in the wool; in another case the man pricked his wrist with a "faller," one of the sharp needles of a preparing machine, and anthrax developed twenty-four hours later. Of course, shaving the face might increase the liability to infection, but it was difficult to determine that, as there were so few bearded men doing the work. Possibly one or two of the pustules on the lips which he had seen were due to the shaving. Still, one occurred in a man who wore a moustache. He had at home some samples of Sobernheim's serum, but he had had good results with Slavov's serum, so good that he hesitated to try a fresh kind. For immunization purposes the number of people who would have to be inoculated was large, and the immunity so produced would be but short-lived. He could understand it doing good in the jail mentioned by Dr. Legge, where the dangerous work would probably not last long. But in the Bradford industry the work was continuous, and one never knew when an infected bale would be opened. Seeing how often the serum would have to be administered, there was a danger of anaphylaxis occurring. To prevent anaphylaxis the only safe plan would seem to be to alternate the two sera. As a prophylactic, probably the efficacy of the serum would be greater when combined with a vaccine. Still, he questioned whether the worker would submit to it. The classification of these diseases, or many of them, in foreign countries was very unsatisfactory. He had derived the impression from reading, and the same was said by Dr. Bell, that many diseases which were called anthrax were not that condition; while, e.g., many cases called plague were probably anthrax. Also, the veterinary inspection in those countries was by no means ideal. Still, it was to be hoped that our

Consular bodies would be interested in the question, and send home regular reports. He was much interested in Dr. Collis's speech, and the mistaking of a vaccination pustule for one due to anthrax. The same thing had happened to himself; he was called in to see a woman who had a pustule on the chin. She did not work in a wool factory, but her doctor thought she had been infected from having worn another woman's shawl. He (Dr. Eurich) asked how the baby was, and learned it was recently vaccinated. There was no anthrax in the pustule. Careful inquiry should be made into the duration of the pustule. The fifth day of an anthrax pustule looked like the pustule of vaccination at the ninth or tenth day. Workers in scheduled materials had instructions to inform the foreman as soon as there was the appearance of a pustule, or a prick, but many were very careless about themselves. At all these factories there were means and facilities for dressing wounds. In some cases the sufferers had neglected the foreman's recommendation to seek medical advice. Here, as elsewhere, familiarity too often breeds contempt.