BYSSINOSIS IN THE COTTON TRADE*

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The word byssinosis is derived from the Greek word *byssos*, meaning fine linen. Originally the word was used in a wider, more general sense, whereas to-day it indicates a specific industrial entity. Byssinosis is a respiratory disease affecting workers inhaling dust in cotton mills. The condition has been known to exist for many years, and was first recorded by Greenhow in a report to the Privy Council of London in 1861. The cotton trade has been the Cinderella of occupational hazards and it is only recently that research into the causes of byssinosis has been undertaken. In 1930 the Industrial Health Research Board published a study of sickness among operatives in Lancashire cotton mills, and in 1932 the Home Office issued the *Report of the Departmental Committee on Dust in Card Rooms in the Cotton Industry*. This report collected the existing information about conditions in the mills, types of machinery in use, and the nature of the cotton dust, and included an account of the clinical examination and radiological findings in a group of workers suffering from the disease. The post-mortem findings in a few cases where death had occurred were also described.

In 1936 Prausnitz published an account of investigations on respiratory dust disease in operatives in the cotton industry. The mass of information from these two reports gives the most recent and authoritative knowledge on byssinosis, and forms the structure on which further investigations can be based. Foreign literature on the subject is scanty and does not contribute any additional knowledge. Zipperlen (1935) reported on an investigation of patients suffering from asthma in Württemberg, where there is a textile industry. His report contained the following statement: 'A few words should be said concerning industry. In spite of all protective appliances cotton dust cannot be excluded, and we have actually observed

a large number of severe asthma patients in whom strong allergic reactions could be obtained with suitably prepared dust from the factories.'

The Process

Cotton is obtained chiefly from Egypt, America, and India. Although cotton dusts show variations, there is no evidence that such variations materially influence the injurious effect of long-continued inhalation. The cotton arrives in this country in bales, highly compressed and containing particles of leaf and seed coat, cotton hairs, fragments of mould, and fine sand. The raw cotton has to be cleaned, and it passes through several processes in the cotton chamber and blowing room before being ready for the card room. In the cotton chamber the bales are uncovered, and the tightly compressed cotton is pulled off in layers and hand-fed by the cotton feeder into a machine known as a hopper bale opener. It then passes into the blowing room, where it is dealt with successively by hopper openers, hopper feeders, porcupine openers with high-speed Shirley cages attached, and finally by Crighton openers and finisher scutchers. The purpose of all these machines is similar, namely, to open out the compressed cotton, to spread it well, and, by a beating action aided by powerful currents of air, to free it from a high percentage of its impurities and at the same time ensure adequate mixing of the different qualities of cotton. With the exception of the cotton feeder tending the hopper bale opener, all the machines are enclosed in dust-proof covers. The machines, however, have to be hand-cleaned, and this is a particularly dusty job; the operatives engaged on this work are suitably clothed and wear respirators. The cotton, emerging from the blowing room, passes to the carding engines: and it is here that trouble from byssinosis begins, for, though the Industrial Health Research Board report showed that blowing-room operatives had high sickness rates from respiratory causes, it was thought that

* Based on a paper read to the Association of Industrial Medical Officers in Manchester on May 16, 1946.

this might have been due to transfers from the card-room taking up work there. Women working in the card-room, the engine-head tenters, slubber tenters, and intermediate tenters are only rarely affected by byssinosis. It is, in fact, the strippers and grinders, the operatives in charge of the carding engines, who are the principal sufferers.

Usually each stripper and grinder is in charge of 16 carding engines (fig. 1): each engine is cleaned four times daily by a vacuum process (fig. 2), and twice weekly it is brush stripped (figs. 3, 4, and 4A). The brush stripping is necessary because the vacuum process fails to clean sufficiently deeply, and the evidence is very strong that the dust liberated by the carding process in the immediate vicinity of the carding engine contains the injurious element or elements causing byssinosis. The farther away from the carding engine, the safer the atmosphere.

Symptomatology

For convenience the symptoms of byssinosis may be divided into two stages—early and late.

The early stage.—Although not so common to-day as it was some years ago, the condition called mill fever, Monday morning fever, or factory fever is known to many card-room operatives. On entering the card room on Monday morning these workers experience a dry, irritative feeling in their throat and chest. This is followed by a short, slight, dry cough. There may be an attack of sneezing; and, in a few cases, principally among the women, a slight urticarial type of rash appears on the forearms. Some operatives complain of sore eyes; a mild conjunctivitis is sometimes present. After a few hours—or at most a day or so—the symptoms disappear, and for the remainder of the week no discomfort is experienced. There is little or no constitutional disturbance. The appetite remains good, and the condition does not result in a loss of working hours. A few operatives exhibit a mild pyrexia, not sufficient to incapacitate them. Many never experience mill fever. Others experience it for a few weeks or months and then apparently become immunized. Some years ago the condition was regarded by such workers as a necessary baptism to their trade. In some operatives—who might be described as the card-room-susceptible type—the condition subsides only to recur after months or years, or never subsides entirely, but continues as mill fever. Except in strippers and grinders, mill fever at this stage rarely progresses any further or causes any serious respiratory damage. The symptoms and recurring cyclic nature of mill fever, however, do seem to

suggest an allergic sensitivity to some constituent in the cotton dust.

The late stage.—The stripper and grinder is the operative who usually succumbs to the late stage of mill fever. The symptoms of fever gradually reappear ten or twenty years after the earlier attacks—that is, when the workers are 35 or 40. The cough becomes dryer, harder, and of a metallic character; and symptoms tend to spread over all the working days of the week. At first there is little sputum; after a severe attack of coughing a small quantity of clear, sticky, glairy mucus is brought up with great difficulty. The patient at this stage complains of easy fatigue, and his capacity for effort is considerably reduced. After a week or so off work most of the symptoms abate, the cough moderates, the physical capacity improves, and the operative is again fit for his job. With intervals of rest from work, the stripper and grinder may continue for several more years. Insidiously, however, the condition progresses. In the later cases expectoration becomes freer and possibly muco-purulent; dyspnoea increases, and the capacity for effort decreases. Operatives will tell you that several times on their way to and from work they have to stop to get their breath. They complain of tightness in their chest—‘I feel as if I had a rope tied round my chest.’ Inspiration is difficult. Attacks of bronchitis become increasingly frequent, and more and more time is lost. Ultimately the continued cough, dyspnoea, easily induced fatigue, and loss of sleep due to asthma-like nocturnal attacks, render the sufferer unfit for this work, and, unfortunately, in many cases unfit for alternative work: there is the tragic picture of a man in middle life condemned to chronic invalidism. The constant complaint of strippers and grinders at this late stage is that they have to sit up in bed at night to get their breath.

Physical Signs

Clinical examination of operatives suffering from mill fever in the early stage does not reveal objective signs except those already mentioned, though the mucous membrane of the nasopharynx may be somewhat thickened and hyperaemic. Examination in the late stage reveals the classical signs of chronic bronchitis and emphysema. The patients at this stage look ill, their skin has an unhealthy, sallow colour, the cheeks are sunken, and there is general loss of weight. Respiration is laboured, with the accessory muscles called more and more into use. The diaphragm moves badly. The shoulders are raised, and a stooping, kyphotic

FIG. 1.—Stripper and grinder 'feeding' the cap into the 'taker in' of the carding engine—the first process of carding. A good deal of dust is produced at the 'taker in.'

FIG. 2.—Cleaning by vacuum process. (It was found unsatisfactory to take this photograph with the machinery actually in motion.)

FIG. 3.—Brush-stripping and grinding. Similar operation using (a) brush, (b) emery roller. Requires two operatives.

FIG. 4.—Stripper and grinder cleaning out 'fly,' 'trash' and fine dust from underneath the carding engine. A very dusty job. (See Fig. 4A.)

FIG. 4A.—Cleaning out 'fly,' 'trash' and fine dust from underneath the carding engine by recently installed vacuum process. Note the dust extraction hood which can just be seen over the carding engine.

curvature is common. The patients sit in a characteristic attitude, the body bent slightly forward, the legs spaced widely, and the hands placed on the knees. The thorax becomes typically barrel-shaped, with the usual prominent sternum. In fact the patient exhibits the physical signs of extreme emphysema. The vital capacity of the thorax is greatly impaired, and the chest expansion of these late cases is often found to be only one or one and a half inches.

Between the early mill-fever patient and the late stage just described, there are many intermediate types. The progressive tendency for the vital

capacity to decrease often precedes the stage of advanced pulmonary damage. Alternative work should therefore always be advised for any operatives exhibiting this feature. Another early sign is a slow but progressive loss of weight.

Radiographic Appearances

Among 100 patients* who had radiographs taken of their chests, no specific appearances diagnostic of byssinosis were detected. In the late stage changes

* These cases were radiographed by Dr. George Fletcher, Chief Tuberculosis Officer, Lancs. C.C. My own series were radiographed by Dr. A. Richardson, Radiologist to the Oldham Royal Infirmary: his reports agree with Dr. Fletcher's.

FIG. 5.—Radiograph of an advanced case of byssinosis. The patient, now aged 69, has not been able to work for many years.

FIG. 6.—Radiograph of a man 45 years of age with typical clinical signs of byssinosis. He has been found alternative work outside the card-room.

were consistent with those of chronic bronchitis and emphysema. The films, however, tended to show bronchial shadows of a greater intensity than those generally found in patients suffering from bronchitis and emphysema (figs. 5 and 6). Cotton dust is not 'aggressive' in the same way as the causative dusts of asbestosis or silicosis, and x-ray films are not, therefore, a pointer to diagnosis, as they are in these latter diseases. Diagnosis of emphysema due to cotton dust rests, in fact, only on a history of exposure for many years, on the patient's symptoms, and on clinical examination. A successful appeal for compensation for byssinosis requires that the patient shall have been exposed to the dust for a minimum period of 20 years. Claims for compensation are made under The Byssinosis (Benefit) Scheme, 1941—assessment being in the hands of a medical board appointed by the Secretary of State.

Pathological Changes

Post-mortem examinations have been carried out in ten cases. The examination has revealed no specific feature for byssinosis, the changes in the respiratory system being those of bronchitis and emphysema. Dilatation of the right heart was frequent in the series of cases examined post mortem by Dunn and Sheehan (1932).

Causative Agent

A complete investigation of the causative agent of byssinosis has been carried out by Prausnitz, who used Shirley cage dust as providing the best cross-section. The dust consisted of a greyish-brown fleecy material, which, if shaken, produced masses of fine grey dust which remained floating in the air for a considerable time. Microscopical examination showed the dust to consist of fragments of cotton fibre and green and brown scales of the leaf and husks. There was no sand, and, in fact, no demonstrable mineral matter. When the dust was examined by the ultra-microscope, extremely fine particles became visible; there appeared to be no lower limit to the size of these particles. It was reasonable to assume that these ultra-fine particles could readily find their way into the deeper portions of the respiratory system, even to the extent of passing through the alveolar wall into the inter-alveolar tissues.

Animal experiments have demonstrated the power of cotton dust to penetrate into the deepest parts of the lungs and to produce a chronic inflammatory reaction. Numerous experiments have also been carried out on individual fractions of cotton dust. From these experiments Prausnitz (1936) suggested that the pathogenesis of the illness was as follows:

1. Irritating soluble protein of the cotton dust penetrated into the alveolar tissue and gradually produced thickening of the alveolar walls.
2. Simultaneously, or perhaps even before, super-sensitiveness was acquired.
3. Superficial irritation of the bronchial mucous membranes by the dust led to chronic bronchitis and cough—in some cases accompanied by intensive expectoration—and ultimately to emphysema.

Probably a percentage of strippers and grinders are predisposed to become sensitive to cotton dust, while others are immune. The allergic or sensitized subjects become the victims of mill fever. They tend to develop a chronic cough, which, helped by irritation of the bronchial mucosa, leads to mild bronchitis. The deep penetration of the respiratory system by the ultra-microscopic portions of the dust—with their protein content—causes a thickening of the alveolar walls and peri-bronchial inflammation; and this state eventually leads to the development of emphysema. It is difficult to escape the convictions that an allergic condition pre-exists, and that it probably prepares the way for the late stage of peri-alveolar thickening. The author has not yet seen a case of byssinosis in which the late stage has developed without a preceding history of mill fever and long-continued cough; usually the stripper and grinder with developed byssinosis has been coughing fairly steadily for many years. Christie (1944) states that in emphysema the primary lesion is loss of elasticity, the most common cause of which is the stress and strain of cough or respiratory obstruction on the structures concerned in respiration.

Prevention

It was not until 1908 that attempts to control the dust were made. Obviously the ideal method is to ensure that the cotton dust does not escape into the atmosphere. This has not yet been found possible. Considerable improvements have been achieved by the introduction of dust covers and exhaust fans for machines in the cotton chamber and blowing rooms. Unfortunately today, even in the best equipped mills, at least one-third of the trash is carried into the card room in the laps; it is this third which is eliminated in the carding process. The sliver emerging from the carding engine is almost dust-free. The modern flat carding engine is not totally enclosed—there being considerable technical difficulties in achieving this. A recent attempt to do so was made by completely hooding the whole of the top of the carding engine,

and exhausting by means of a quarter horse-power motor fan—the air, drawn through the hood, being filtered before re-entering the room. The under-space of the carding engine is completely sealed off, and to clean under the engine the stripper and grinder has only to pull a small lever: the entire collection of dust is then swept away by the creation of a vacuum. This arrangement has greatly reduced the amount of dust in the atmosphere; 3·66 lb. were extracted from the hoods of 12 carding engines, through which 11,400 lb. of cotton had passed in 44 hours. These figures do not include the weight of debris from underneath the carding engine.

Many mills have insufficient air space, with the machinery crowded into too small an area. Greater air space means a greater dilution of the dust. Improved air conditioning, in conjunction with improved dust extraction, is necessary. Air conditioning must include a correctly controlled temperature, the right humidity, and adequate air movement—and these are also the best conditions for the cotton fibre.

A careful selection of operatives for the card room, and regular examination of existing workers, offer the best protection. All intending card-room operatives should be medically examined before engagement, and every effort should be made to exclude those types likely to be susceptible to the disease. Any operative who gives a personal or

family history of asthma, bronchitis, hay fever, eczema, or recurrent urticarial attacks should be excluded from the card room. The general build and shape of the thoracic cage should be noted, and also the type of respiration. Mouth breathers are bad subjects. Malformation of the nasal bones, deflected septums, nasal polypi, enlarged tonsils, and extensive adenoid vegetations are all contra-indications for card room workers. A chest expansion below two and three quarter inches is suspect. All operatives are urged to practise nasal inspiration and to wear protective respirators. If a simple skin patch test for allergy could be obtained it would be a valuable help, both in the examination of intending card room operatives and as a diagnostic measure in suspected cases of byssinosis. To-day the disease is not nearly so common as formerly, but it still exists, and constitutes one of the main industrial hazards in the cotton industry.

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