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TRANSACTIONS

3—NEP FORMATION IN WORSTED CARDING *

By P. P. Townend, and E. Spiegel.

INTRODUCTORY

Modern methods of wool combing demand that the wool be fed to the comb in a sliver form. Scoured wool is transformed from its loose lock state to the sliver by one of two processes—carding or preparing. The choice of process is primarily governed by the staple length of the wool, the longer fibres of, say, 9 inches or more, being passed through the preparing process whilst the shorter fibres are carded. Since there is a direct relationship between length and diameter of wool fibres, it follows that the preparing process is confined to the long coarse fibres, whilst carding converts the shorter fine fibres to a sliver suitable for combing. This paper is confined, in the main, to the carding process and has particular reference to the processing of merino wools of 60-70's quality.

A worsted card sliver is judged by two major standards (*a*) the degree of fibre breakage which has occurred during the process, and (*b*) by the clear appearance of the sliver leaving the back doffer of the machine. The extent of fibre breakage will affect the tear of the wool during combing, a subject of very great importance, but this paper is concerned with nep formation and fibre breakage will, therefore, only be discussed in so far as it affects nep formation.

A cloudy sliver might result from two causes: the presence of vegetable matter, and the presence of neps. The causes and mode of removal of the former fault are fairly obvious, but the origin of neps is more obscure.

The precise causes of nep formation are extremely difficult to elucidate since the process of carding, where they first make their appearance, is a combination of many actions and it is impossible to isolate the effect of each one in turn. Kraus[1] carried out a fairly comprehensive survey of the problem, using a Continental card, which differs from the standard Bradford model in that the licker section of the British machine is replaced by a breast complete with workers and strippers. It can be argued that the carding actions of these opening sections are not the same so that some of Kraus' experiments have been repeated on the Bradford card; these, together with his conclusions, will be dealt with in the experimental section.

Microscopic examination of neps reveals that the majority are clusters of fibres, knotted together or twisted round one another, forming little balls of fibre. There are a few, but they are definitely in a minority, which possess a nucleus of vegetable matter or grease, around which the fibres are bound.

A length analysis of the fibres going to make the nep shows that 70 per cent. of them are below 2 cms. Fig. 1 shows the length-frequency distribution curves of the fibres of a normal card sliver and the neps extracted from this sliver. This graph might be misinterpreted to conclude that short fibres

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are responsible for the formation of neps, were it not for the work of Kraus. He took a combed top and dyed 10 per cent. of it in a cold liquor to a blue colour. The dyed top was then cut into small lengths of 10-20 mm. and mixed with the remaining 90 per cent. of undyed white top by means of a teaser. When the mixture was carded no blue neps could be found in the card sliver, showing that neps do not necessarily result from the presence of short fibres in the blend, but that the shortness of their length is due to fibres being broken off the main body of the nep as it passes through the machine.

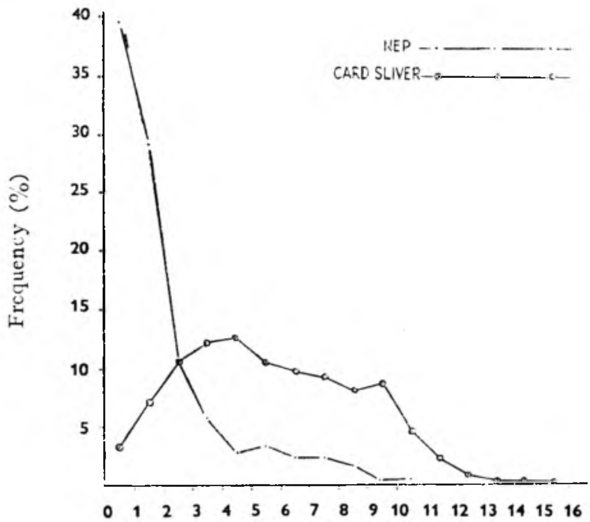

Fig. 1

The diameter of the fibre is not, however, without importance, for Kraus has shown that the fibres constituting the nep are on the average 35 per cent. finer than the normal ones in the card sliver. He confirmed this point by considering the relationship existing between wool quality and neppiness, as shown in Table I.

Table I

Wool quality		Neps per unit weight of card sliver
Australian, 64's-70's	...	1466
,, 58's-64's	...	1135
New Zealand, 58's	...	640
,, ,, 56's	...	410
,, ,, 50's	...	277
,, ,, 46's	...	204

Two factors are probably responsible for this increase in neps with increasing quality of wool, viz., the tendency of fine wool fibres to mill or matt together and the use of an emulsion scouring system to clean greasy wool. Speakman and Stott[2] have shown that a fabric made from an 80's quality wool will shrink 43·2 per cent. in its width, whilst a 56's wool fabric shrinks only 26·3 per cent. This ability of the wool fibre to matt is well known and it is also known that the fibre, regardless of quality, will matt more in certain alkaline solutions than in others. Milling of the fibres is at a minimum in the region of pH 4-8 and gradually increases with rise in pH. Emulsion scouring takes place in the region of pH 10, so that any agitation given to the wool will tend to exaggerate the matting of the fibres. The form of scouring used in the case of fine wools is such as will impart the least agitation to the fibres, but it is obvious that some agitation is necessary or the dirt cannot be removed. Fine wools are, therefore, unavoidably matted in the scouring process: this matting is a fault and a well-scoured wool is expected to be clean and lofty, but it is obvious that some fibres will tend to felt together and form the nuclei for neps. Examination of scoured wool does not show any neps, as such, but there is a tendency for the locks of wool to be rolled together and these are probably the nucleus of the subsequent nep. In keeping with the preceding argument, Kraus has shown that the emulsion scouring system is responsible for a large proportion of neps. A summary of his results is given in Table II.

Table II

Method of washing	Neps per unit weight
Hand washed, using soap and soda	225
Hand washed, using benzene	305
Machine washed, using soap and soda	1125
Machine washed, using soap and soda, but no pressure applied to the top squeeze rollers ...	982

They show that the matting of the fibres by the machine is responsible for the very large increase in nep formation, compared with that obtained when a gentle hand washing was applied. It is also interesting to note that a reduction of the pressure on the wool by the squeeze rollers causes a reduction in the number of neps, no doubt because the squeeze rollers operating under a load of 4-8 tons, are bound to have a felting action on the wool as it passes between them. It would appear, therefore, that the emulsion method of washing wool should give way to a better system, but up to the present no other method can compete with it as regards simplicity and cost, so that the worsted scourer and carder finds himself in the unenviable position of knowing that the present system is unsatisfactory, that it is the basis of nep formation, but is unable to alter the state of affairs. There is no doubt that the lofty condition of the wool entering the carding machine is respousible for a large decrease in nep content of the sliver, but however lofty the wool is, there is always some nep formation in carding, and it has been considered desirable to study the effect of variations on the conditions of carding on the number of neps in the resulting sliver. For obvious reasons, most of the experiments were conducted on wool which was in the same condition as regards incipient felting, but two series were so large and extended over such a long period that it was considered better to scour the wool required for each experiment immediately prior to carding rather than to scour the whole lot at once.

Effect of neps on further processing

The presence of neps in a card sliver has an adverse effect on the tear in combing, the clearness of the top, and, consequently, the value of the top.

The tear, or ratio of combed sliver to noil, cannot be predicted solely from the number of neps in the card sliver, for there are other factors which probably have just as large a bearing on this ratio, not least being the extent of fibre breakage incurred during carding. As shown in Table III, however, the data obtained from five different experiments demonstrate that there is an inverse relationship between the number of neps in a card sliver and the tear of the wool. There is no universal relationship between the number of neps and the tear for all the experiments because they were carried out under varying conditions. Consideration of the combing action clarifies the point, for it is surely evident that the neps will tend to crowd the spaces between the finer pins of the Noble comb circles and prevent the easy movement of the fibres during the drawing off action. The more neps there are present, the more chances there are of crowding up these spaces, resulting in a breakage of fibres as the rollers pull them forward. The same effect will be brought about in the French comb, for the neps will prevent the pins of the segment fallers passing freely through the tuft presented to them so that the fibres which are in front of the neps will be subjected to extra drag by the faller pins which will again lead to extra breakage. The action of the top comb resembles the action in a Noble comb, for here again the fibres are pulled through a grating. From what has been said it is obvious that the size of the nep is important: the smaller it is, the finer must be the grating to prevent its escape into the top, but finer pinned circles will lead to greater fibre breakage during the drawing off motion, and large neps would, therefore, seem to be preferable to small ones. On the other hand, large neps will cause a greater obstruction to the flow of fibres. The size of the nep is governed largely by the setting of the workers to the two swifts of the standard Botany card ; the tighter this setting is, the smaller will the neps be, no matter what setting has been adopted in the licker section.

Table III

Experiment	Neps per gram	Tear
1a	12	7·6 : 1
1b	179	5·4 : 1
2a	55	10·8 : 1
2b	257	5·8 : 1
2c	310	5·2 : 1
2d	422	3·4 : 1
3a	31	8·1 : 1
3b	50	6·8 : 1
4a	82	9·7 : 1
4b	177	6·8 : 1
4c	281	5·9 : 1
5a	178	7·2 : 1
5b	283	6·1 : 1
5c	538	5·3 : 1

It can also be demonstrated that a greater number of neps in the card sliver results in a greater number being left in the combed sliver and consequently in the top, since there will be more chances for them to slip through the comb pins. Their presence in a top will hinder the free flow of fibres during the drafting process and probably lead to irregularities in the yarn. They will also limit the spinning power of the wool by protruding from the surface of a fine yarn.

The chief difficulty in any series of experiments on nep estimation is the definition of what shall constitute a nep. It was therefore decided that any cluster of fibres which does not come apart on being pulled in a direction at right-angles to the length of the sliver shall be termed a nep. With this definition in mind, a number of commercial tops were obtained from reputable Bradford combers and examined. Table IV gives an estimate of the number of neps found in these tops. It might be contended that the figures obtained are high but this is due to the arbitrary definition of a nep, and they must be interpreted as such. These figures are given solely to indicate the standard adopted in examining the various slivers for neppiness.

Table IV

Quality of top	Neps per gram
60's	5
64's	8
64's	8
70's	9
70's	8

1 gram is equivalent to 3 inches of a 256 dram top.

EXPERIMENTAL

The work of Kraus has shown that the nep content of a card sliver is governed to some extent by the quality of the wool and its treatment prior to carding. These factors are, in practice, more or less constant since the quality cannot be altered and the wool must be scoured. The aim of these experiments has therefore been to investigate the effect of the different variables which might be encountered in the carding process. There appeared to be at least two aspects of this problem ; firstly, the condition of the wool, which might vary as regards its water content and the amount of added oil, for example, and, secondly, the actual carding conditions, which might be altered as regards speeds and setting. It was thought that a series of experiments conducted on these two lines would enable one to obtain a clearer picture of the formation of neps.

PART I. EFFECT ON NEP FORMATION OF ALTERATIONS IN THE STATE OF THE WOOL FED TO THE CARD

Preliminary experiments

It was first necessary to determine how neps are distributed in a card sliver. There are two possible variants ; they might vary along the sliver, that is, the first yard of sliver issuing from a card may differ in nep content from that leaving the machine at any later period, or the neps may vary across the width of sliver due to some mechanical action of the card.

Stenersen[3] observed that neppiness increased with carding time or, in other words, the neppiness increases along the sliver, but the throughput in his case was very low, namely, 20 lbs. per hour.

It was decided to carry out this preliminary investigation in a worsted card room, so that sampling might extend over a longer period than would be possible on an experimental plant.

A machine was cleaned and run on with a blend of 60 per cent. 64's Australian and 40 per cent. 64's Cape wool. Samples of the sliver were taken throughout the running period up to the time when the card was considered to require cleaning. This test extended over a period of 45 hours. Samples of 2 yard lengths were taken periodically and from these, lengths of 1 foot were cut at 3 feet intervals and examined for nep content. At the same time as the sample lengths were being taken from the machine, the left-hand side of the sliver was marked so that it could be identified later. During examination, the 1 foot lengths were split down the centre so that it was possible to estimate the neps in the left and right hand halves of the sliver, and by summing the two a measure of total neppiness in the foot was obtained. This method of testing enabled one to study neppiness throughout the length of the sliver, across it, and at known intervals along the length. The results showing the deviations across the machine are shown in Table V, whilst their totals are graphed against carding time in Fig. II.

Table V

Sampling time (hours)	Neps per gram	
	Right side	Left side
$\frac{1}{4}$	12	13
1	13	12
$2\frac{1}{4}$	16	21
$3\frac{1}{4}$	20	15
$4\frac{1}{4}$	10	15
$5\frac{1}{4}$	16	11
$19\frac{1}{4}$	17	18
$21\frac{1}{4}$	18	20
$23\frac{1}{4}$	17	21
$25\frac{1}{2}$	19	15
$27\frac{1}{2}$	13	15
$29\frac{1}{2}$	19	13
$42\frac{3}{4}$	30	22
45	23	18

The results show that there is no material difference in neppiness across the sliver as it leaves the card. Out of fourteen pairs of results, the left-hand side is more neppy in seven cases, and the right-hand side also more neppy in seven cases. The figures for the 1 foot lengths taken from the same portion of sliver were quite consistent, so that in future work a series of nine 1 foot legnths of sliver was examined for each experiment.

Taking the series of totals there is a slight tendency for the number of neps to increase with carding time, e.g., the averages of the first and last 3 hours' running are 30 and 46, respectively. There does not appear to be any great increase in neps over a period of time extending up to 20 hours' continuous running, and when it is remembered that this machine was carding 55 lbs. per hour it will be seen that there is no need to take account of carding time in a series of small experiments. Nevertheless, the nine samples required for nep estimation were always spaced over the entire test.

Before discussing the various experiments it will facilitate explanation if a general description of the experimental technique is given.

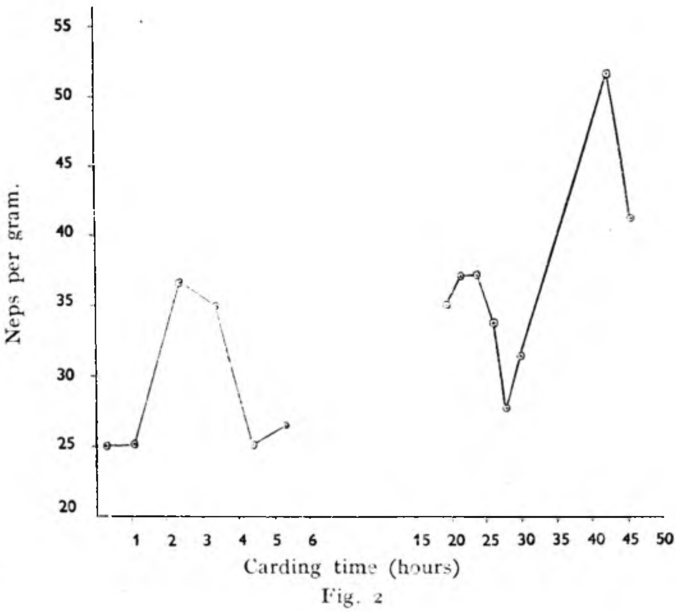

Fig. 2

The various wool lots were scoured by means of a swing harrow machine using soda ash and soap as the cleansing agents unless otherwise stated. Any drying of the wool was carried out in a machine using hot air. Additions such as oil and fat were dissolved or emulsified in suitable solvents and sprayed onto the scoured wool by means of a hand spray. The carding was performed on a half width botany type of machine, consisting of four lickers and two swifts, and unless otherwise stated the swift speed was 120 r.p.m. During the carding process, samples of wool were caught as they dropped into the hopper scale pan and samples of the sliver were taken at intervals throughout each test; these were used to determine the moisture content of feed wool and sliver. Again, the weight of sliver delivered by the back doffer was ascertained for several one minute periods, and the throughput per hour calculated from these weights as for a full-width machine. Three further samples of sliver, some 20 yards long, were also retained for nep examination, three counts being made from each length, so that each figure quoted for neppiness is the average of nine determinations. In each case the nep content is based on the dry weight of the wool. Where the various lots were combed for tear they were passed twice through an intersector gill box, 4 ends up, 4 of a draft, and then processed on a French comb. The setting of the latter remained constant throughout the tests.

Effect of wool grease

The first series of experiments was devised to observe the effect of wool grease on nep formation. 60 lbs. of 64's Australian wool were scoured, using Lissapol C paste and sodium carbonate. This wool was divided into equal lots and sprayed with a solution of anhydrous lanoline in carbon tetrachloride. The amount of grease added to the blends was 0, 0·4, 0·8, 1·2, 1·6, and 2·0 per cent. on the dry weight of the wool, the first lot being intended as a control. Each greasy lot was carded damp in ascending order of grease content, the machine having previously been stripped. The moisture content of the wool was approximately 34 per cent. regain and the throughput 15 lbs. per hour. Samples of the card slivers from the various lots were examined for nep content. These are shown plotted against the additions of wool grease in Fig. 3. The ether and alcohol extracts of the control card sliver were 0·38 per cent. and 1·04 per cent., respectively.

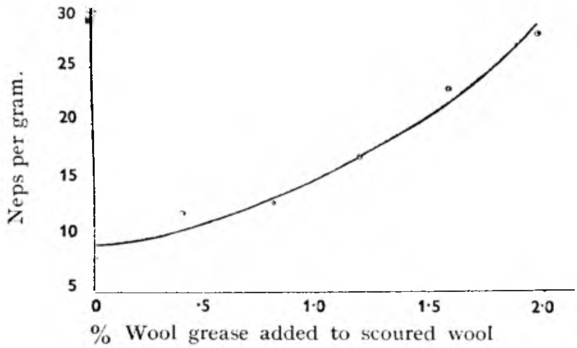

Fig. 3

It will be seen that there is a steady increase in neppiness with increasing grease content. An addition of 1·2 per cent. grease doubles the nep content of the original wool, whilst 2·0 per cent. grease trebles this amount, despite the fact that the throughput was very low.

A higher throughput would probably have increased the nep content still further.

Effect of soap

The next series of experiments was carried out to determine the effect on neppiness of the soap content of the wool. 70 lbs. of the same blend were scoured with the Lissapol C scour and the clean wool sprayed with varying amounts of soap solution, equivalent to 0, 0·25, 0·5, 0·75, 1·0 and 1·5 per cent. on the dry weight of the wool. The ether and alcohol extracts from the control sliver were 0·29 per cent. and 0·94 per cent., respectively. Carding was carried out on the same machine which had again been stripped. The regain of the wool was 46 per cent., the throughput was 26 lbs. per hour, and the number of neps per gram in the various slivers is shown as a function of the amount of added soap in Fig. 4.

The graph suggests that increasing soap content first leads to a decrease in nep formation and then causes a steady increase.

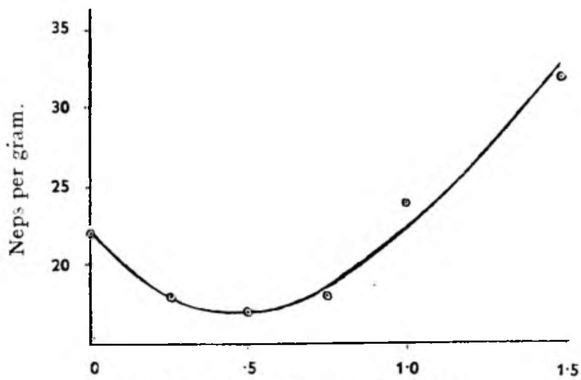

Fig. 4

Effect of grease and soap

A final series of experiments was made, using the same wool and scour, but this time both wool grease and soap were added to the clean wool. Four blends were carded :—the first contained no addition of soap or grease ; the second 0·5 per cent. grease and 1·5 per cent. soap ; the third 1·0 per cent. of each, and the fourth 0·5 per cent. soap and 1·5 per cent. grease, so that the total of added impurities was the same amount in each case. The regain of the wool was approximately 37 per cent., the ether and alcohol extracts of the control card sliver were 0·24 per cent. and 0·99 per cent., respectively, whilst the throughput averaged 31 lbs. per hour. The results are shown in Fig. 5. It will be seen that the nep content in the control experiment was 17 per gm., and this increased in sympathy with the increasing grease content. It is interesting to observe the differences in neppiness of the slivers, each containing the same proportion of impurity, for it will be seen that the increase of grease content from 0·5 to 1·0 per cent. caused an increase of 12 neps per gm., but a further increase of 0·5 per cent. in grease content only caused a rise of 6 neps. This small rise is attributed to the fact that the 0·5 per cent. soap content is not acting so drastically as it did in the second experiment when 1·5 per cent. of it was present. The main conclusions from these three series are that increasing amounts of wool grease will cause an increase in the number of neps, whereas small amounts of soap do no tact so drastically. This is probably due to the more adhesive nature of the former, but it is interesting to note that a soap content of more than, say, 0·75 per cent., will act in the same manner as wool grease. In fact, the slope of the curve is steeper above 1·0 per cent. in the case of the soap than in the case of the grease, but the results are not comparable because the throughput of the former was greater. These results surely emphasise the importance of clean wool. If the fibres go to the machine containing an adhesive, the card wires are unable to disentangle them so easily, for it must be remembered that many fibres can lie between adjacent teeth on a card roller and especially so in the forepart of the machine where the clothing is comparatively coarse.

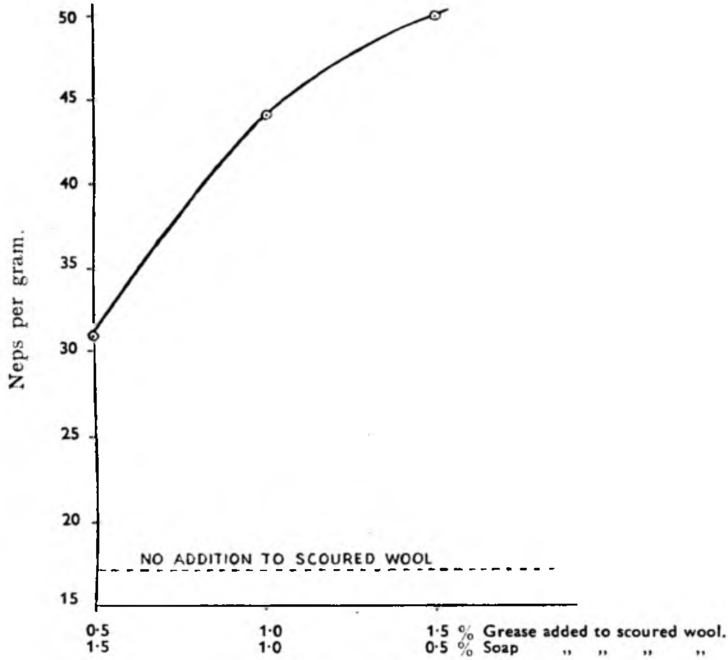

Fig. 5

Effect of burr

The third form of impurity found on wool is vegetable matter. It has been stated that the majority of neps contain no other nucleus except fibre, but some are found with a nucleus of vegetable matter. A further series, in collaboration with Mr. C. O. M. Steward, was therefore carried out to discover whether the presence of vegetable matter does lead to more neppy slivers. This large-scale experiment was made possible through the generosity of Messrs. W. & J. Whitehead, Ltd., of Laisterdyke, who loaned 1,000 lbs. of 64s clear Australian wool for the purpose. Nine 50 lb. lots of wool were scoured and carded with varying burr and moisture contents as set out in Table VI.

Table VI

Burr content of feed wool (%)	Moisture content of feed wool (% regain)	Neps per gram
1·30		185 ±4
3·41	19	181 ±3
11·79		184 ±3
1·46		106 ±2
3·49	45	115 ±2
11·47		102 ±2
1·06		106 ±3
3·49	54	96 ±2
10·61		108 ±4

The results show the neps per gram in the various card slivers, together with the standard error, each figure being the average of nine determinations. A consideration of the data would appear to indicate that there is no relation between burr content of feed wool and the neppiness of the card sliver produced from that wool. It is however probable that burry wools may be neppier than those made from clear wools due to the action of the burr beaters on the wool as it passes beneath them.

Some explanation for the general increase in neppiness of these slivers as compared with those of previous experiments is clearly desirable. The chief difficulty in this series was that of procuring a natural wool which was uniformly burry. This is obviously impossible so that artificial means had to be used to produce one. Burrs were extracted chemically from some burry card waste, and these were then mixed with the scoured wool by passing the wool plus the required amount of burr through a teaser. This shaking action caused the wool to become more matted, and this led to a greater number of neps in the card sliver. Each lot of wool was, however, subjected to the same amount of shaking so that the results are comparative amongst themselves.

Effect of oil

Dickinson[4] carried out a series of experiments on the effect on nep content of varying the amount of added olive oil to a 64s wool. At 47 per cent. moisture content the neps per gram and fibre breakage of the card sliver were :—

Olive oil added to wool (%)	Neps per gram	Fibres below 65 m.m. (%)
0·0	61	61·9
0·5	60	57·7
1·0	67	50·0

Although the differences between the various slivers are small, they suggest that there is a critical oil content beyond which it is unwise to go if the neppiness of a carded web is to be at a minimum. It is interesting to note the beneficial effect of oil on fibre breakage.

Stenersen[3] compared the effect of various wool lubricants on the neppiness of merino card slivers and obtained the following results :—

Sample	Neps per gram
Unoiled	31
1% Oleine	23
1% Olive oil ...	25
1% Mineral oil ...	30
1% Glycerine ...	27

In a further series of tests he showed that oleine does not produce so many neps as olive oil, although the trend of results obtained from the one oil was very similar to that with the other. For this reason, oleine was used as the lubricant in the following experiments.

100 lbs. of 64's Australian wool were scoured and the lot divided into five portions. The first was processed as a control lot, whilst the others were sprayed with a 50 per cent. emulsion of oleine in water so as to contain 0·5, 1·0, 2·0 and 8·0 per cent. of lubricant on the dry weight of wool. These lots were processed in the order of increasing amount of lubricant, and the slivers again examined for nep. The results shown in Table VII, together with the standard errors, indicate that there is a marked increase in nep

content when the lubricant exceeds 1 per cent., for it will be seen that an increase of a further 1 per cent. results in double the number of neps, whilst 8 per cent. oleine produced an exceptionally neppy sliver. The appearance of the wool on the workers during this experiment suggested that it was being rolled into a series of small pellets. It is interesting to note that these results conflict with Stenersens in that the unoiled wool had less neps than the oiled, whereas he found the reverse to be the case. The results are, however, comparable with those obtained in the wool grease series for there the untreated sliver had also the least number of neps. There is no doubt that wool containing more than 1 per cent. of oil will produce a more neppy sliver than that with less than 1 per cent. of lubricant.

Table VII

Oleine added to scoured wool (%)	Neps per gram (card sliver)
0·0	160 ± 6
0·5	178 ± 8
1·0	178 ± 8
2·0	283 ±17
8·0	538 ±78

Moisture content of feed wool = 43%
Throughput = 40 lbs. per hour.

The increase in nep content which accompanies the use of more than a certain amount of lubricant is attributed to the fact that this lubricant is acting as an adhesive and preventing the fibres from freely moving apart. Speakman and Greenwood[5] have shown that the force necessary to break a worsted roving oiled with various lubricants increases with an increase of oil and it is suggested that the same mechanism is acting in this case. If the addition of fairly small quantities of oil causes a large increase in the nep content of the sliver, one is obliged to ask why the product of the woollen card is comparatively free from this fault. An investigation was conducted to solve this problem and will be described in a later section. It must be remembered that the ratio of nep to fibre in a sliver is very small indeed, namely 1 : 230 by weight, so that it is quite possible to cause a large increase of nep by a small addition of any substance which has a tendency to produce that fault.

Effect of moisture

A further variable factor which might influence nep formation is the moisture content of the wool entering the card. A series of experiments was carried out by Lambert[6], working in collaboration with Mr. C. O. M. Steward, the wool again being loaned by Messrs. W. & J. Whitehead, Ltd. This series utilised 1,000 lbs. of greasy 64s Australian matchings, each experiment being carried out with a 50 lb. lot. The object of the series was to determine the effect on neppiness of the moisture content of the wool fed to the card. Each lot of wool was scoured and dried where necessary, to varying moisture contents. Carding was performed on the same machine with the same throughput in each case. The results are shown in Fig. 6. Each observation is the average of nine nep determinations on the card slivers from each experiment. It is evident that dry wool produces more neps than damp wool, whilst there are least neps formed when the regain of the wool is between 30 to 50 per cent. The increase in nep formation at 70 per cent. regain is attributed to the fact that the wool was in a very wet condition and tended to adhere in the lock form.

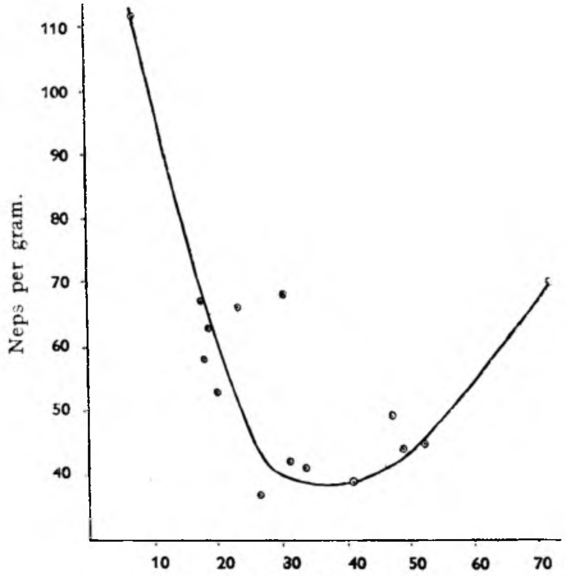

Fig. 6

The above results are confirmed by the data of Table VI, which have been rearranged in Table VIII to bring out the effect of moisture content on nep formation. It will be seen that each group of results shows the same tendency, namely, an increase in the moisture content of the feed wool is accompanied by a decrease in the nep content of sliver.

Table VIII

Neps per gram	Moisture content of feed wool (% regain)	Approximate burr content of feed wool (%)
185 ±4	19·6	
106 ±2	41·2	1
106 ±3	51·0	
181 ±3	13·8	
115 ±2	46·8	3·5
96 ±2	51·5	
184 ±3	24·3	
102 ±2	48·3	11
108 ±4	59·0	

In presence of oil, too, the neppiness of the carded sliver decreases with increasing moisture content, as is shown by the results of Table IX. Here again the wet wool possesses less neps than the dry, whilst both the oiled wools are neppier than the unoiled.

Table IX

Condition of wool fed to card	Neps per gram
40% moisture, no lubricant ...	95
40% moisture, 8% oleine ...	188
18% moisture, 8% oleine ...	232

Wool—64s Australian.
Throughput = 39 lbs. per hour.

This decrease in nep content at higher moisture contents is accounted for by Speakman's observations on the elasticity of wool fibres and Stenersen's theory of nep formation. According to the former, the percentage extension of wool fibres before breaking increases with increasing moisture content; and according to the latter, most neps are formed during carding by the wool fibres being stretched and suddenly released, when, due to their elasticity, they coil up. If two card rollers act on such a coil, it will become entangled with the neighbouring fibres and form a nep. The extension and contraction, which play an important part in nep formation, occur whenever a wool entanglement is acted on by the card wires. Some of the fibres while being stretched are thus suddenly relaxed. If, however, the fibre is able to extend an additional fraction at this critical moment, it might avoid breakage and the consequent recoil. The percentage extension of wool fibres is greater at higher moisture contents, so there is less chance of them being broken in the disentanglement, particularly because the highest possible breaking load, which occurs when the wool fibres are absolutely dry, is negligible compared with the forces employed in a carding machine. Hence less neps are formed when wool is carded with a fairly high, as opposed to a low moisture content.

Effect of heat

Finally the card was heated by means of two steam cannons, in further work which was carried out in collaboration with Mr. C. O. M. Steward. The previous experiments on neppiness were repeated, using the same blend of wool, but this time the machine was heated. The results are given in Table X. There are nine pairs of comparable results, each pair being carded with more or less the same moisture content. It will be seen that where the moisture content of the feed wool is below 25 per cent., there is not a great difference between the nep contents of the steam-heated and ordinary slivers, although the "steam on" results are slightly better. When dealing with higher moisture contents, which have been shown to be essential for a reduction in nep content, the "steam off" series gives a better result in every case.

Table X

Steam On				Steam Off		
Moisture content of feed wool (regain %)	Moisture content of sliver (regain %)	Neps per gram	Neps per gram	Moisture content of feed wool (regain %)	Moisture content of sliver (regain %)	Approximate burr content of feed wool (%)
13·2	11·6	163 ±3	185 ±4	19·6	11·1	
39·7	14·3	143 ±8	106 ±2	41·2	16·4	1
48·0	17·5	125 ±3	106 ±3	51·0	18·2	
14·0	10·3	175 ±6	181 ±3	13·8	9·1	
39·5	16·1	121 ±5	115 ±2	46·8	18·3	3·5
48·5	16·1	122 ±1	96 ±2	51·5	19·2	
18·5	11·9	195 ±4	184 ±3	24·3	11·8	
42·5	18·8	106 ±2	102 ±2	48·3	20·8	11
65·0	20·8	126 ±3	108 ±4	59·0	23·3	

The effect of steam heating the front part of the card is to dry the wool during the carding operation. S. Townend[7] has shown that wool tends to leave the card at a regain dependent on the humidity and temperature of the atmosphere in the carding room, regardless of its original moisture content. If the forepart of the card is steam-heated, the greater part of the loss of moisture will take place between the feed sheet and first worker of the first swift, whereas without steam heating this reduction in moisture content is not so great at this stage and is more evenly distributed along the length of the card. This retention of moisture allows the fibre to extend more easily and thus minimises the breakages which occur at lower moisture contents with a consequent reduction in the number of neps. The drying effect of the cannons is not so important when the wool is already in a dry state because there is then little loss of moisture during carding.

PART II. EFFECT ON NEP FORMATION OF MECHANICAL ALTERATIONS TO THE WORSTED CARD

Having shown how the nep content of a sliver is varied by modifying the condition of the wool, further experiments were carried out to determine the effect of modifying the carding conditions.

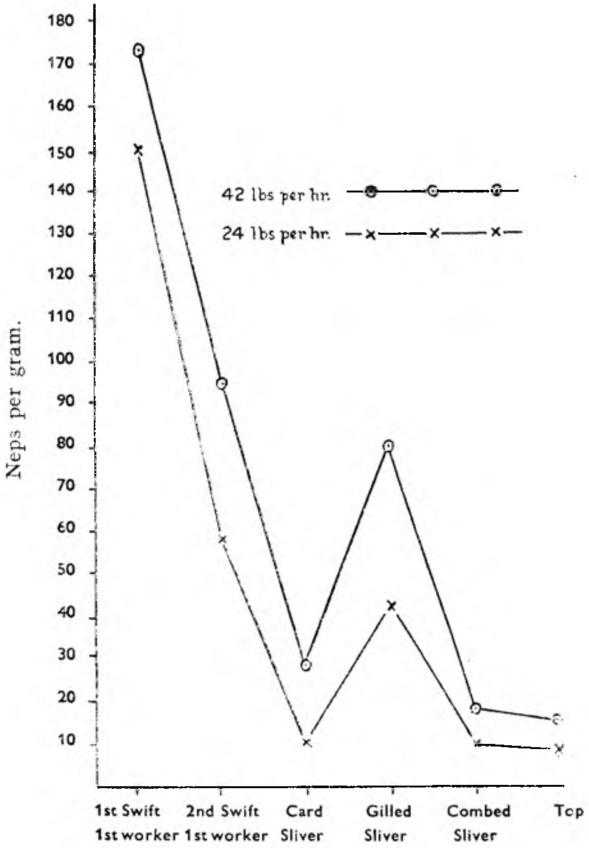

Fig. 7

It seemed necessary, first, to determine the location of neps in the machine. Two experiments were carried out, using 64s wool with a swift speed of 120 r.p.m. and throughputs of 24 and 42 lbs. per hour. Samples of wool were removed from the 1st workers on the 1st and 2nd swifts and the card sliver. Their nep content was then determined. Whilst it is recognised that the workers may be selective in action it is felt that since they are stripped at every revolution they will pick up the wool protruding from the swift face, whereas the swift is not entirely cleaned at each revolution, so that greater difficulties are entailed in sampling from this roller. The results of these experiments are shown in Fig. 7, which has several interesting features. In the first place, there is a gradual reduction in the number of neps as the material proceeds through the card; secondly, the larger throughput gives more neps; thirdly, the two curves are nearly parallel. It would appear therefore, that, providing the machine is functioning in a normal manner, neps are formed by the time the wool reaches the 1st swift, and one of the functions of these two cylinders and their rollers is to comb out or reduce the number made in the licker section. Again, the thicker the stream of wool passing through the machine the greater will be the neppiness of the resulting sliver ; this is no doubt due to the fact that there are more wool locks to disentangle, and the workers are only able to deal with a certain number.

Details of other tests carried out under varying conditions are given in Table XI. Each set of data was taken from a machine where the rollers were functioning in the normally accepted manner.

TABLE XI

Swift speed	Throughput	Neps per gram		
		1st Swift 1st Worker	2nd Swift 1st Worker	Sliver
80 r.p.m.	15 lbs. per hour	139	23	10
80 ,, ...	31 ,,	139	59	21
120 ,, ...	55 ,,	271	81	29
120 ,, ...	50 ,,	143	92	18
120 ,, ...	50 ,,	185	142	25

A further feature of Fig. 7, and one which throws a good deal of light on the problem of nep formation, is the continuation of the curves. The card slivers were passed twice through an intersector gill box, 4 ends up, 4 of a draft, combed on a French comb and again gilled twice on the same intersector, 4 ends up, 4 of a draft. The nep content was ascertained after each process.

The graph shows that the gilling operation following carding increases the number of neps. It is probable that this increase is due to the fibres in a card sliver not being arranged in a perfectly parallel order, although they tend to lie in that manner. When the high speed movement occurs at the front roller of a gill box the fibres lying in a crosswise direction will pull with them groups of other fibres and cause neps.

The combing process naturally reduces the number since the fibres are passed between very fine pins which prevent the neps going forward with the sliver, but the interesting feature is that there is no increase in neppiness when the same two gilling processes are repeated. There are two possible explanations of this fact : (*a*) the comb has removed most of the short fibres, or, (*b*) the fibres are now in a more parallel state. The first explanation is hardly feasible or the continental type of top would always be neppy. The second reason is suggested as being the correct one, namely, that the fibres, being parallel, are simply displaced by the drafting operation, and cannot form neps unless they pull other fibres forward with them, which is far less likely to occur in a set of parallel fibres.

This statement is substantiated by a series of experiments in which a 64s top was pulled up by hand and carded. The nep content of the sliver is shown in Table XII, and it will be seen that when the fibres enter the machine in an open state, so that they are easily disentangled by the various rollers, there is very much less chance of neps being formed, even when oil is applied.

It is now possible to refer back to Dickinson's work where an increase of nep content was accompanied by an increase in fibre length. Since the neps in the sliver are present by the time the wool reaches the first swift, it is suggested that the oil up to that time has acted as a lock lubricant rather than a fibre lubricant, its presence being restricted to small areas and is therefore more concentrated. This oil acts as an adhesive and helps to form neps. When the wool reaches the swifts, however, the fibres are being separated and mixed so that the oil distribution is far more uniform and it now acts as a fibre lubricant and minimises breakage.

Table XII

Oleine added to top (%)	Moisture content of top fed to card (% regain)	Neps per gram (card sliver)
0·0	9·9	1·3
1·0	11·5	2·3
8·0	11·0	1·4
0·0	49·0	2·5
0·5	49·6	1·7
1·0	43·0	1·9
2·0	48·2	1·6
8·0	45·0	7·3

Average throughput of the " dry " series, 43 lbs. per hour.
Average throughput of the " wet " series, 37 lbs. per hour.
Neps per gram of top before carding, 4·5.

Effect of rate of production

The production of a machine may be affected in two ways : by altering the throughput, i.e., the thickness of the stream passing through the machine, or by altering the speed at which the stream moves, i.e., by altering the dimensions of the main drive to the machine. A series of experiments was devised to determine the part each plays in the formation of neps. The same blend of 64s Australian wool was used in each experiment. In the first place, the wool was carded at varying throughputs and a constant swift speed of 120 r.p.m. The machine pulleys were then changed to give a swift speed of 80 r.p.m., so that the speed of every roller was two-thirds of that used in the former experiment. Again, the wool was carded with varying throughputs. A summary of the results is given in Table XIII, illustrated in Fig. 8.

Table XIII

Swift speed r.p.m.	Nature of wool			Throughput (lbs./hour)	Neps per gram.
	Regain (%)	Ether extract (%)	Alcohol extract (%)		
120	34·5	0·67	0·62	15·0	14·4
				20·6	12·0
				26·4	14·5
				38·8	15·1
				46·8	19·2
120	41·9	0·44	0·89	19·6	11·6
				56·2	20·2
80	46·7	0·39	0·98	14·7	10·2
				31·0	20·5
80	47·3	1·76	1·02	15·0	11·9
				21·0	20·2
				23·0	30·6
				26·2	35·8
				33·6	62·0

It will be seen that with both swift speeds, increasing throughput results in a gradual increase in neppiness. The slopes of the curves for a slow swift speed are, however, steeper than those for the high speed. This is attributed to the fact that a machine is only capable of processing a certain thickness of material, beyond which the wires are unable to disentangle any more fibres. It will be evident that an increase in the speed of passing the same stream of wool through the machine will enable a larger throughput to be obtained for the same degree of carding. If, therefore, the machine is taxed to its utmost by processing 56 lbs. per hour at a swift speed of 120 r.p.m., it is clear that when the speed is reduced to 80 r.p.m. the machine will be taxed to its utmost when the throughput is two-thirds that amount. In other words, 56 lbs. per hour at 120 r.p.m. is equivalent to carding 37 lbs. per hour at 80 r.p.m. An inspection of curves 2 and 3 shows that the same degree of neppiness is experienced by carding 56 lbs. of wool per hour at 120 r.p.m. and 30 lbs. per hour at 80 r.p.m.

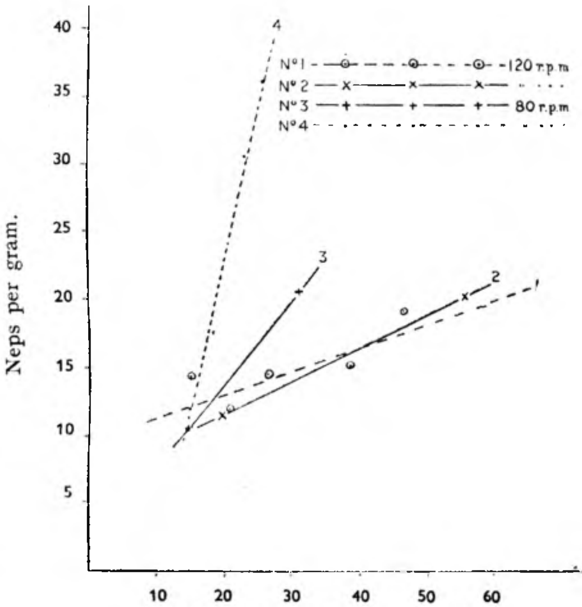

Fig. 8

Machine speed does not appear to have any effect on neppiness at low throughputs, for it will be seen that curves 2, 3 and 4 pass, very nearly, through the same point ; namely, 10 neps per gram, at a throughput of 14 lbs. per hour. This is probably because the stream is so thin that the workers are able to deal more or less adequately with the material passing through the machine.

Curve No. 4 has been plotted purposely to stress once again the influence of grease and soap. The combined ether and alcohol extracts in the case of this wool amounted to 2·78 per cent., compared with 1·37 per cent. for No. 3. The shift over to the left, denoting increased neppiness, is attributed to the presence of unclean wool.

It therefore appears that an increase in throughput will result in increasing neppiness, using the same swift speed, but there will be less neppiness at the same high throughput when a high swift speed is employed, providing that the machine is not taxed beyond its capacity as a carding agent.

Effect of feed roller speed

The object of this series was to determine whether the rate of presentation of wool to the first licker-in affected nep formation. Eighty pounds of greasy merino wool were scoured for this test. The card was cleaned before starting each experiment. In the first experiment one-half of the available wool was carded with a fast feed roller speed (1·33 revolutions per minute), and in the second experiment the remainder was carded with the normal speed (0·67 revolution per minute). The licker-in made 15 revolutions per minute in both cases, so that the relative surface speeds of licker-in and feed roller were 96 : 1 and 193 : 1, respectively. Samples of sliver were taken at intervals throughout the experiments. A summary of the results of neppiness is given in Table XIV.

Table XIV

Ratio, surface speed of licker to feed roller	Neps per gram	Moisture content of feed wool (% regain)
96 : 1	36 ±2·6	25·4
193 : 1	43 ±2·5	22·8

It will be seen that the fast feed roller speed produced a better result than the slow one, suggesting that a faster feed roller speed, or, since the speed of the licker-in remained unchanged, a smaller relative surface speed between feed roller and licker-in produces less neps. This is probably due to the fact that the carding action commences between the feed roller and the first licker-in, whilst the wool is still in its matted state. Hence a more gentle opening action at this point is less conducive to nep formation than when the maximum opening is affected at this part of the card.

Effect of setting

Kraus studied the effect which the setting of the various carding rollers on a Continental machine had on the amount of neps in the card sliver. The details are given in Table XV. It will be seen that the nep content of the sliver decreased as the workers were more closely set to the swifts. At the same time the fibre breakage, as indicated by the amount of noil, increased with the tighter settings.

Table XV

Setting	m.m.	m.m.	m.m.
Breast—1st worker	6·0	4·0	3·0
,, 2nd ,, ...	5·0	3·0	2·5
1st Swift—1st worker... ...	5·0	3·0	2·5
1st ,, 2nd ,, ...	4·0	2·0	2·2
2nd ,, 1st ,, ...	3·0	1·8	1·2
2nd ,, 2nd ,, ...	2·5	1·0	0·6
2nd ,, 3rd ,, ...	2·4	0·6	0·5
2nd ,, 4th ,, ...	2·3	0·5	0·4
2nd ,, 5th ,, ...	2·2	0·5	0·4
2nd ,, 6th ,, ...	2·0	0·4	0·3
Neps	1240·0	840·0	590·0
Noils (%)	9·1	11·3	11·7
Fibres less than 40 m.m. (%) ...	28·8	31·8	31·8

There is no doubt that the setting of the rollers one to the other will influence the nep content of the sliver. If the machine is set open, that is, the rollers are set well apart from each other, then there will be more neps in the sliver, since the worker teeth will be less able to comb the clusters of fibres which go to make this particular fault. If, on the other hand, the rollers are closely set, the teeth will act on more fibres and less neps will result. This argument is confirmed by Kraus' work, but, as already stated, the Continental card differs from the British in that it does not possess the licker section. The setting of this section, whether open or close, is a debatable one, so it was decided to carry out an experiment, using both settings on the same 64's Australian wool. The licker section was set close for the one test and open for the second, but the swift settings remained unaltered. A summary of the results is given in Table XVI.

Table XVI

Setting of licker section	Throughput lbs. per hour	Neps per gram
Close	25	13
Open	24	11
Close	47	25
Open	42	28

In each case the test was performed at a low and a high throughput. The differences between the two pairs of results are not considered significant, and it is evident that any difference in nep content produced by a more open setting of the licker section can be nullified by a close setting on the swifts. Unfortunately, when this experiment was carried out, the disposition of neps along the card was unknown so that samples were not taken from the first worker on the first swift, but further tests are being performed to verify this conclusion.

Effect of dividers

The preceding work on the setting of rollers in the licker section led to further experiments in which the action of the divider rollers was studied.

The preliminary opening of the wool locks is performed in the British botany card by the licker-in section, each roller being clothed slightly finer and having an increased surface speed over the preceding one. This portion of the machine incorporates the divider and stretcher rollers. The card used has two top and two bottom dividers and also two stretcher rollers. Their object is to relieve the licker-in rollers of some of the wool, and by means of a working action to open the wool locks. This action is considered rather drastic.

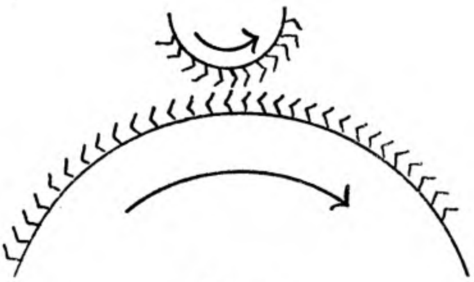

Fig. 9a

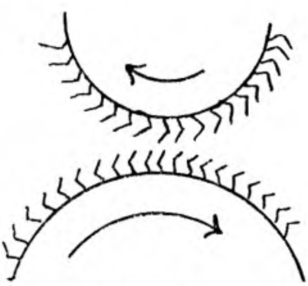

Fig. 9b

Two card rollers work the wool, if while acting on the fibres their teeth are moving "point to point." This is achieved with ordinary workers and swifts by the two rollers moving in the same direction at their point of contact, their pinning opposing each other as shown in Fig. 9a, and the swift having the greater surface speed. The working action can also be accomplished by two card rollers moving in opposite directions at their point of contact with their pinning opposing each other, as illustrated in Fig. 9b. This latter state exists between divider and licker-in, but instead of separating the wool gently, the divider tends to reverse the direction of the wool locks. Whilst a working action is attained in this manner, it must of necessity be a drastic one and was thought to be one source of nep formation. In the case of dividers this arrangement is inevitable (unless a special stripper is installed to clear each divider), because whereas the divider acts as a worker to one licker-in, the following licker-in acts as a stripper to the divider. The dividers, however, are not essential from the carding point of view, since each licker-in is stripped by the succeeding one.

The results of the feed roller series indicated that disentanglement of the wool locks should be accomplished in as gentle a manner as possible. It would therefore appear better to distribute this work throughout the entire card, rather than impose the major opening of the wool on the first few rollers. The present experiments were devised to test this theory.

A hundred pounds of greasy merino wool were scoured, yielding approximately 45 lbs. of clean wool. This was then divided into three equal portions. The first lot was carded with the machine running normally, the second without the two top dividers, and finally the remainder with all the dividers and the two stretcher rollers moved out of contact and inoperative. The "throughput" was maintained the same, and the card run off between each experiment. A summary of results is given in Table XVII.

Table XVII

Neps per Gram		
Normal running	Top dividers out of contact	All dividers and stretchers out of contact
46 ±1·7	39 ±1·1	33 ±1·1

Moisture content: feed wool, 31·4% regain.

These experiments demonstrate that divider rollers definitely increase the nep content of the sliver, for it will be observed that there is a decrease in the number of neps from 46 to 33, that is roughly 30 per cent., when these rollers are removed. This is probably due to the gentler carding action between the licker-in rollers when the drastic interference of the dividers is omitted. It would therefore seem an advantage, from the point of view of nep formation, to dispense with these rollers, but that would also bring about some disadvantages. The high throughput of the machine could not be maintained for any long period at the normal level, the card would need more frequent fettling and clearing, because the dust from the wool would not be so well removed in the first stages, and, most important of all, the present system of burr removal could not be used. One solution would be to employ a separate stripper roller to each divider, so that each one would make contact with one licker-in only, and reverse the direction of rotation of the divider. This would enable the same amount of disentanglement to be performed, but it would eliminate the reversal of the wool fibres and consequently reduce nep formation. Such a method would not allow the use of burr beaters on the dividers, so that they would either have to be placed to deburr the wool as it passed over the stripper as is done on the breast part of woollen cards, or, they might be placed over the licker after the divider, or some other method would need to be employed such as the Morel or a crushing device. At present, the latter can only operate on slivers. It appears to be a question of the relative advantages of less neppy slivers against the disadvantages of allowing vegetable matter to pass forward into the finer card clothing of the swifts, that is, unless some other deburring mechanism can be evolved.

Comparison of slivers produced from a woollen and a worsted card

More light can be thrown on the action of the licker section by comparing the slivers produced from a woollen scribbler and a worsted card. It was hoped that this experiment would allow a comparison to be made between the British and Continental types of machine, since the latter approximates to the woollen card so far as the arrangement of rollers is concerned.

The two machines were run at the same swift speed, namely 80 r.p.m., and the setting of the rollers was as nearly alike as possible. The breast of the woollen card was set with a 24's gauge, the 1st swift with 26's and second swift with 28's. In the case of the worsted machine the setting of the licker section was normal,* the 1st swift a 26's and the 2nd swift 28's gauge.

Both machines were specially ground for the experiment so that the carding conditions were as similar as possible, and a 64s Australian wool was again used. The throughputs of the two machines were adjusted so that they were approximately the same. Each experiment was repeated with 5 per cent. of oleine added to the wool, with the object of comparing the effect of oil on the neppiness of the slivers from the two machines. A summary of the results is given in Table XVIII.

Table XVIII

Process	Throughput lbs. per hour	Neps per gram
Woollen	28	18 ± 1
Worsted	26	24 ± 1
Woollen, 5% oleine ...	23	28 ± 3
Worsted, 5% oleine ...	26	75 ± 13

Moisture content of feed wool, 52·0% regain.

The sliver from the woollen scribbler is less neppy in both instances, and in the oiled experiment is very much better than the one produced from the worsted card. This increase in nep content, in the case of the oiled wools, is ascribed to the combined action of the licker section and the presence of oil. This again strengthens the argument that oil may act first as an adhesive and later as a lubricant, for the wool is converted into the fibrous form very much sooner in the case of the woollen scribbler than the worsted card, due to the action of the workers placed over the breast cylinder of the former machine.

Effect of fancy speed

The trend of results has shown that nep formation is likely to occur when a rolling of the fibres is brought about. It was therefore decided to investigate the effect on the neppiness of the card sliver of varying the speed of the 1st swift fancy roller over as wide a range as possible.

100 lbs. of 64s greasy Australian wool were scoured and carded. The swift and its rollers were stripped after every experiment, the duration of each being 45 minutes. It was considered that such a period would allow the effect of any change to be seen.

The slivers were examined for nep content and the results are shown in Table XIX, whilst Fig. 10 shows the neps plotted against the ratio of the

* Setting of licker section of worsted card:—

		Gauge
Feed rollers	—1st licker ...	20
1st licker	—2nd licker ...	20
2nd licker	—3rd licker... ...	28
3rd licker	—4th licker... ...	28
4th licker	—1st swift	28
1st licker	—1st divider ...	20
1st divider	—2nd licker ...	20
2nd licker	—2nd divider ...	20
2nd divider	—3rd licker... ...	20
3rd licker	—3rd divider ...	24
3rd divider	—4th licker... ...	24
4th licker	—4th divider ...	28
4th divider	—1st swift	28
1st licker	—1st stretcher ...	20
1st stretcher	—2nd licker ...	20
3rd licker	—2nd stretcher ...	28
2nd stretcher	—4th licker... ...	28

surface speeds of fancy and swift. It will be seen that there is a great increase in neppiness as the surface speed of the fancy approximates to that of the swift. There is a minimum value at a certain ratio, but it again increases when this is passed.

Table XIX

Revs. per min. of 1st swift fancy	Ratio surface speed of fancy to swift	Weight of material removed from swift and rollers (drams)	Neps per gram
454	1·31 : 1	129	72 ± 3
440	1·30 : 1	—	55 ± 3
385	1·14 : 1	218	257 ± 8
366	1·08 : 1	253	310 ± 8
345	1·02 : 1	254	422 ± 18

Swift speed, 118 r.p.m.
Throughput, 23 lbs. per hour.

The build up in neppiness with a decrease in the relative surface speeds of the two rollers is due to the fact that the fancy is no longer acting as an efficient clearing agent, i.e., it is unable to raise the material to the surface of the swift teeth for removal by the doffer, and so these gradually fill up as more material comes forward. Less effective combing of the wool between swift and worker is the result. In other words, the stream of material is so thick that the rollers are unable to cope with it, and a rolling of the wool occurs between the swift and workers. This statement is borne out by comparing the weights of wool removed from the swift and its accompanying rollers.

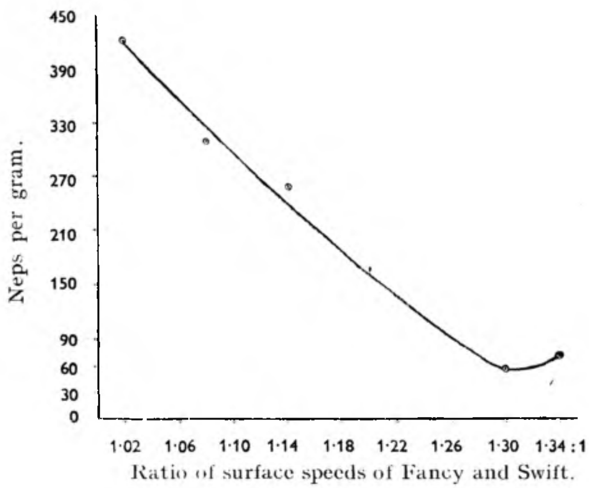

Fig. 10

The increase in neppiness with a speed ratio greater than the critical one is quite feasible, for above a certain swift-fancy ratio the teeth of the latter roller will raise the material so violently that it will be passed round the fancy and again be presented to the raising action ; so that an over-crowding and rolling of the wool takes place at this point and an increased nep content will result.

It is not suggested that an optimum ratio of 1·3 : 1 for fancy-swift speed ratio is valid in all cases, but only for the particular card under consideration. This optimum speed ratio depends on many factors, e.g., depth of setting of fancy wire into swift teeth, flexibility of fancy and swift teeth, population of each roller, throughput of the machine, type of wool being processed, all of which may vary. The results of this particular experiment have, however, demonstrated that the swift-fancy speed ratio is fairly critical and any adjustment on either side of the optimum value will cause more neps to be formed.

Effect of grinding

The grinding operation is considered to be a necessary one in worsted card rooms. The importance attached to it is emphasised when it is realised that the grinding action must wear away the wire teeth of the rollers, but evidently this decrease in the life of the card clothing is thought to be less important than that the card should work in an unground state. It was therefore decided to investigate the effect of grinding on the neppiness of the card sliver.

Only 700 lbs. of wool had been processed on the half-width card since the last grinding so that the wire was in a fairly good condition before the experiment was carried out. Nevertheless 40 lbs. of 64's Australian wool were scoured and carded and samples taken for the usual testing routine. The machine was then ground throughout. 50 lbs. of the same lot were then scoured and carded, so that the only difference between the two experiments was the condition of the wire teeth. The two slivers were compared for neppiness and a summary of the results is given in Table XX.

Table XX

Before grinding		After grinding	
Moisture content of feed wool (% regain)	Neps per gram	Moisture content of feed wool (% regain)	Neps per gram
23	43 ±2·5	26	22 ±0·7

It will be seen that the nep content of the sliver produced after grinding is half that of the unground card. This statement emphasises the importance of maintaining the card wire in a sharp condition, for it must be remembered that the machine had only processed 700 lbs. of wool (1,400 lbs. full width) since the previous grinding. In mill practice 10,000-12,000 lbs. of wool are carded before the machine is re-ground.

SUMMARY

The purpose of this investigation was to discover the factors responsible for the formation of neps in worsted carding, and to define the best conditions for minimising neppiness. The experiments, which were carried out on 64's Merino wool, may be classified under two headings, viz., those concerned with the state of the wool fed to the card, and those concerned with mechanical alterations to the machine.

As regards experiments of the former type, it was found that the neppiness of the carded sliver is at a minimum when the regain of the feed wool lies between 30 and 50 per cent. Steam heating of the forepart of the card does not appear to influence nep content to any large extent ; with wool containing this critical amount of water the sliver is slightly more neppy when steam heating is used, whereas with wool at lower regains neppiness is slightly reduced.

The most important cause of nep formation is undoubtedly the tangled nature of the scoured wool normally fed to the card, for when pulled-up tops are carded the sliver is practically free from neps. From this point of view it would undoubtedly be best to use the solvent system of scouring greasy wool, and so long as the emulsion scouring method continues to be used, every precaution must be taken to ensure that felting—even incipient felting—is avoided. The need for such precautions is emphasised by the fact that there is a steady decline in the neppiness of the wool as it proceeds from the first swift to the final sliver in the standard British type of botany card. Whatever method of scouring is employed, however, the wool should be as clean as possible, because it has been found that the neppiness of a carded sliver increases steadily with increasing grease content. In addition, if the amount of residual soap in the wool exceeds 0·5 per cent., the neppiness is accentuated, just as it is when the amount of added oil exceeds 1 per cent. The presence of burr in scoured wool is without influence on neppiness, except in so far as it necessitates the use of burr beaters, which promote nep formation.

As regards mechanical alterations to the machine, the nep content of the carded sliver decreases with increasing speed of the card as a whole, but an increase in throughput leads to a higher nep content. On the other hand, a reduction in the relative surface speed between feed rollers and first licker-in causes a reduction in neppiness. A further factor of importance is the setting of the workers to the swift; the closer these rollers are set to each other, the clearer is the sliver. Assuming a constant worker-swift setting, however, any alteration to the setting of the licker section is not reflected in the nep content of the sliver.

The action of the dividers, in reversing the direction of the wool at the divider-licker point of contact, is responsible for a fair proportion of neps, and the ratio of the surface speeds of fancy and swift is highly critical. If the fancy runs at a surface speed higher or lower than the critical value, there is a large increase in the nep content of the sliver. As would be expected, too, grinding has a great influence on neppiness; a newly ground card reduced the nep content to half the number present in a sliver produced immediately before grinding.

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Department of Textile Industries,
Leeds University.

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