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THE EFFECT OF RAISING THE MIDDLE ROLLER AND SOME OTHER FACTORS ON THE YARN STRENGTH OF SINDHI COTTON

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INDIAN CENTRAL COTTON COMMITTEE TECHNOLOGICAL LABORATORY.

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I SUMMARY.

Sixteen samples of yarns spun in a local mill were tested for strength with the object of ascertaining the influence of the following three factors:—(*i*) the height of the bottom middle roller with respect to the other two rollers, (*ii*) the weight of the top middle roller, and (*iii*) the weight of the top back roller. For (*i*), the bottom middle roller was raised by means of specially constrained roller stands so that its top surface stood respectively 1/32″ and 2/32″ above the tangent to the first and third rollers. For (*ii*), the weights of the top middle roller employed in these tests were 5 oz., 4 oz., 3 oz., and 2 oz. For (*iii*), the weights of the top back rollers used were 2½ lbs. and 3½ lbs., respectively. The following conclusions are drawn from the results :—

I.—*The effects of raising the middle roller from* 1/32″ *to* 2/32″.—

(*i*) The lea-breaking strength of the yarns spun with 2/32″ middle roller elevation lies between 75 to 80 lbs., while that of the yarns for which the rollers were lifted by only 1/32″ is only about 65 lbs. Thus, by a small change in elevation of the middle roller, an improvement of 10—15 lbs. in test was obtained. This improvement is attributed to the better control exerted over the fibres when they are made to adopt a curved instead of a straight path in their passage through the rollers.

(*ii*) The best strength results were obtained when the ordinary top back roller was used in combination with 2/32″ middle roller elevation, while the heavy back roller in combination with 1/32″ middle roller elevation gave the poorest results.

(*iii*) The average difference in yarn strength on elevating the middle roller from 1/32″ to 2/32″ became progressively less as the weight of the middle roller was reduced showing that the combination of the lighter top middle rollers with 2/32″ elevation gave on the whole stronger yarns.

Both the interactions (*ii*) and (*iii*) show that a rigid control of the fibres as represented by a heavy back or middle roller is likely to give weaker yarns than relatively elastic control exerted by a comparatively lighter back or top middle roller.

II.—*The effect of using middle top rollers of different weights varying from* 5 *oz. to* 2 *oz.*—

With 2/32″ middle roller elevation, the use of the comparatively light top middle roller in place of the 5 oz. one affected the yarn-strength one way or another depending upon the weight of the top back roller.

But with 1/32″ middle roller elevation the use of the lighter middle rollers gave an increase in the yarn-strength regardless of the weight of the top back roller.

III.—*The effects of using ordinary or the heavy back roller.*—

(*i*) The effect of replacing the ordinary with the heavy back roller is, on the whole, a reduction in yarn-strength, the decrease being greater with the smaller than with the larger middle roller elevation. It appears as if the better control of the fibres resulting from lifting up of the bottom middle roller can neutralise, to some extent, the adverse effect of using a heavy back roller.

(*ii*) The adverse effect of using the heavy back roller becomes progressively less as the weight of the top middle roller is reduced, the only exception to the rule being the lightest of the four rollers weighing only 2 oz. for which there is a reversal of the effect.

II INTRODUCTION.

The sixteen samples of yarns, which provided the material for the tests described in this report, were spun in a local mill from Sindhi cotton into 13's nominal counts with 18.17 (calculated) turns to the inch. These yarns were spun with a draft of 8.80 direct from an intermediate roving of 1.50 hank, the spindle speed employed being 8529 r.p.m. The diameters of the ring frame rollers were 7/8″, 5/8″ and 7/8″. So far the spinning conditions were common for all the 16 yarns. There were, however, three factors in the ring frame which were varied for the different yarns. These were as follows :—(1) The height of the bottom middle roller with respect to the other two rollers, (2) the weight of the top middle roller, and (3) the weight of the top back roller. As regards (1), the bottom middle roller is ordinarily supported in such a manner that its top surface is flush with the surface of the other two rollers, so that the roving passing over the three bottom rollers lies practically in a straight line as shown in Fig. 1A. In the present case, by means of specially constrained roller stands, the bottom middle roller was raised so that its top surface stood respectively 1/32″ and 2/32″ above the tangent to the 1st and the 3rd rollers as shown in Fig. 1B.

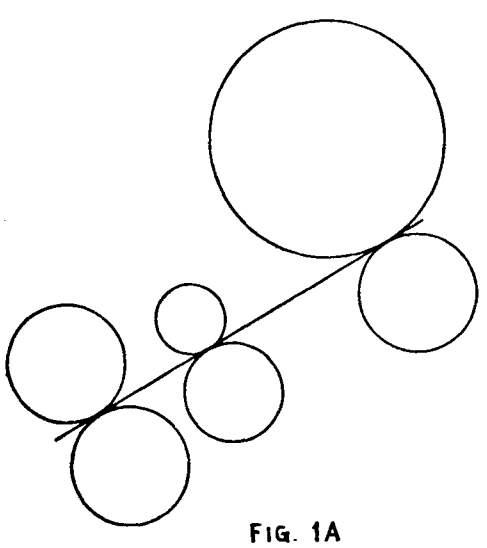

FIG. 1A

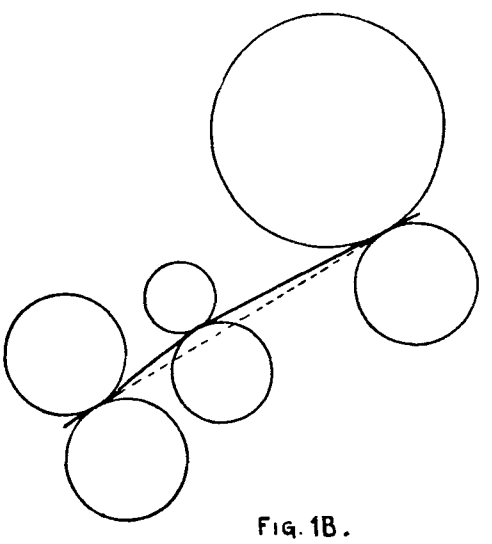

FIG. 1B.

It will be seen that in this case, especially with the middle roller elevation of 2/32", the roving makes an arc while passing over the three rollers as a result of which the fibres remain longer in contact with the middle roller.

As regards (2) and (3) the weights of the top middle rollers employed in these tests were 5 oz., 4 oz., 3 oz., and 2 oz., respectively, while the two top back rollers used weighed $2\frac{1}{2}$ lbs., and $3\frac{1}{2}$ lbs., respectively, the former typifying the ordinary back roller while the latter represented a heavy one.

III TESTS.

The object of these tests was to ascertain the effect of these three factors on the yarn-strength of Sindhi cotton. The manner in which these factors were varied for the different yarns will be seen from Statement I.

STATEMENT I.

Yarn No.	Top Middle Roller weight.	Middle Roller elevation.	Top Back Roller.
1	5 oz.	2/32"	Ordinary Back Roller.
2	5 oz.	2/32"	Heavy " "
3	5 oz.	1/32"	Ordinary " "
4	5 oz.	1/32"	Heavy " "
5	4 oz.	2/32"	Ordinary " "
6	4 oz.	2/32"	Heavy " "
7	4 oz.	1/32"	Ordinary " "
8	4 oz.	1/32"	Heavy " "
9	3 oz.	2/32"	Ordinary " "
10	3 oz.	2/32"	Heavy " "
11	3 oz.	1/32"	Ordinary " "
12	3 oz.	1/32"	Heavy " "
13	2 oz.	2/32"	Ordinary " "
14	2 oz.	2/32"	Heavy " "
15	2 oz.	1/32"	Ordinary " "
16	2 oz.	1/32"	Heavy " "

These yarns were tested for their lea-breaking strength, actual counts, and actual number of turns per inch. The results of the tests are given in Table I, which also shows the relative humidity prevailing during the tests in the Yarn Testing Room as well as the number of tests carried out for each of the three above-mentioned yarn characteristics.

TABLE I.

Yarn doffing No.	Turns per inch Warp-way.	Counts.	Mean Strength (lbs.)	Highest Reading (lbs.)	Lowest Reading (lbs.)	Co-efficient of variation of strength (%).	Count Strength product.	R.H.%.
1	17·1	11·9	92·9	115·0	68·0	12·7	1106	74
2	19·2	12·3	83·5	109·5	56·0	15·9	1027	73
3	17·8	12·8	71·4	106·0	37·0	22·5	914	72
4	18·1	13·0	68·8	98·0	38·0	19·8	894	74
5	17·9	11·7	92·8	123·0	49·0	18·6	1086	72
6	18·5	11·3	102·4	124·0	76·5	11·8	1157	71
7	16·9	12·9	72·6	93·0	50·0	15·9	937	71
8	18·3	13·1	71·7	106·0	48·5	19·8	939	70
9	19·6	11·7	93·8	115·0	70·5	12·1	1097	70
10	19·1	11·4	99·3	123·0	72·0	10·7	1132	72
11	18·7	12·8	75·4	98·5	50·5	16·7	965	72
12	17·6	13·0	68·2	88·5	45·0	16·7	887	69
13	18·4	12·1	92·3	128·5	48·0	22·7	1117	72
14	18·2	11·5	100·3	123·5	53·0	17·6	1153	72
15	17·3	12·4	84·5	107·0	68·5	11·3	1048	72
16	19·0	12·6	79·6	97·5	56·5	13·0	1003	72

No. of tests : Twist : 100 tests per doffing.
Lea : Yarns Nos. 1—6 and 14 :—40 tests per doffing.
Yarns Nos. 7—13 and 15 :—50 tests per doffing.
Yarn No. 16—48 tests.

It will be seen that, apart from the variation in the actual counts, there is considerable variation in the number of turns per inch inserted in the different yarns. Both actual counts and the number of turns per inch influence yarn strength ; therefore, in order to bring out the effects, if any, of such factors as middle roller elevation or the weight of top middle or back roller, it is necessary to make due allowance for the variation in counts and twist. The variation in counts can easily be allowed for either by considering the count strength product or calculating from it the lea-breaking strength for a given constant count. But, in order to allow for the variation in twist, it was necessary to make a series of supplementary tests with a view to finding out the rate of change in the strength of these yarns with twist. For the purpose of these tests, three yarns, namely Nos. 1, 7 and 12, were selected and their single thread strength was found after the insertion of additional 0.5, 1.0, 1.5 and 2.0 turns to the inch. These tests were made on an electrically driven Schopper single thread tester which is fitted with an attachment for inserting additional twist in a yarn before breaking it. The results, each of which is the mean of 100 determinations, are given in Tables II—IV.

TABLE II.

Yarn No. 1.

Mean Count.	Mean Strength (oz.)	Count Strength Product.	Turns per inch.	Mean R.H. (%).
12.12	13.83	167.6	17.1	69
12.02	14.15	170.1	17.5	69
11.97	14.85	177.8	18.0	69
12.10	15.06	181.2	18.5	69
12.10	15.48	187.3	19.0	69

TABLE III.

Yarn No. 7.

Mean Count.	Mean Strength (oz.)	Count Strength Product.	Turns per inch.	Mean R.H. (%).
13.24	10.59	140.2	16.9	71
12.81	11.63	149.0	17.5	71
13.01	12.26	159.5	18.0	71
13.05	12.86	167.8	18.5	71
13.09	13.61	178.1	19.0	71

TABLE IV.

Yarn No. 12.

Mean Count.	Mean Strength (oz.)	Count Strength Product.	Turns per inch.	Mean R.H. (%).
12.44	12.80	159.2	17.6	69
12.88	12.56	161.8	18.0	69
13.07	12.34	161.3	18.5	69
13.44	12.29	165.2	19.0	69

It will be seen that the values of the percentage increase in strength with additional twist is different for the different yarns. In order to reduce the sampling error as far as possible, the means of the three sets of determinations are taken for applying the necessary correction, and the assumption is further made that the rate of increase with twist would be the same for the lea as for the single thread test. In applying

this correction the strength of each yarn is computed for 17 turns to the inch. A further correction is necessary to allow for the small variation in the relative humidity prevailing in the testing room. The values of yarn strength, corrected for variation in counts, twist and relative humidity, are given in Table V.

TABLE V.

Yarn No.	Count Strength Product.	Strength for 13s. nominal.	Top Middle Roller weight.	Middle Roller elevation.	Top Back Roller.
1	1076	82.8	5 oz.	2/32″	Ordinary
2	875	67.3	5 oz.	2/32″	Heavy
3	856	65.8	5 oz.	1/32″	Ordinary
4	812	62.5	5 oz.	1/32″	Heavy
5	1010	77.7	4 oz.	2/32″	Ordinary
6	1049	80.7	4 oz.	2/32″	Heavy
7	939	72.2	4 oz.	1/32″	Ordinary
8	866	66.6	4 oz.	1/32″	Heavy
9	961	73.9	3 oz.	2/32″	Ordinary
10	976	75.1	3 oz.	2/32″	Heavy
11	853	65.6	3 oz.	1/32″	Ordinary
12	850	65.4	3 oz.	1/32″	Heavy
13	1014	78.0	2 oz.	2/32″	Ordinary
14	1060	81.5	2 oz.	2/32″	Heavy
15	1014	78.0	2 oz.	1/32″	Ordinary
16	870	66.9	2 oz.	1/32″	Heavy

IV DISCUSSION.

We shall first of all make a preliminary examination of the results with a view to ascertaining the spinning factors which gave the best results. We shall follow it up by a more detailed analysis.

If the strength values given in Table V are arranged in descending order of magnitude in the groups, 85—80, 80—75, etc., to 65—60 lbs., we obtain the following distribution of results given in Table VI.

TABLE VI.

85—80				80—75				75—70				70—65				65—60			
Lea Str. (lb.)	M.R. wt. (oz.)	M.R. Ele.	Back Roller.	Lea Str. (lb.)	M.R. wt. (oz.)	M.R. Ele.	Back Roller.	Lea Str. (lb.)	M.R. wt. (oz.)	M.R. Ele.	Back Roller.	Lea Str. (lb.)	M.R. wt. (oz.)	M.R. Ele.	Back Roller.	Lea Str. (lb.)	M.R. wt. (oz.)	M.R. Ele.	Back Roller.
(82.8)	5	2/32″	Ordinary	(77.7)	4	2/32″	Ordinary	(72.2)	4	1/32″	Ordinary	(67.3)	5	2/32″	Heavy	(62.5)	5	1/32″	Heavy
(80.7)	4	2/32″	Heavy	(75.1)	3	2/32″	Heavy	(73.9)	3	2/32″	Ordinary	(65.8)	5	1/32″	Ordinary				
(81.5)	2	2/32″	Heavy	(78.0)	2	2/32″	Ordinary					(66.6)	4	1/32″	Heavy				
				(78.0)	2	1/32″	Ordinary					(65.6)	3	1/32″	Ordinary				
												(65.4)	3	1/32″	Heavy				
												(66.9)	2	1/32″	Heavy				

It will be seen that with the exception of one value the strength of all the yarns spun with 2/32″ middle roller elevation lies in the two higher groups, namely 85—80 and 80—75 lbs., while with the exception of two values the strength of all the yarns spun with 1/32″ middle roller elevation lies in the three lower groups. Among the two latter exceptional cases, one value is 73.9 lbs., which is on the border line between the two groups. It will further be seen that, apart from the few exceptional cases mentioned above, the lea-breaking strength of the yarns spun with 2/32″ middle roller elevation lies between 75 to 80 lbs., while that of the yarns for which the rollers were lifted by only 1/32″ was only about 65 lbs. Thus by this slight change, a difference of 10—15 lbs. in test was obtained which shows that lifting the middle roller by 2/32″ definitely improved the strength of the yarns spun from this cotton. This improvement in yarn strength is no doubt due to the better control exerted over the fibres when they are made to adopt a curved instead of a straight path in their passage through the rollers. It would definitely be interesting and useful to push this enquiry further and to ascertain the effect of lifting the middle roller through a wider range using different types of cottons.

We shall now discuss in greater detail the effect of changing one of the three factors at a time, keeping the other two constant, and the interaction of one factor with the other two factors. We shall first consider the effect of raising the middle roller from 1/32″ to 2/32″. In Table VII below, the percentage differences computed on the basis of the value for 1/32″ elevation have been shown for the eight sets of yarns treated in this manner.

TABLE VII.

Top Middle Roller weight.	Top Back Roller.	Middle Roller elevation.	Percentage difference.	Samples Compared.
5 oz.	Ordinary	Between 1/32″ and 2/32″ on 1/32″.	+25.8	3 & 1
5 oz.	Heavy	Do. do. ..	+ 7.7	4 & 2
4 oz.	Ordinary	Do. do. ..	+ 7.6	7 & 5
4 oz.	Heavy	Do. do. ..	+21.2	8 & 6
3 oz.	Ordinary	Do. do. ..	+12.7	11 & 9
3 oz.	Heavy	Do. do. ..	+14.8	12 & 10
2 oz.	Ordinary	Do. do. ..	0	15 & 13
2 oz.	Heavy	Do. do. ..	+21.8	16 & 14

It will be seen that, except in one case, lifting the middle roller by 2/32″ resulted in an appreciable increase in yarn strength, which ranged from 7.6 to 25.8 per cent. with a mean value of 14 per cent. This represents a very considerable increase and shows the advantage that might be obtained by raising the middle roller through a small height. Further, if we group the values obtained with the ordinary and the heavy back rollers, we find that the average difference with the former is +11.5 per cent. as against +16.4 per cent. with the latter. The smaller difference with the ordinary back roller shows that its combination with the 2/32″ middle roller elevation gave better results than

that of the heavy back roller. Similarly, the percentage differences in yarn strength with the 5 oz., 4 oz., 3 oz., and 2 oz., middle rollers come out + 16.8, + 14·4, + 13·8 and +10.9 respectively. The progressive decrease in these differences shows that the combination of the lighter top middle rollers with 2/32″ elevation gave stronger yarns. Both these interactions point to the operation of the same causes, namely if the control on the fibres is sufficiently elastic to enable them to glide smoothly, the resulting yarn is strong, while if the control is rigid the yarn is comparatively weak. The ordinary back roller and the comparatively light top middle roller represent the former conditions, while the heavy back and the top middle roller represent the latter conditions.

We shall now consider the effect of using middle top rollers of different weights varying from 5 oz. to 2 oz., keeping the other conditions the same. The relevant values have been grouped below in Table VIII, which shows the percentage difference in lea-strength obtained when the top middle rollers of different weights are employed.

TABLE VIII.

Middle Roller elevation.	Top Back Roller.	Top Middle Roller weights.	Percentage difference.	Samples compared.
2/32″	Ordinary	Between 5 oz. & 4 oz. on 5 oz.	— 6.2	1 & 5
2/32″	Heavy	Do. do. ..	+19.9	2 & 6
1/32″	Ordinary	Do. do. ..	+ 9.7	3 & 7
1/32″	Heavy	Do. do. ..	+ 6.6	4 & 8
2/32″	Ordinary	Between 5 oz. & 3 oz. on 5 oz.	—10.7	1 & 9
2/32″	Heavy	Do. do. ..	+11.6	2 & 10
1/32″	Ordinary	Do. do. ..	— 0.3	3 & 11
1/32″	Heavy	Do. do. ..	+ 4.6	4 & 12
2/32″	Ordinary	Between 5 oz. & 2 oz. on 5 oz.	— 5.8	1 & 13
2/32″	Heavy	Do. do. ..	+21.1	2 & 14
1/32″	Ordinary	Do. do. ..	+18.5	3 & 15
1/32″	Heavy	Do. do. ..	+ 7.0	4 & 16
2/32″	Ordinary	Between 4 oz. & 3 oz. on 4 oz.	— 4.9	5 & 9
2/32″	Heavy	Do. do. ..	— 6.9	6 & 10
1/32″	Ordinary	Do. do. ..	— 9.1	7 & 11
1/32″	Heavy	Do. do. ..	— 1.8	8 & 12

TABLE VIII—(*contd.*)

Middle Roller elevation.	Top Back Roller.	Top Middle Roller weights.	Percentage difference.	Samples compared.
2/32″	Ordinary	Between 4 oz. & 2 oz. on 4 oz.	+ 0.4	5 & 13
2/32″	Heavy	Do. do. ..	+ 1.0	6 & 14
1/32″	Ordinary	Do. do. .	+ 8.0	7 & 15
1/32″	Heavy	Do. do. ..	+ 0.5	8 & 16
2/32″	Ordinary	Between 3 oz. & 2 oz. on 3 oz.	+ 5.5	9 & 13
2/32″	Heavy	Do. do. ..	+ 8.5	10 & 14
1/32″	Ordinary	Do. do. ..	+ 1.9	11 & 15
1/32″	Heavy	Do. do. ..	+ 2.3	12 & 16

It will be seen that, with a 2/32″ middle roller elevation and the ordinary back roller, if we replace the 5 oz. top middle roller with a lighter one (4, 3 or 2 oz.) the result in each case is a reduction in yarn strength, the average decrease being 7.6 per cent. If, on the other hand, with the same elevation but with a heavy back roller we employ lighter middle rollers weighing 4, 3 or 2 oz., there is an average gain of 17.5 per cent. in yarn strength. Thus, with the same middle roller elevation the use of comparatively light top middle roller would affect the yarn strength one way or another depending upon the weight of the top back roller. However, if the bottom middle roller is lifted by 1/32″ instead 2/32″, the use of the 4 oz., 3 oz., and 2 oz., top middle rollers instead of the 5 oz. one gives an increase in yarn strength regardless of the weight of the top back roller, the average increase (9.3%) being somewhat greater with the ordinary than with the heavy back roller (6.1%).

We consider next the effect of replacing the 5 oz. top middle roller with one weighing 4 oz., 3 oz., or 2 oz., respectively, without, for the time being, taking into consideration the elevation of the middle or the weight of the back roller. We find that the average increase in strength is 7.5%, 1.3%, and 10.2%, respectively. These results show that so far as the weight of the top middle roller *alone* is concerned, the best results would be obtained by using the lightest of the four rollers, namely, the one weighing 2 oz.

On applying similar analysis to the results for the change over from the 4 oz. to a lighter roller, we notice that the effects are not pronounced in any one case with 2/32″ elevation and ordinary back roller. This change gives an average increase in strength of only 2%, while the same elevation but with the heavy back roller there is an average loss of 3%. The corresponding values with 1/32″ elevation are 0.6% average loss with the ordinary as well as the heavy back roller. All these differences are small enough to be within the sampling error and show that the substitution of the 4 oz. roller with a lighter one did not produce any marked change in yarn strength.

We will next consider the effect of using the ordinary or the heavy back roller the other conditions remaining the same. The percentage differences in lea strength produced by this change are given in Table IX below.

TABLE IX.

Top Middle Roller weight.	Middle Roller elevation.	Top Back Rollers.	Percentage difference.	Samples compared.
5 oz.	2/32″	Between ordinary and heavy on ordinary.	—18.7	1 & 2
5 oz.	1/32″	Do. do. ..	— 5.0	3 & 4
4 oz.	2/32″	Do. do. ..	+ 3.9	5 & 6
4 oz.	1/32″	Do. do. ..	— 7.8	7 & 8
3 oz.	2/32″	Do. do. ..	+ 1.6	9 & 10
3 oz.	1/32″	Do. do. ..	— 0.3	11 & 12
2 oz.	2/32″	Do. do. ..	+ 4.5	13 & 14
2 oz.	1/32″	Do. do. ..	—14.2	15 & 16

It will be seen that with 2/32″ elevation the result of using a heavy instead of the ordinary back roller is an average loss of 2.2% in yarn strength while with 1/32″ elevation the result is an average loss of 6.8%. These results show that the effect of replacing the ordinary with the heavy back roller is, on the whole, a reduction in yarn strength, the decrease being greater with the smaller elevation. It follows that the better control on the fibres resulting from lifting up of the bottom middle roller can neutralise to some extent the adverse effect of using a heavy back roller.

Finally, we consider the interaction of the weight of the top middle roller with that of the back roller. We find that with the 5 oz. middle roller the effect of using the heavy instead of the ordinary back roller is a loss of 11.8% in yarn strength, while with the 4 oz., 3 oz. and 2 oz. rollers the corresponding differences are —2.0, +0.6 and —4.8 per cent., respectively. These results show that the adverse effect of using the heavy back roller becomes progressively less as the weight of the middle roller is reduced, the only exception to this rule being the lightest of the four rollers weighing only 2 oz. for which there is a reversal of the effect. Thus, as in the case of the middle roller elevation, a lighter roller gives on the whole a better play to the fibres which serves to neutralise, to some extent, the comparatively rigid control exercised by an especially heavy back roller.

V ACKNOWLEDGMENTS.

As mentioned in the Introduction, these yarns, together with the necessary details, were kindly supplied by a local mill. I welcome this step as an indication of the closer co-operation between the industry and the Technological Laboratory and hope that it will continue to develop to their mutual benefit. My thanks are due to Mr. M. U. Parmar for making the supplementary tests with additional twist and to Mr. V. Venkataraman for assisting me in preparing the tables.