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SOME SPECIAL FEATURES OF THE OPEN-END SPUN COTTON YARNS[1]

by

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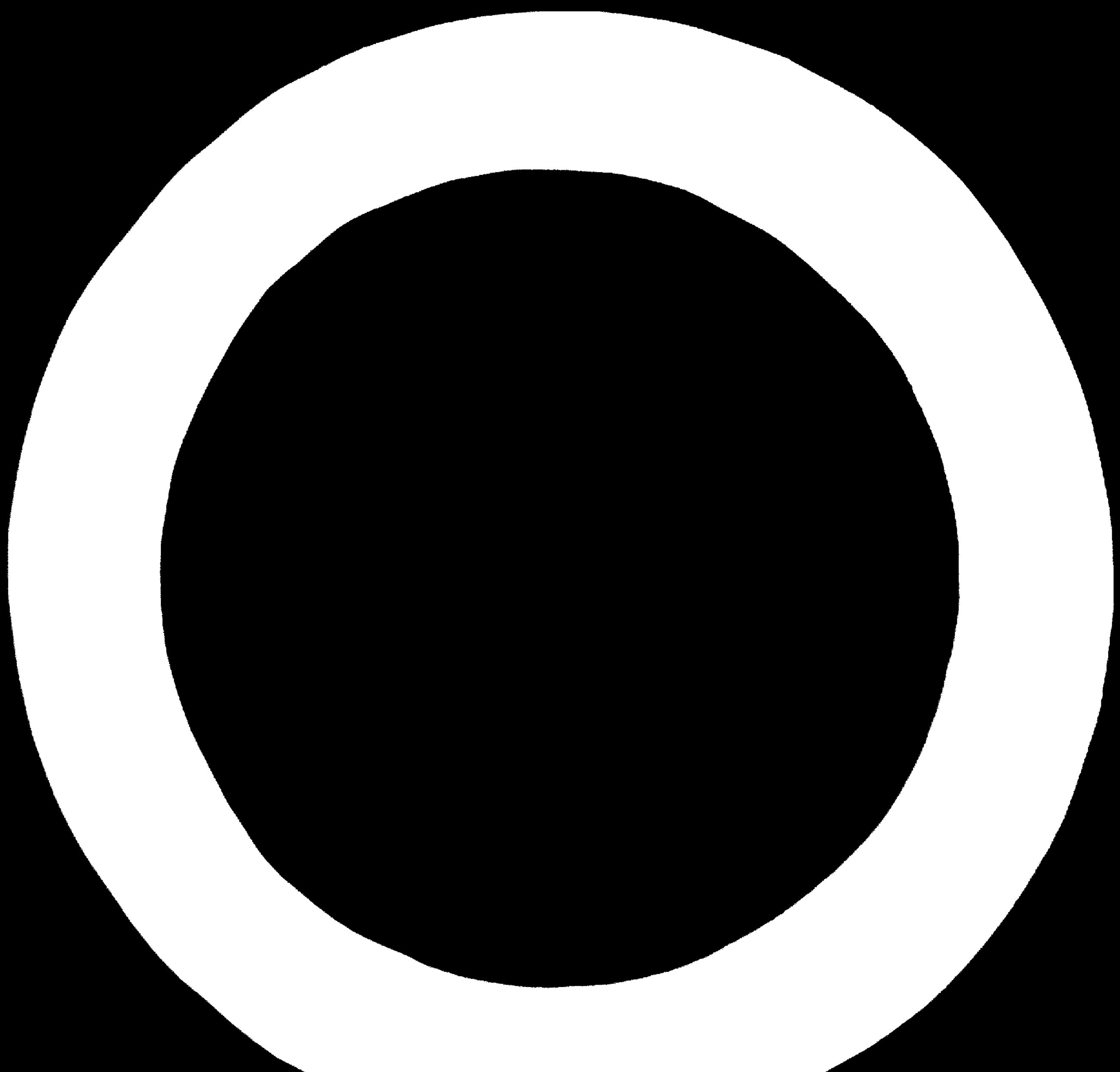

SOME SPECIAL FEATURES OF THE OPEN-END SPUN COTTON YARNS

1. Introduction

1.1 There are numerous publications on the comparision of the physico-mechanical properties of "open-end" yarns, particularly those produced on the machine BD 200, and of conventionally spun cotton yarns. Most of the work has been concerned with what are customary considered more important practical parameters, such as tensile properties and regularity. However, this does not imply that other properties have not been considered as shown by the mass of existing literature. (1 - 7)

1.2 However, certain interesting characteristics other than those referrred to above have been neglected somewhat. One of them is hairiness, the other friction. As regards the former, Lünenschloss and Hummer (8) simply remark that open-end yarns are less hairy than conventional yarns. This fact was eventually confirmed by Barella and his associates (9) (10) and, to a certain extent, by Kirschner and Kleinhansi (11). However, neither the cause nor the nature of the hairiness was investigated for either type of yarn. Study of this factor and of its variability in conventional and "open-end" yarns has been carried out quite recently by Barella (12 (13) and is the object of special attention in the present work.

1.3 On the other hand, data on the coefficient of friction in open-end yarns were published recently by Barella and Segura (14) (15) and this question is re-considered below.

1.4 Little literature is available on twist-strength and twist-elongation-to-break curves of open-end yarns. Only Morikawa and Horiuchi (16) and, incidentally, Halleux (17) refer to this question, which was the subject of more extensive recent investigations by Barella and Vigo (18). The third part of the present paper is devoted to this question, and also to the consideration of the relationship between twist and resistance and elongation to repeated extensions, as well as between twist and abrasion resistance. These factors have been investigated only by the above authors (19) (20) (21), and their findings published in part.

1.5 The present paper will consider the following points: nature of hairiness, variability of hairiness, coefficient of friction, twist-breaking-strength curves and twist-breaking-elongation curves, twist-resistance-to-repeated-extensions curves and twist-elongation-to-repeated-extension, and twist-abrasion-resistance curves; the comparison of open-end yarns and conventional yarns of equal characteristics and materials.

2. Analysed Yarns

2.1 Table I lists data on eighteen yarns used in the various experiments.

Table I

No.	Reference	Spinning	Nominal metric count	Linear density (tex)	Twist (t.p.m.)
1	A	Conventional	28	35,5	640
2	A'	"	28	35,5	720
3	A''	Open-end	28	35,5	740
4	B	Conventional	40	25	800
5	B'	"	40	25	920
6	B"	Open-end	40	25	920
7	C	Conventional	50	20	922
8	C"	Open-end	50	20	1100
9	D	Conventional	60	16,7	1016
10	D"	Open-end	60	16,7	1220
11	F	Conventional	35	28,5	661
12	F"	Open-end	35	28,5	884
13	G	Conventional	50	20	897
14	H"	Open-end	50	20	1146
15	J	Conventional	30	33,3	792
16	J"	Open-end	30	33,3	1090
17	K	Conventional	40	25	790
18	K"	Open-end	40	25	1090

...

Yarns 1 to 6 (references A and B), supplied by the Cotton Textile Research Institute at Ústí nad Orlicí (Czechoslovakia) were Russian cotton - Ri, 108F 31/32 - with two different twists (A, A' and B, B'). A third twist was produced on the machine BD 200 (A" and B").

Yarns 7 to 10 (references C and D) from the same supplier, were all Giza cotton (Egyptian).

Yarns 11 to 20 were Spanish cotton, the conventional yarns being spun in Spain and the open-end yarns in Czechoslovakia; the operations prior to actual spinning were carried out in a Spanish mill.

2.2 The experiments were carried out in a conditioned laboratory (65% RH ± 2% and 20° C ± 2°), after a minimum storage of 48 hours in the same room.

3. <u>The Nature of Hairiness</u> (12)

3.1 The first comparative studies on hairiness of open-end and conventional yarns showed open-end yarns to be less hairy. This is to be derived from the papers by Lünenschloss and Hummel (8) and Kirschner and Kleinhansl (11) who used the CRITER-DAN (22) apparatus to measure hairiness, as well as from the work by Barella and Viaplana (9) (10) who used their new electronic hairiness meter. The latter two also established the hypothesis that in the hairiness of open end yarns short fibre ends predominate over the longer hairs to greater extent than in conventional yarns and that hairiness was more irregularly distributed in open-end yarns.

3.2 A more profound analysis of the problem makes it necessary to use customary optical measuring techniques. Barella's method (21) was applied, which consists of projecting a magnified image of the yarn (100x) on to a screen and counting the number (N_1) of fibre ends protruding from the yarn core per unit length (10 mm in this instance). The number of fibre loops protruding from the yarn core (N_2) are also counted and the length of the protruding fibre ends (l_1) measured. Measurements were carried out on 100 random samples per bobbin. The length of each sample was 8 mm, the total explored length being 800 mm per bobbin.

Table II

Yarns	Spinning method	Metric count Nm	Length examined (cones)	Length examined (mm)	Number of ends measured	N_1	N_2	$N_1 + N_2$	L_1	N_1L_1	Raw material
1	C	28	100	800	826	3,58	12,48	17,06	0,71	2,47	Russian cotton
2	C	28	200	1600	460	2,88	13,68	16,56	0,67	1,93	
3	OE	28	200	1600	408	2,54	14,12	16,66	0,56	1,42	
4	C	40	100	800	253	3,16	12,11	15,27	0,63	1,98	Russian cotton
5	C	40	200	1600	541	3,38	12,12	15,50	0,54	1,83	
6	OE	40	100	800	172	2,15	13,25	15,40	0,52	1,12	
7	C	50	100	800	418	5,22	14,84	20,06	0,66	3,44	Egyptian cotton
8	OE	50	100	800	247	3,09	19,00	22,09	0,46	1,42	
9	C	60	100	800	309	1,86	12,60	16,46	0,51	1,96	Egyptian cotton
10	OE	60	100	800	269	3,37	18,85	22,22	0,44	1,55	
11	C	35	100	800	298	3,72	14,00	17,72	0,65	2,52	Spanish cotton
12	OE	35	100	800	166	2,08	15,60	17,68	0,58	1,21	
13	C	50	100	800	263	3,29	14,75	18,04	0,56	1,81	Spanish cotton
14	OE	50	100	800	162	3,02	16,50	18,52	0,48	0,97	

C = Conventional
OE = Open-end.

3.3 The results show that open-end yarns have less protruding ends (N_1) but more loops (N_2) than conventional yarns, as is to be expected from the structural differences of the two yarns.

On the average, it is found that

	Conventional yarns	Open-end yarns
N_1	3,63	2,54
N_2	13,44	16,22

The mean length (L_1) of the protruding ends in open-end yarns is less than in conventional yarns (0,50 mm against 0,61 mm) which together with smaller number of protruding ends makes the N_1L_1 parameter, the best indicator of "visible" hairiness (24), smaller for open-end than for conventional yarns (an average of 1,27 mm as against 2,25 mm).

3.4 Considering the distribution characteristics of the protruding ends for each yarn group which according to Barella (25) and Pillay (26) are exponential, and according to Lappage and Onions (27) are of the gamma type, it is to be seen from Tables III and IV that the major differences are, on the one side, the percentage of very short ends (< 0,30 mm) and, on the other the percentage of long ends. The number of very short ends in open-end yarns is larger than in conventional yarns (48,7 % : 37,4 %).

Long ends, exceeding 1,2 mm, 2,1 mm and 3 mm are to be found as follows:

	Conventional yarns	Open-end yarns
1,2 mm	11,2 %	9,1 %
2,1 "	2,6 %	2,8 %
3 "	1,1 %	0,3 %

Proportionally, the greatest difference is in the number of ends longer than 3mm, which are the only ones to be detected by electronic hairiness meters (22). Furthermore, in view of the lower H_1 value in open-end yarns, it can be concluded that the difference in hairiness levels between the two types of yarn is appreciable.

Table III

Conventional yarns

Yarn no / Class (mm)	1	2	4	5	7	9	11	13	Mean
0-0,30	35,0	32,0	38,0	46,0	35,0	44,0	30,5	38,0	37,4
0,31-0,60	28,0	27,0	27,0	26,0	27,5	27,0	28,0	30,0	27,5
0,61-0,90	14,0	18,5	14,0	10,0	14,0	12,0	21,0	17,0	15,0
0,91-1,20	8,0	8,5	9,5	8,0	10,0	9,0	12,5	6,0	8,9
1,21-1,50	3,0	5,0	4,0	4,0	5,0	2,0	3,5	3,5	3,7
1,51-1,80	3,0	2,5	2,0	2,0	2,0	2,0	1,5	1,5	2,1
1,81-2,10	2,5	1,5	1,5	1,5	2,0	2,0	0,5	1,5	1,6
2,10-2,40	1,5	2,0	1,0	1,5	1,0	0,5	0,5	0,5	1,2
2,41-2,70	1,5	1,0	1,0	0,5	1,0	0,5	0,5	0,5	0,8
2,70-3,00	1,0	1,0	0,5	-	1,0	0,5	1,0	0,5	0,7
3,01-3.30	1,0	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,6
3,31-3,60	0,5	0,5	0,5	-	0,5	-	-	0,5	0,3
3,61-3,90	0,5	-	-	-	-	-	-	-	0,2
3,90	0,5	-	-	-	0,5	-	-	-	

Table IV

Class no. (mm) \ Yarn	3	6	8	10	12	14	Mean
0 - 0,30	46,0	55,0	51,0	50,5	42,0	48,0	48,7
0,31 - 0,60	25,0	21,0	28,0	23,0	26,0	25,0	24,7
0,61 - 0,90	12,5	9,0	8,5	11,0	12,0	15,5	11,4
0,91 - 1,20	7,5	4,5	6,0	5,0	8,0	5,5	6,1
1,21 - 1,50	1,5	4,5	1,5	3,0	3,5	2,5	2,8
1,51 - 1,80	1,5	3,0	2,0	3,0	2,0	1,5	2,2
1,81 - 2,10	1,5	1,0	1,0	1,5	2,0	0,5	1,3
2,11 - 2,40	1,0	1,0	1,0	1,0	3,5	-	1,3
2,41 - 2,70	1,0	0,5	0,5	1,0	0,5	0,5	0,7
2,71 - 3,00	1,0	-	0,5	1,0	0,5	-	0,5
3,01 - 3,30	1,0	0,5	-	-	-	-	
3,30	0,5	-	-	-	-	-	0,3

4. **The Variability of Hairiness**

4.1 Initial studies by Barella and associates (9) (10) seemed to indicate a more irregular distribution of hairiness in open-end yarns than in conventional yarns. This hypothesis, however, was based on deductions (12).

4.2 A methodical study has since been carried out, using the electronic hairiness meter developed by Barella and Viaplana (28). Two cotton yarns of the same count Nm 50 (20 tex) and material were tested; six bobbins were spun conventionally and ten others on a BD 200 machine. Each bobbin was measured at different traverse speeds as follows:

Speed	Readings per unit	Total length analysed per unit
1 m/min	30	30 m
2 " "	25	50 m
10 " "	20	200 m
20 " "	15	300 m

In addition to the mean values of the two hairiness parameters (index of total hairiness and length index) indicated by the instrument, the coefficients of variation (total within bobbin and between bobbins) were calculated and the analysis of variance established.

4.3 Table V summarizes the most relevant results of the experiments.

Leaving aside a few results which can be considered anomalous, it is clear from Table V that total between-bobbin and within-bobbin coefficients of variation are higher for total hairiness than for length, and are greater in open-end yarns than in conventional yarns.

Generally, the coefficients of variation within and between-bobbins are higher in open-end yarns than in conventional yarns, confirming the previous assumption that hairiness is more unevenly distributed in the open-end yarns. Other interesting conclusions stem from the analysis of variance (tables have been omitted for the sake of brevity). Analysis shows that for all traverse speeds in both conventional and open-end yarns there are between-bobbin differences significant at the 1% level whereas within-bobbin differences are not significant save for conventional yarns analysed at a speed of 2m/min (significant at the 5% level) and for open-end yarns analysed at 20 m/min (total hairiness significant at the 5% level and length at the 1% level). In conventional yarns, the significance may perhaps be attributed to periodic variation due to up-and-down movement of the ring rail, checked by previous investigators (29) (30) (31) (32). In open-end yarns it could be one more reason in favour of higher variability in such yarns.

The analysis of variance also shows the existence of a significantly greater between bobbin than within-bobbin variability for both conventional and open-end yarns. This is not clearly reflected in Table V, because of the experimental error included in the within-bobbin variation, which in some instances can mask the results.

Table V

Traverse speed	Conventional yarn		Open-end yarn	
	Hairiness	Length	Hairiness	Length
1 m/min	CV_T = 19.7% CV_b = 3.3% CV_w = 19.6%	CV_T = 17.1% CV_b = 5.5% CV_w = 16.2%	CV_T = 23.3% CV_b = 16.3% CV_w = 16.0%	CV_T = 19.3% CV_b = 12.2% CV_w = 15.0%
2 m/min	CV_T = 20.4% CV_b = 15.7% CV_w = 13.0%	CV_T = 16.5% CV_b = 12.8% CV_w = 10.4%	CV_T = 24.8% CV_b 16.9% CV_w = 18.1%	CV_T = 19.8% CV_b = 13.6% CV_w = 14.43
10 m/min	CV_T = 24.8% CV_b = 21.5% CV_w = 12.4%	CV_T = 15.0% CV_b = 13.3% CV_w = 8.2%	CV_T = 25.4% CV_b = 17.1 CV_w = 18.1%	CV_T = 27.2% CV_b = 23.1% CV_w = 14.3%
20 m/min	CV_T = 28.2% CV_b = 24.9% CV_w = 13.1%	CV_T = 15.0% CV_b = 13.9% CV_w = 13.0%	CV_T = 43.5% CV_b = 39.8% CV_w = 18.7%	CV_T = 26.4% CV_b = 22.9% CV_w = 13.2%

CV_T = Coefficient of total variation

CV_b = Coefficient of variation between-bobbins

CV_w = Coefficient of variation within-bobbin

4.4 Finally, it has been observed that the variance /length curve is practically asymptotic to the axis of the lengths from 2 metres on for conventional yarns, whereas in the case of open-end yarns, this occurs from 1 meter on; i. e. the curve is steeper but assumes higher values than for conventional yarns after levelling off.

5. Coefficient of friction of open-end yarns

5.1 This study was carried out using the F/Meter type R1082 (Rothschild) (33) (34) (35). Friction was against an aluminium oxide cylinder, 7mm diameter, and the test conditions were as follows:

Friction angle: the following angles were studied (36): 180°, 360°, 450°, 540° and 720o.

Speed of yarn traverse: The following speeds were used: 4m/min, 20 m/min, 40 m/min and 60 m/min.

The applied pre-tension was 3 gf in some series of tests and 11gf in others. For certain yarns the number of friction angles and traverse speeds were kept to a minimum.

5.2 The more characteristic results are graphically displayed in figures 1 to 3.

Yarns 13 and 14	Fig. 1
" 15 and 16	" 2
" 17 and 18	" 3

Generally, comparisons between conventional and open-end yarns are not based upon the same twist values, since open-end yarns are usually more twisted than conventional yarns.

Figures 1 to 3 show characteristic comparisons between conventional and open-end yarns from the same raw material. Assuming that in practice these yarns are equivalent (a relative equivalence, of course, since it must be borne in mind that the physico-mechanical characteristics will not correspond to each other) it is found that the coefficient of friction in open-end yarns is smaller than that of 'equivalent' conventional yarns. The difference is maximum for small angles of friction and decreases as the friction angle increases. This is illustrated in Fig. 1 where at 720° the curves are practically superimposed.

5.3 However, it is possible to study what happens when the twist in both conventional and open-end yarns is the same. A comparision of this kind was carried out for yarns 1 to 6. The coefficients of friction of such yarns corresponding to three friction angles and two speeds of traverse (180°, 360° and 540° and 4 m/min and [illegible] m/min) are shown in Table VI.

Table VI

Yarn	Spinning	Nm	Twist t.p.m.	Mean coefficient of friction
1	C	28	640	0,270
2	C	28	720	0,269
3	OE	28	740	0,268
4	C	40	800	0,272
5	C	40	920	0,264
6	OE	40	920	0,261

It can be seen that the coefficient of friction of conventional yarns decreases slightly when twist increases, as already observed by Wegener and Schuler (35). Table VI also shows that with the same twist, open-end yarns tend to present a smaller coefficient of friction than conventional yarns. Though very small, these differences are significant, as shown be Barella and Segura (36). However, the fact that in practice open-end yarns present a smaller coefficient of friction than conventional yarns is rarely noticed as the difference is too small.

6. Twist-breaking-strength and twist-breaking-elongation curves (18)

6.1 While our experiments on this question were in progress, Morikawa and Moriuchi (16) and Malloux (17) published some data, though incomplete, on the same subject.

6.2 The experiments were not carried out by increasing yarn twist directly on the spinning machine and then testing for tensile properties. Instead, additional twist was imparted to the yarn by means of a torsiometer, a technique which has been described previously in detail (37). In fact, the operation consists of taking 50 cm lengths of yarn, the twist having been increased by given amounts on a torsiometer; then testing the yarn for tensile strength and break elongation. In the course of these latter operations, the yarn specimens must be handled with care in order not to loosen any turns of twist. A pendulum strength tester was used to establish tensile properties.

Yarn twist was increased gradually in 5 to 12 stages to obtain corresponding points in the twist-strength and twist elongation curves. The number of test lengths per yarn and twist were 30.

6.3 This twist-increasing technique was also used in the studies on repeated extensions and resistance to abrasion (Chapters 7 and 8) (19) (20) (21). The author is quite aware that either the method or device used to increase twist is not exactly equivalent to increasing twist in the spinning machine itself. However, it is also felt that possible error arising from this technique will not change the general conclusions, though figures can be influenced slightly.

6.4 The experiments were carried out on yarns 1 to 14 as shown in Figures 4 to 7:

Figure 4	Yarns 1 to 3
Figure 5	Yarns 4 to 6
Figure 6	Yarns 7 to 10
Figure 7	Yarns 11 to 14

6.5 For the conventional cotton yarns, the saturating twist multiple or twist for maximum breaking strength varies between 150 and 160 (twist multiple α for Nm and turns per metre), the average value being 155; these values are close to those cited in literature (38 and 39). The twist multiple for maximum yarn breaking strength is known to be dependent on fibre characteristics, decreasing as fibre length increases and increasing with the index "Micronaire" (40), so that twist multiple fluctuates within certain limits. For this report the mean value will be considered indicative, but solely for comparative purposes.

For the elongation to break, saturating twist corresponds approximately to the twist multiple for maximum breaking strength.

6.6 In open-end yarns the twist multiple α for saturating twists ranged from 173 to 181, the average being 176, which corresponds with the few published data (16) (17). As in the previous case, the maximum values of the twist-breaking-elongation curve and the saturating twist for breaking strength coincide closely.

6.7 According to Morikawa and Horiuchi (16), the practical twist to be applied is about 10% to 20% below saturating twist in open-end yarns. In the analysed yarns, the difference between both twists varied from 6% to 20%. In conventional yarns, the difference was larger (from 7% to 23%). The twist-strength curve of open-end yarns tends to flatten slightly more than that of conventional yarns.

7. Twist-resistance-to-repeated-extension curve and twist-elongation (21)

7.1 Nothing has been published previously on this subject. The experiments were carried out by increasing yarn twist in the manner indicated under 6.2, and by transferring the test lengths on to the "Compass" instrument (1) (41) (42). Testing conditions on this instrument were as follows:

Frequency of extensions: 250 cycles/min;
Amplitude of the fatigue cycle 1,66%;
Load applied to the yarn 2gf/tex.

The increments of twist were applied stepwise from 5 to 7 steps, and 30 tests per yarn and twist value were carried out. For the interpretation of the results, the median instead of the mean has been used as the central value parametre, owing to the distribution characteristics of the extension tests (43).

7.2 The results are shown in Figures 8 to 13:

Figure 8	Yarns 1 and 3
Figure 9	Yarns 4 and 6
Figure 10	Yarns 7 and 8
Figure 11	Yarns 9 and 10
Figure 12	Yarns 11 and 12
Figure 13	Yarns 13 and 14

7.3 It can be seen that in conventional yarns the maximum value of the twist-resistance-to-repeated-extensions curve coincides with values of the twist multiple α which are higher than those for the twist-breaking-strength curve. The saturating twist multiple fluctuates between 165 and 175, the average being 170, some 13% higher than the tensile-strength values.

On the other hand, where elongation to repeated extensions is concerned the reverse occurs; the maximum value of the curve coincides with lower twist multiples than in the extension test, which were 125 to 135, an average of 130, i.e., some 20% less than for the twist-elongation-to-break curve.

The shape of the curves suggests a rapid drop in resistance to repeated extensions when saturating twist is exceeded, this drop being more important than the twist-tensile-strength curve.

7.4 In open-end yarns as in conventional yarns the same phenomenon is observed, i.e., a shift to the right of the maximum value of the twist-repeated-extensions curve and towards the left in the twist-elongation-to-repeated extensions curve. In the twist-repeated-extensions curve, the twist multiple α corresponding to the maximum value ranges from 185 to 205, the average being 195, i.e. 12% more than the maximum value of the twist-tensile-strength curve. For the elongation to repeated extensions, the twist multiple corresponding to the maximum value ranges between 150 and 170, giving an average of 160, i.e. some 10% below the maximum value in twist-elongation-to-break curve. Likewise, as in the case of conventional yarns, the drop in the hypersaturation zone is very sharp.

7.5 Generally, the [illegible] curves of open-end yarns [illegible] for conventional yarns, the difference tending [illegible] yarns [illegible] and thinner. Only in the case of yarn "A" [illegible] the curve [illegible] above [illegible] from the same material. These results indicate that the claims of [illegible] open-end yarns being more resistant to repeated [illegible] than conventional yarns cannot be generalized since resistance is dependent upon the instrument used, as was concluded [illegible].

The opposite seems to occur in the case of elongation, i.e., the curves for open-end yarns lie above those for conventional yarns, the difference being greater for coarse than for fine yarns.

7.6 It is obvious that although in weaving, warp yarns should be resistant to repeated extensions it would not make sense to automatically apply the maximum values from the resistance-to-repeated-extension curves, firstly because the twist levels corresponding to the maximum of the twist-resistance-to-repeated-extension curves are already in the hypercritical tensile-strength zone and, secondly, because, as already demonstrated the maximum values does not correspond to optimum conditions for elongation-to-break in the tensile test. Hence, the most important inferences can be made from the tensile elongation-to-break curve. From the point of view of weaving, there is no doubt that optimum conditions are not to be obtained with yarns whose resistance to repeated extensions corresponds to the maximum point, but with yarns whose elongation is at a maximum value, since yarns break more through lack of elongation than through lack of resistance to repeated extensions.

If the above hypothesis is accepted, it can be postulated that a twist multiple of about 140 (between 125 and 155) for conventional yarns and of about 175 (between 150 and 1[illegible]) for open-end yarns is best suited to avoid yarn breaks during weaving. In fact, industrial practice generally confirms this hypothesis. In conventional spinning, twist multiples of 125 and 155 are used for warp yarns and "strong warp" yarns (44) respectively, this type of twist being used to achieve both good tensile strength and a good elongation to break when the yarn is subjected to repeated extensions. In "open-end" yarns practice has led to the adoption of twist multiple values which are very close to those corresponding to the maximum in the twist-elongation-to-break curve.

It is evident that the figures quoted correspond to average conditions, since both the curves and their respective singular points are dependent on fibre characteristics, just as the twist multiples applied in practice also depend on fibre characteristics.

The convergence of "warp" twist of conventional yarns and the maximum of the twist-elongation curve as well as the convergence of this latter point and twist imparted in practice to open-end yarns, seem to be obvious facts stressing the theory put forward here.

8. <u>Twist-abrasion-resistance curves (20) (45)</u>

8.1 Before going any further some comments on the parameter being studied and its incidence in open-end yarns would be pertinent. A great deal of the literature on open-end yarns points out that such yarns are more resistant to abrasion than conventional yarns (4). However, other studies (7) show the contrary.

This contradiction can be attributed to the type of abrasion tester which is being used. With the apparatus used in our studies ("Abrafil") the yarn is subjected to considerable tensile force in conjunction with the abrasion effect, as defined by Schutz (46). This force modifies the results as compared with other instruments in which there is no such circumstance. The type of instrument and testing conditions can, therefore, lead to the abrasion-resistance qualities of an open-end yarn being either more or less than a conventional yarn of the same material and count.

8.2 Less yarns (eight in all) were analysed than in the experiments on tensile strength or resistance to repeated extensions as a function of twist, because the tests are very slow and prohibitively long.

Four yarns were conventional yarns, and four open-end. Yarn twist was increased in the manner described in 6.2, 5 to 7 points per curve being obtained. The "Abrafil" (47) apparatus was used under the following testing conditions: Modality of abrasion: yarn against yarn; load applied to the yarns: 100 gf; speed: 100 cycles/min. For each yarn and twist value there were six groups of experiments with five pairs of yarn each, i.e. 30 pairs of yarn were tested.

8.3 In view of the statistical distribution of abrasion tests, it could be questioned whether the mean should be preferred to the median. In fact, regardless of whether medians or means are taken, there is no important difference either in the shape of the curves or in the position of the maximum values. Since the median was used in the fatigue and repeated extension tests (see section 7.1), it was considered wise to continue with the same criterion.

The results are graphically displayed as follows:

Figure 14	Yarns 1 and 3
Figure 15	Yarns 4 and 6
Figure 16	Yarns 7 and 8
Figure 17	Yarns 9 and 10

8.4 It can be observed that for conventional yarns the maximum of the twist-abrasion-resistance curve corresponds to the twist multipe of about 170, i.e., a value similar to that found in the twist-resistance-to-Repeated-extensions test. The same happens with open-end yarns (T.M. 195). However, it can be observed that as the yarn becomes finer the optimum twist value tends to take up rather more lower twist multiples, especially for conventional yarns.

It has already been explained why, in the experiments reported here, resistance to abrasion should be smaller for open-end than for conventional yarns. The difference increases as the yarn becomes finer, which is quite understandable since, owing to the requirements of the instrument used and the duration of tests, fixed pre-tension has had to be applied. In the resistance-to-repeated-extension tests a load of up to 2gf/tex was applied, whereas the load is now spread stepwise from 2.8 gf/tex for yarn Nm = 28 to 6 gf/tex for yarn Nm = 60.

Although the results cannot be applied generally to other types of abrasion testers, it seems there is a trend for the maximum in the twist-resistance-to-repeated-extension curves to coincide with the maximum in the twist-resistance twist-abrasion-resistance curves, for both conventional and open-end yarns.

9. Conclusions

9.1 In this work consideration was given to new aspects of the properties of open-end yarns, as compared with conventional yarns of the same material and count. The salient conclusions from the investigations are as follows:

9.1.1 The nature of hairiness of open-end yarns differs from that of conventional yarns. In open-end yarns, short ends are more abondant than long ends, giving a lower visible hairiness for the yarn.

9.1.2 Irregularity of hairiness is greater in open-end yarns than in conventional yarns.

9.1.3 The coefficient of fric on is slightly less in open-end yarns that in conventional yarns even at the same twist.

9.1.4 The saturating twist multipe in the tensile test is about 14% greater in open-end yarns than in conventional yarns. The twists utilised in practice are from 6% to 20% below saturating twist in open-end yarns and from 7% to 23% below saturation in conventional yarns. The maximum value of the twist-elongation curve coincides, for both types of yarn, with that of the twist-strength curve.

9.1.5 In the resistance-to-repeated-extensions test, saturating twist is about 13% higher than in tensile strength tests for conventional yarns, and 12% higher for open-end yarns. Conversely, the maximum value of the twist-elongation-to-break curve is 20% below the saturating twist multipe in the tensile test for conventional yarns and 10% below that of open-end yarns.

It is interesting to point out that the maximum value of twist-elongation-to break curve, whether for conventional or open-end yarns, coincides with the twist values used in industrial practice for warp yarns.

9.1.6 In the abrasion resistance test, the maximum value of the curve for both conventional and open-end yarns attains values nearing those found in the resistance-to-repeated-extension test.

10. **References**

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Barcelona -17- Spain

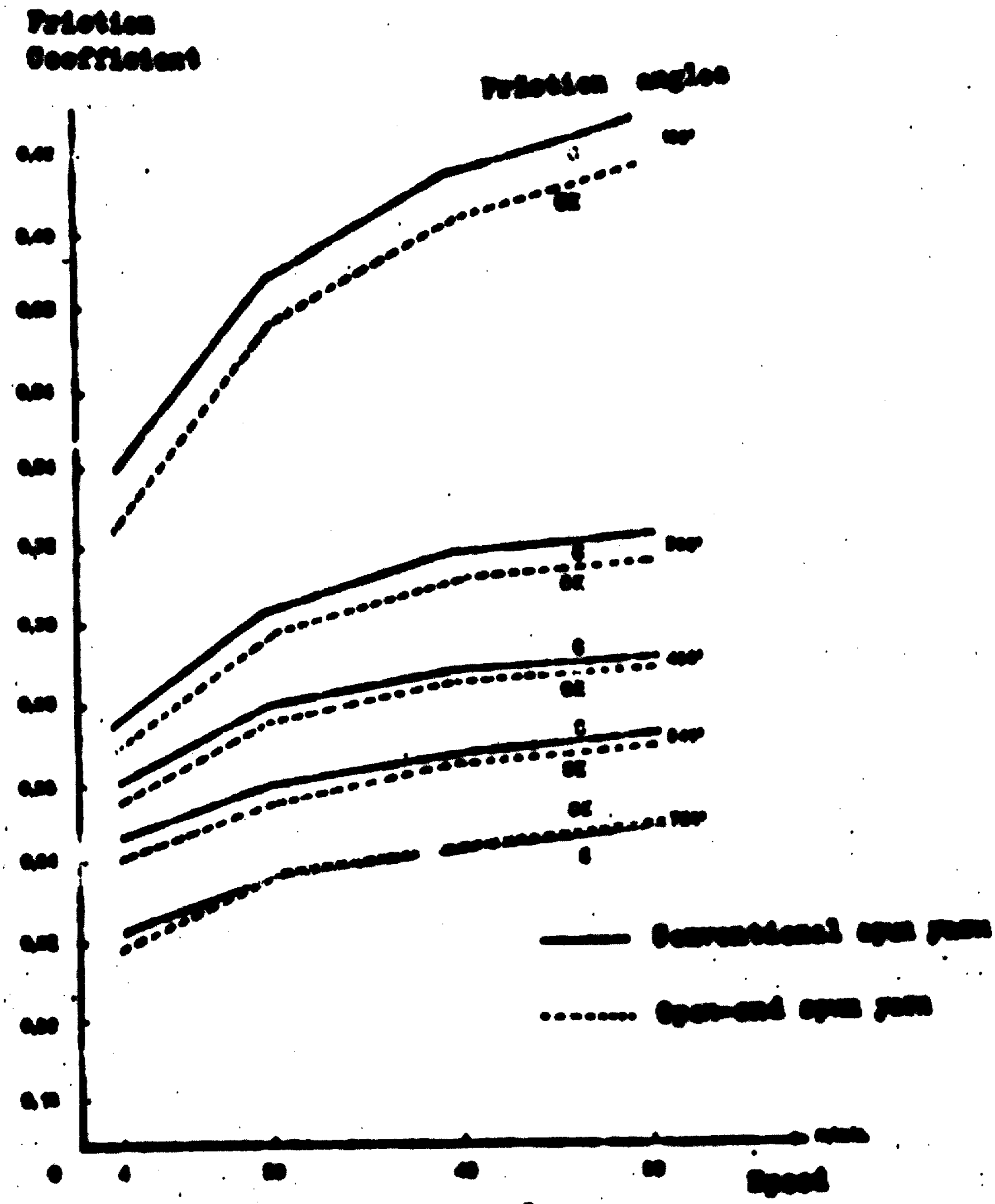
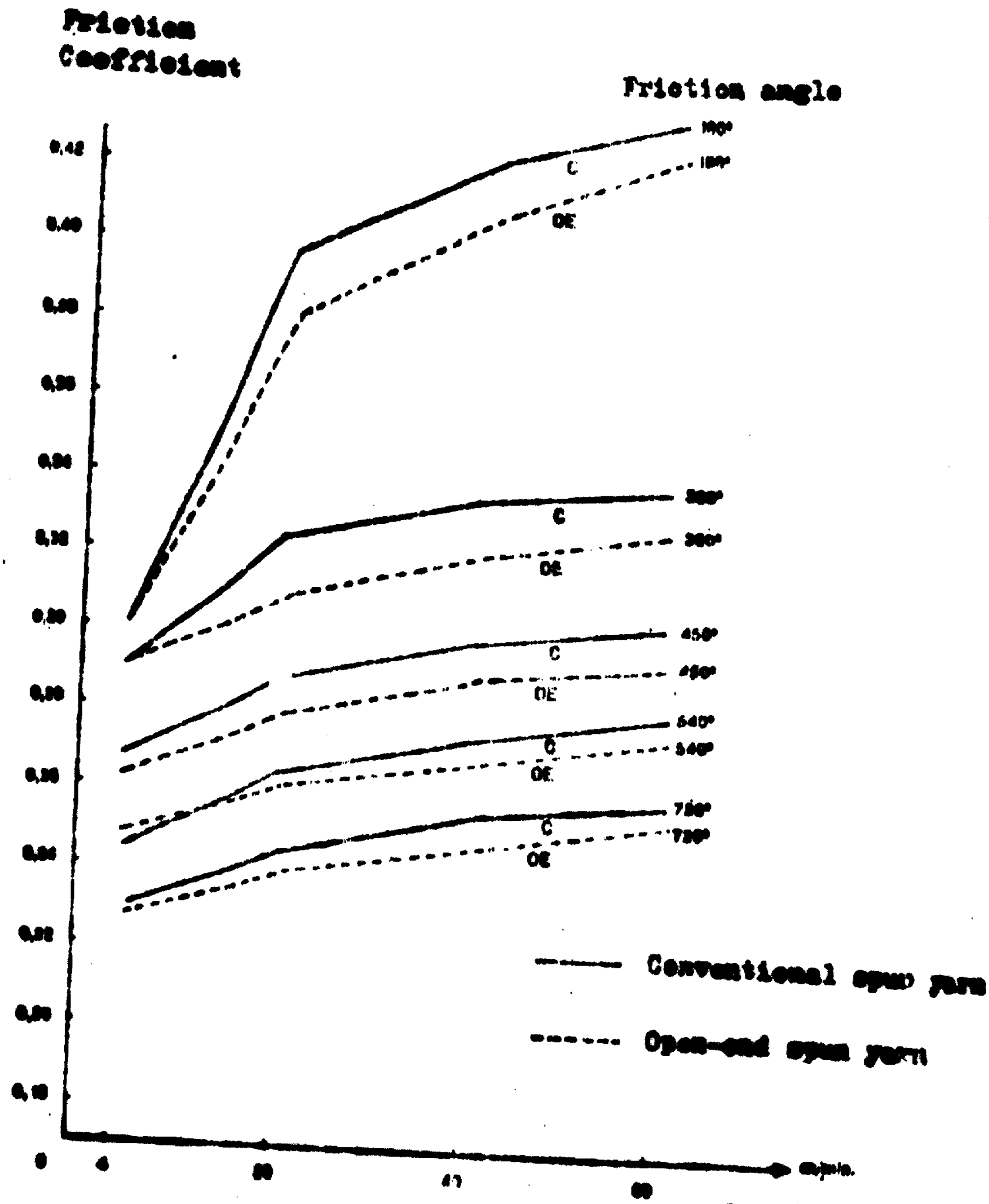


Fig. 1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Friction angle
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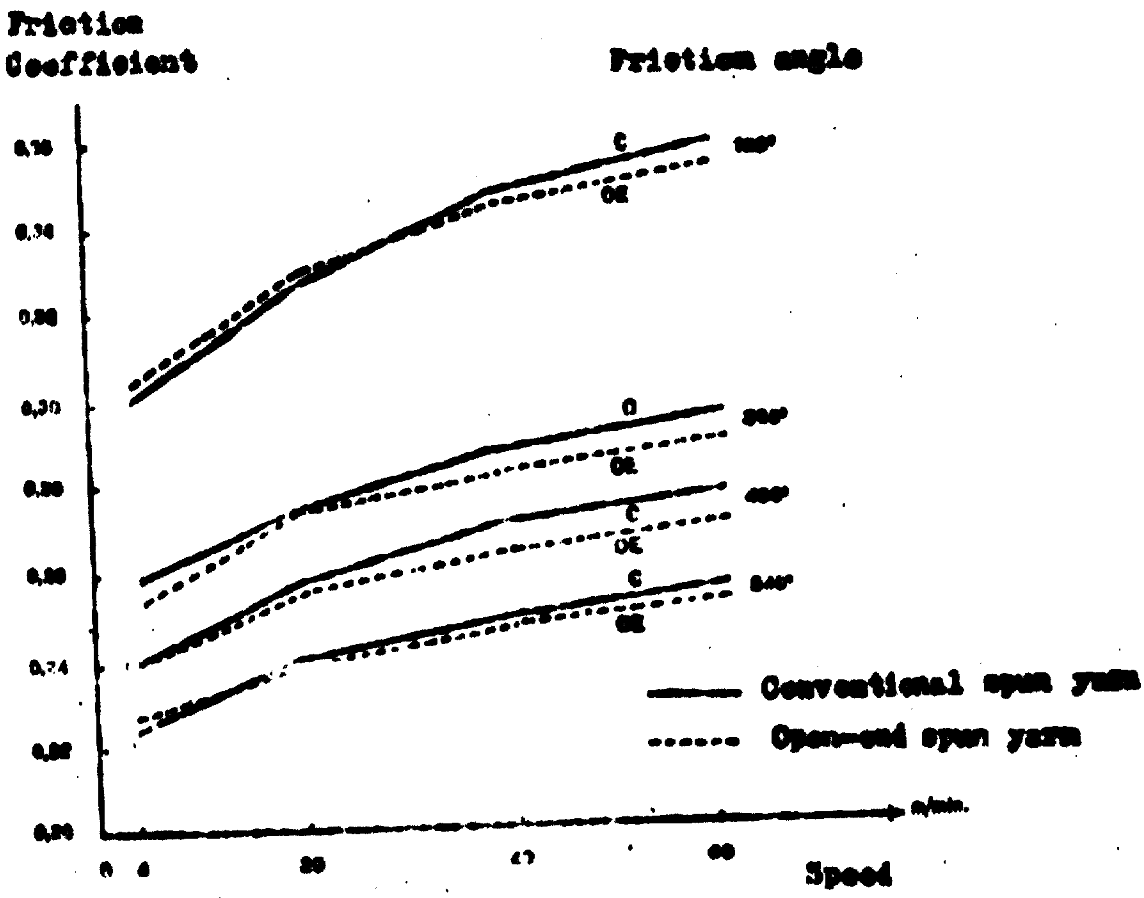
360°
450°
540°
720°
C
OE
Conventional spun yarn
Open-end spun yarn
Speed

Fig. 2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Friction angle
C
OE
0,30
Conventional spun yarn
Open-end spun yarn
m/min.
0
20
60
Speed

Fig. 3

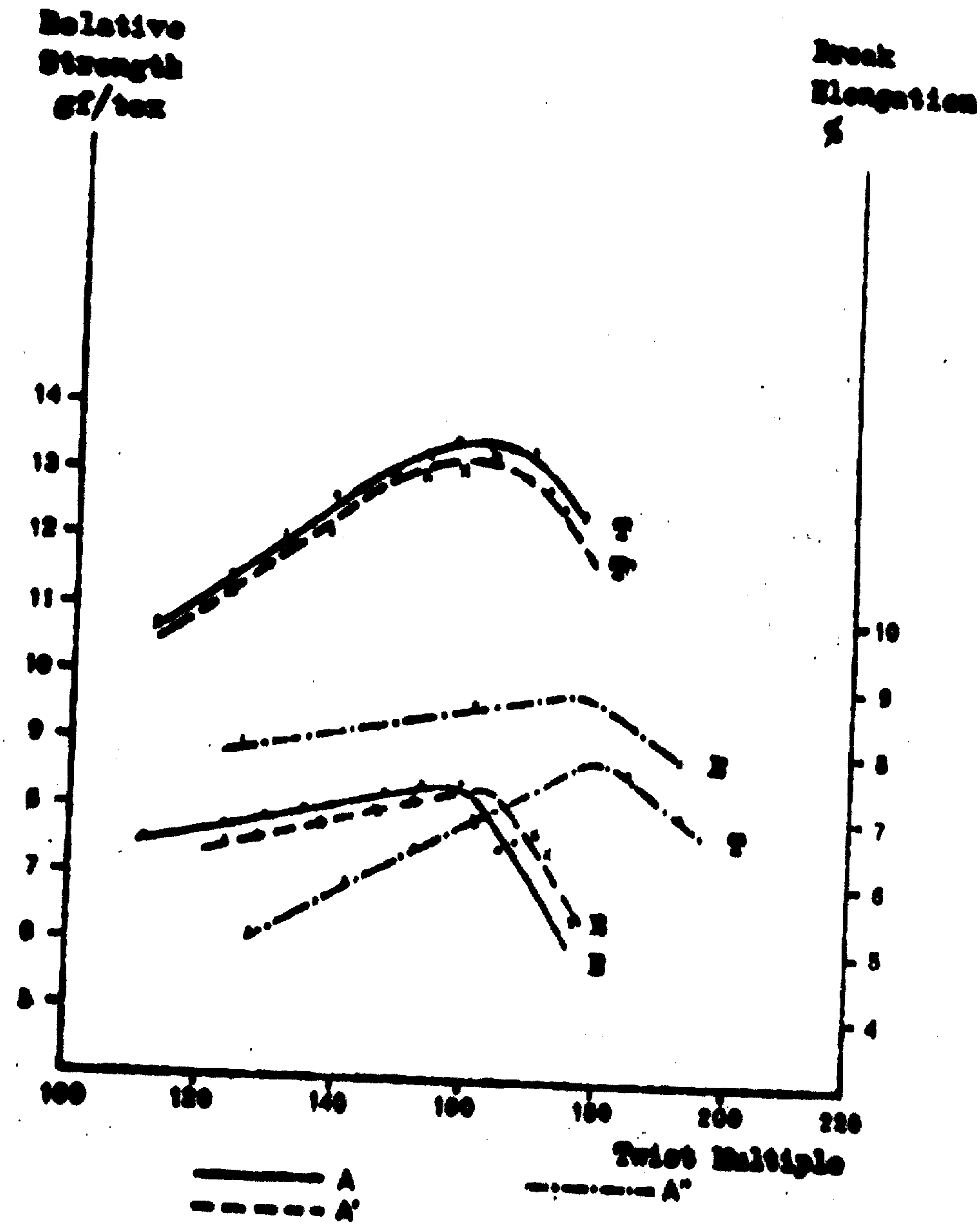
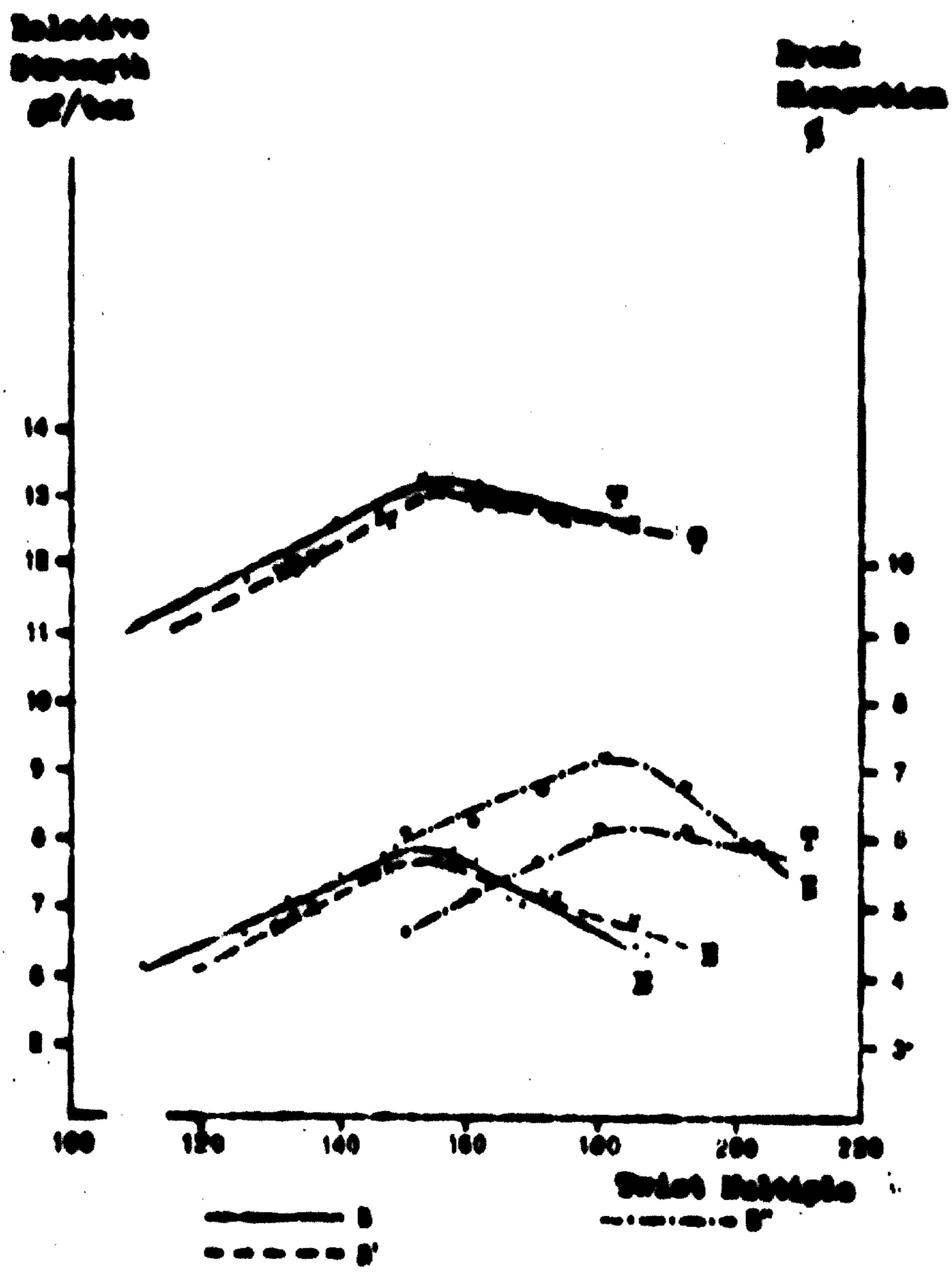

Relative Strength gf/tex
Break Elongation %
14
13
12
11
10
9
8
7
6
5
10
9
8
7
6
5
4
100
120
140
160
180
200
220
Twist Multiple
A
A'
A''

Fig. 4



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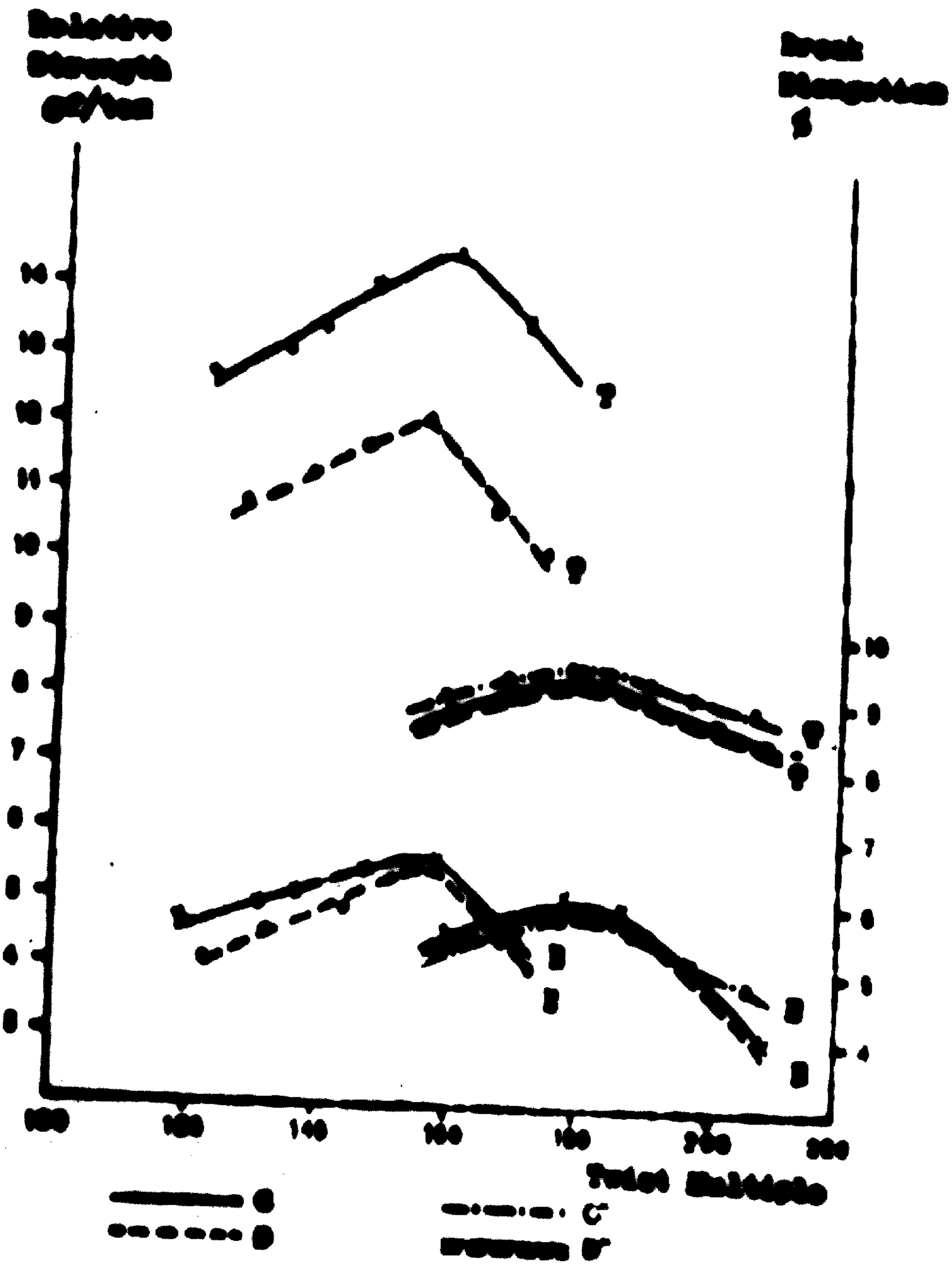

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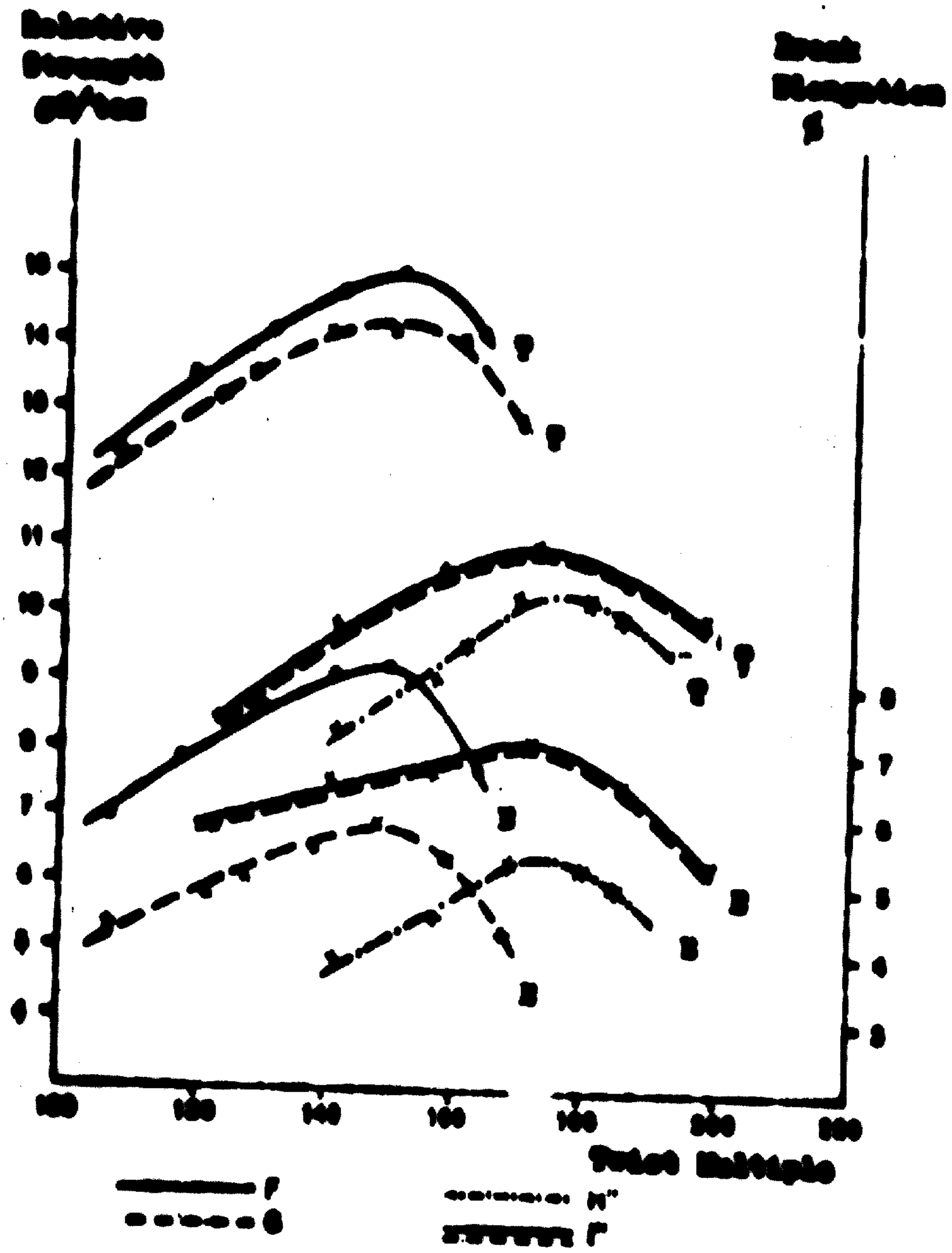

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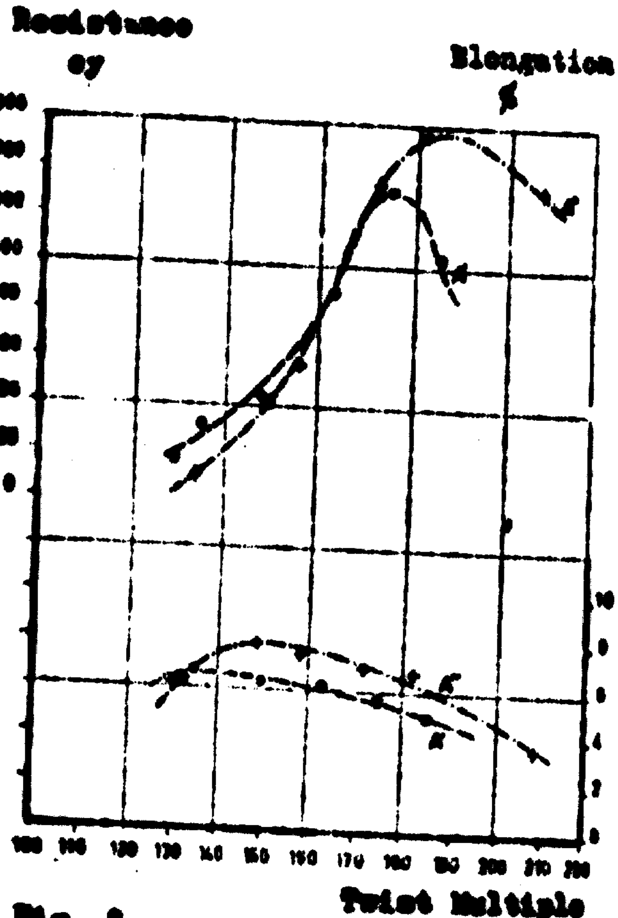
Resistance
cy
Elongation
%
800
700
600
500
400
300
200
100
0
10
8
6
4
2
0
100 110 120 130 140 150 160 170 180 190 200 210 220
Twist Multiple

Fig. 8

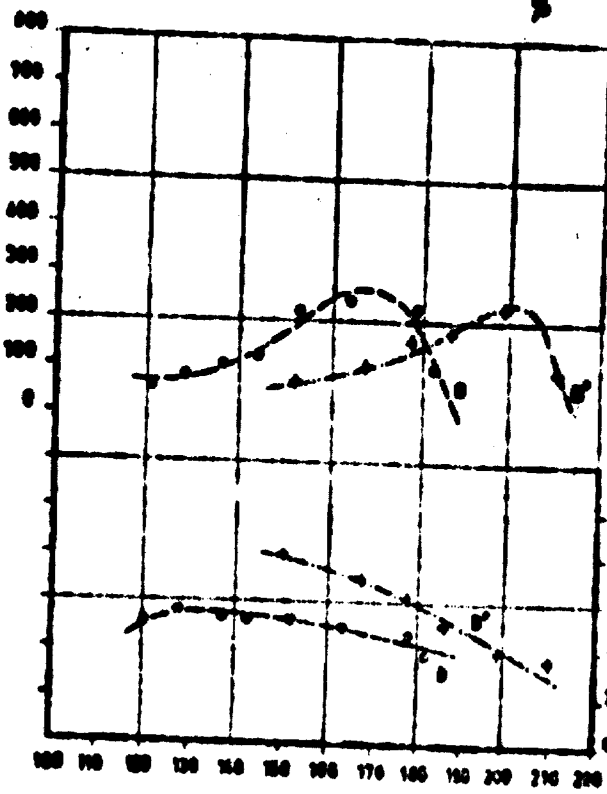

Fig.9

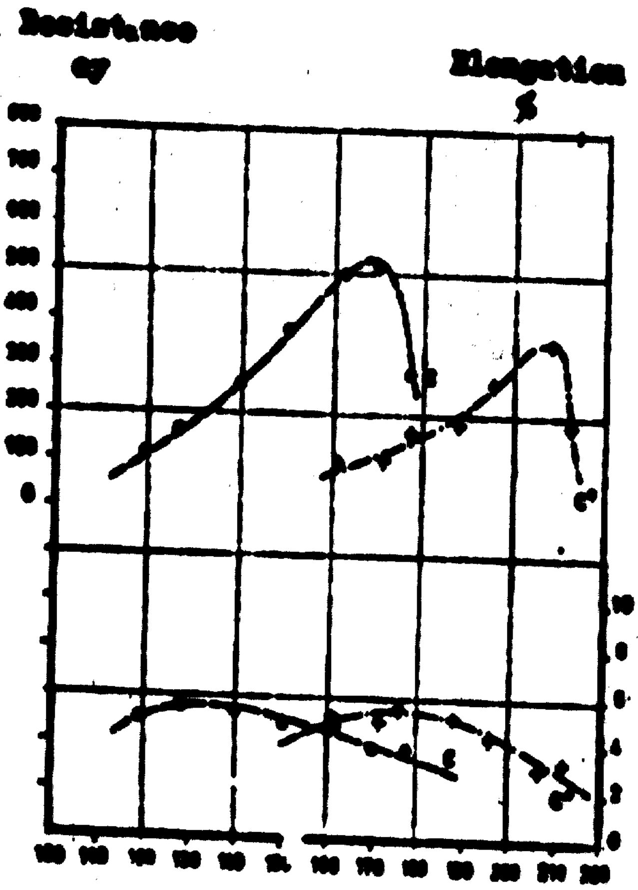
Resistance
gr
Elongation
%
800
700
600
500
400
300
200
100
0
10
8
6
4
2
0
Twist Multiple

Fig.10

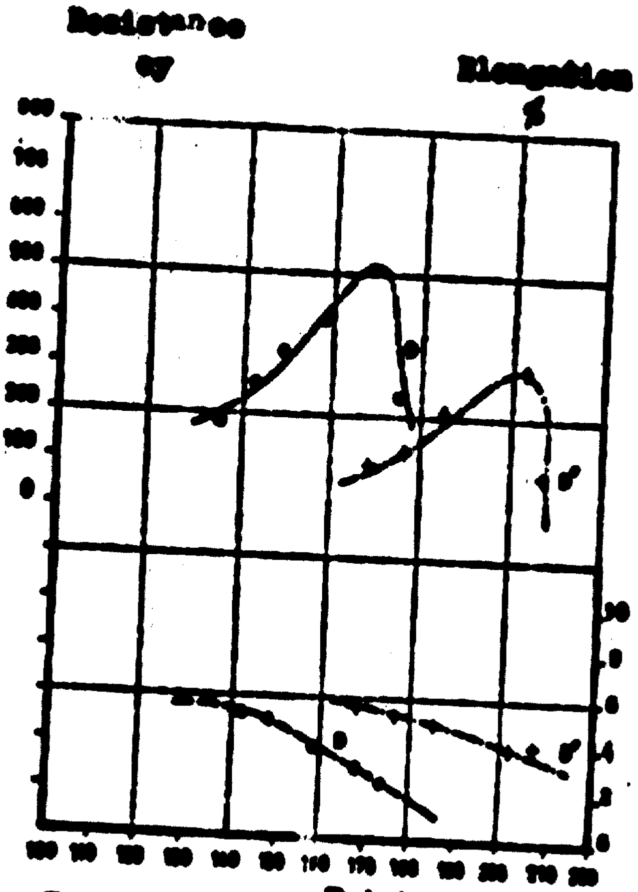

Fig. 11

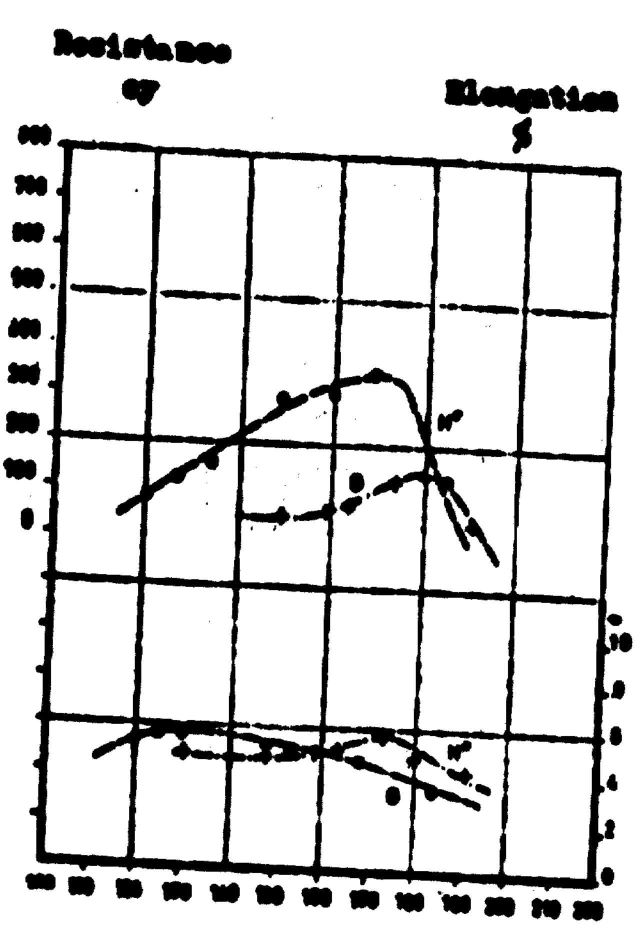

Fig. 12 Twist Multiple

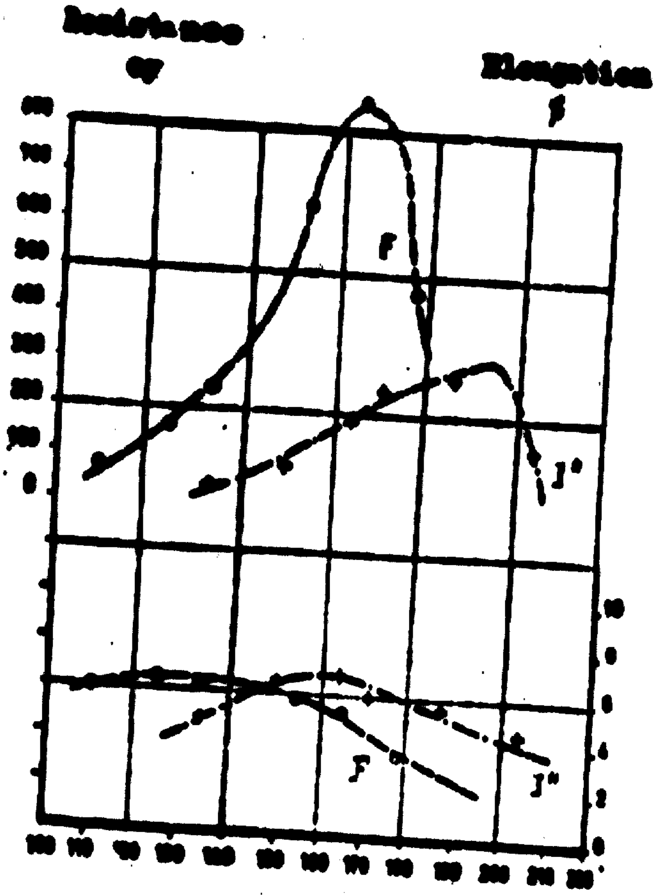

Fig. 13 Twist Multiple

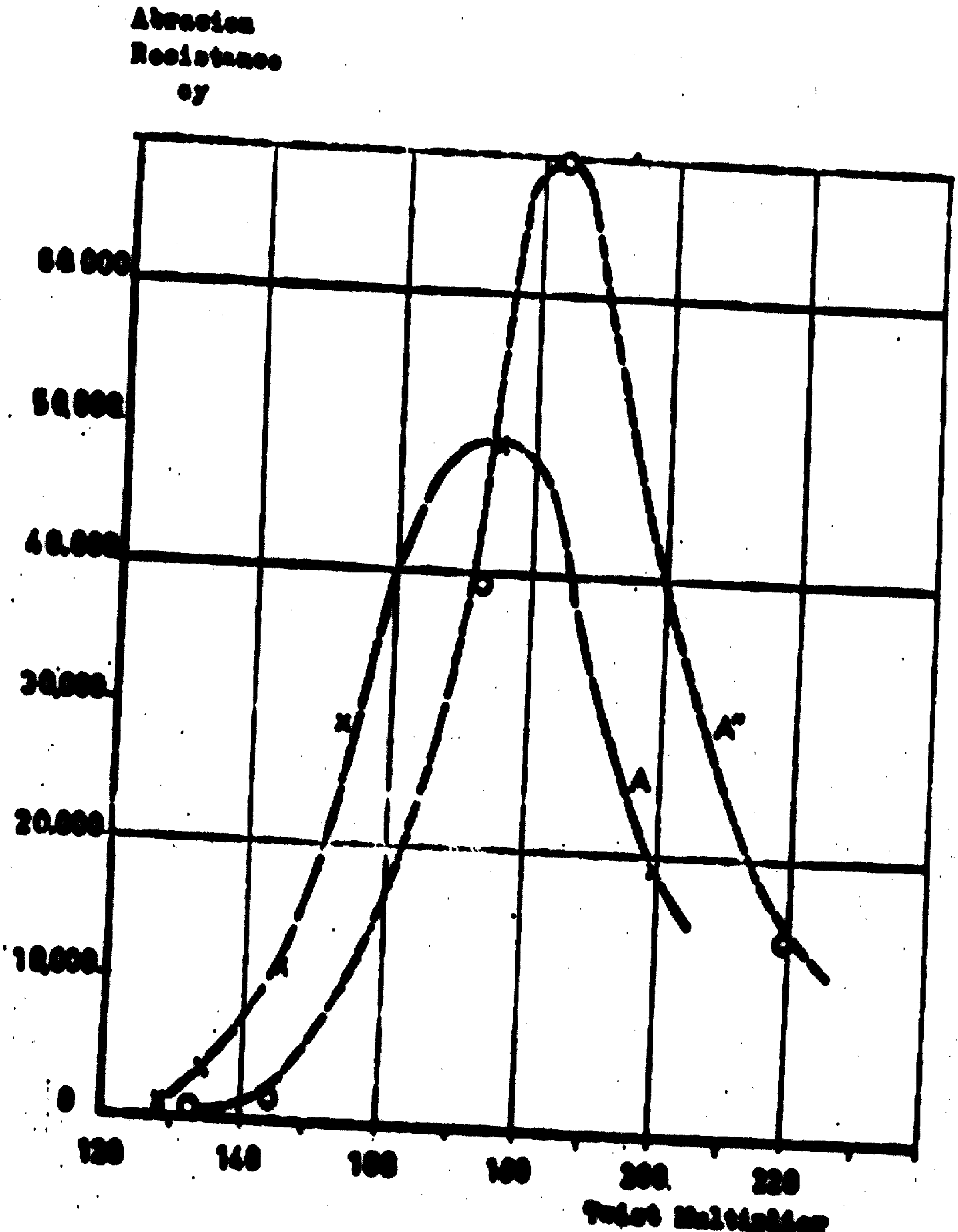
Abrasion
Resistance
cy
60.000
50.000
40.000
30.000
20.000
10.000
0
120
140
160
180
200
220
Twist Multiplier
x
A
A'

Fig. 14

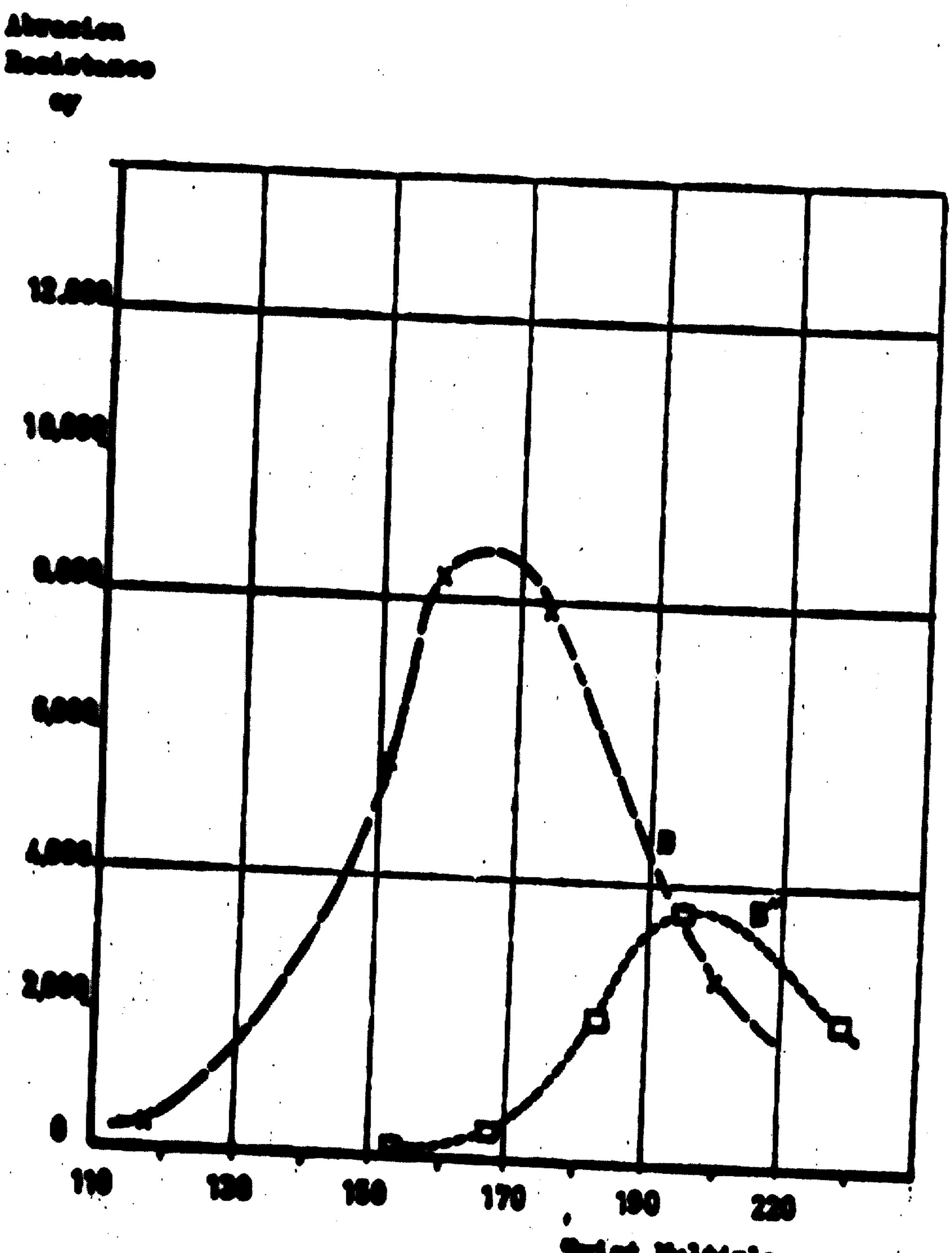
Abrasion
Resistance
12,000
10,000
8,000
6,000
4,000
2,000
0
110
130
150
170
190
220
Twist Multiple

Fig. 15

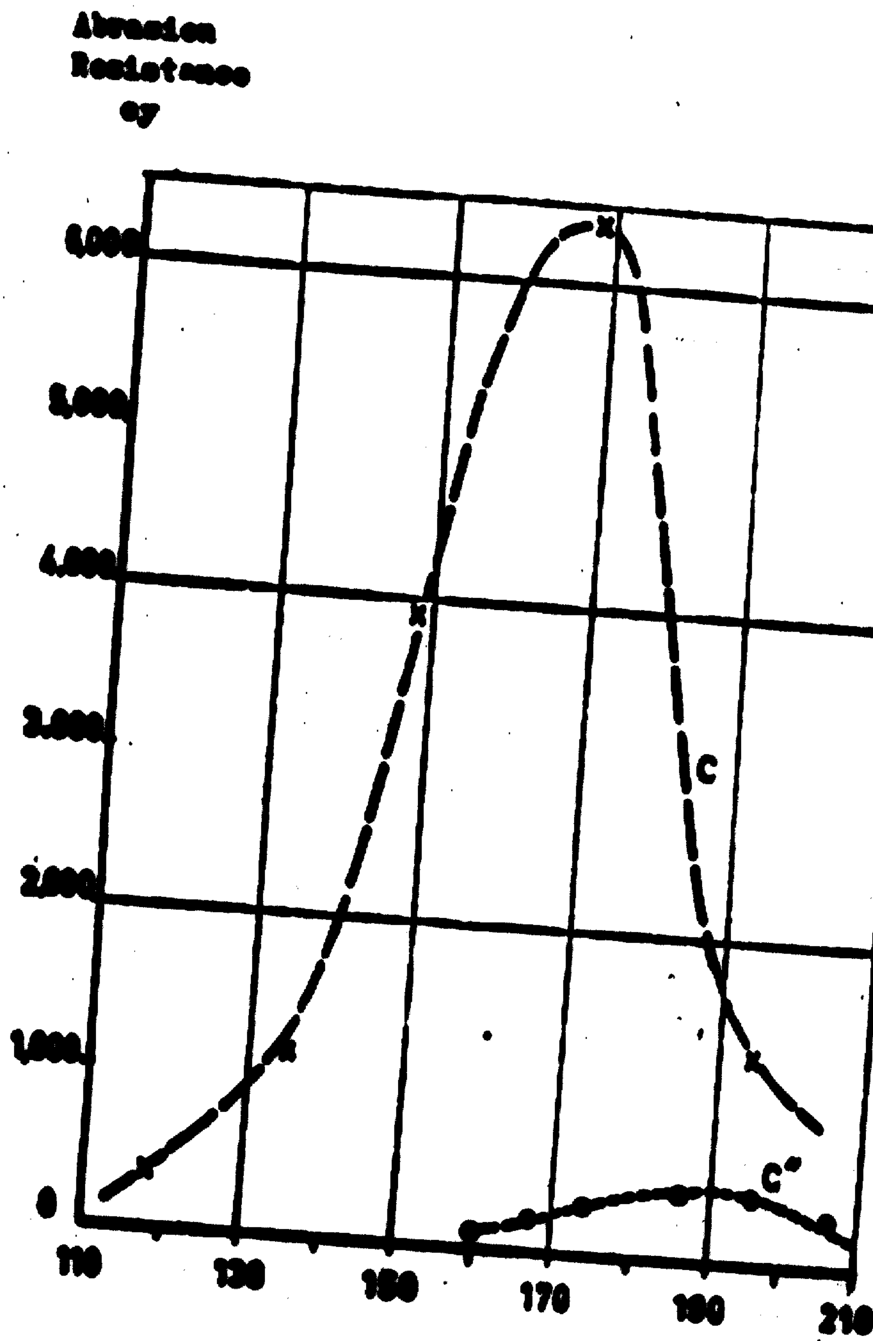

Fig. 26 Twist Multiplier

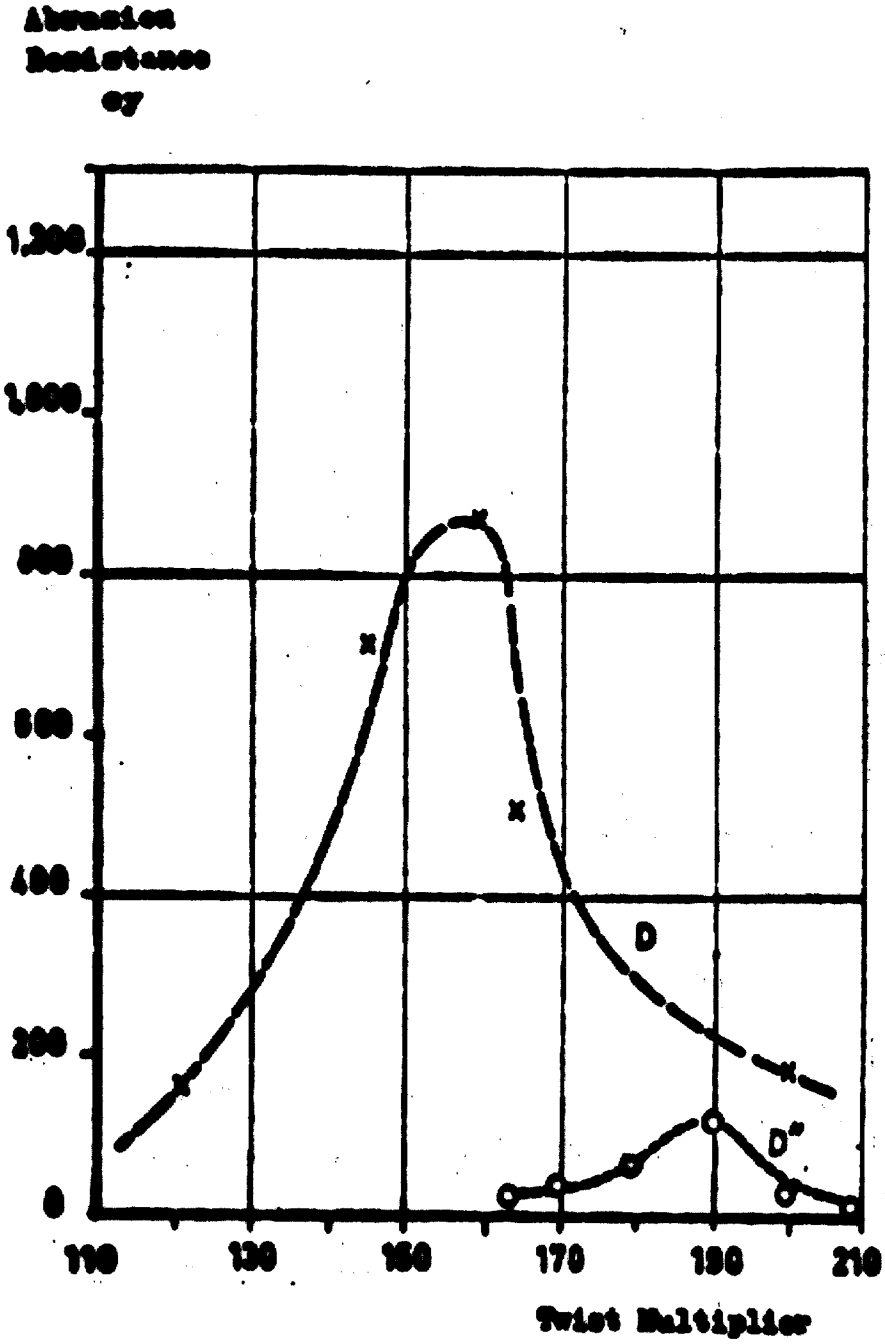

Fig. 17

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