International Institute for Cotton

Research Record No. 202

STARFISH Equations for Single Jersey Fabrics Processed on the Dornier Merceriser and the Gyrostock Dyeing Machine

S. Allan Heap

June 1985

Classification: Fabrics / Knitted / Properties

Key Words: Starfish, Single jersey, Dornier, Gyrostock

Electronic Version: August 2007

Note: The form of the Starfish equations has changed since this report was compiled.

Introduction

Research Record No. 182 described the processing of a series of plain single jersey fabrics on the premises of Messrs. Empresa Textil de Barcelos Sarl (TEBE) in March 1984.

This report presents the results of laboratory tests on those fabrics and also the results of regression analysis to estimate the STARFISH equations for the two fabric types (singles and two-fold) and the two processing routes (Gyrostock and Dornier mercerise + Gyrostock).

Fabrics

The knitting of the fabrics was carried out at TRD and was described in Research Records 114 and 177. They were produced on three plain jersey machines, (18g 1500 needles, 24g 1920 needles, and 28g 2112 needles) from six lots of yarn (1/20, 1/28, 1/36, 2/40, 2/56, and 2/72 Ne). Each yarn was knitted at five different stitch lengths covering the full range of commercially feasible qualities. For each quality, i.e. for each combination of yarn count and stitch length, two pieces of fabric were available, making two sets of 30 qualities. The two sets were assembled in order of their target finished widths, these targets having been calculated using information collected from samples supplied to TRD in advance by TEBE and from the results of a series of preliminary trials carried out in July 1983. One set was processed through the Barriquand Gyrostock dyeing machine in two lots, followed by centrifuging, wet stretching on a Tubetex Tripad, drying in a Tubetex Super Relax dryer, and final calendering. The other set was processed first through the Dornier tubular merceriser and was then dyed and finished in the same way as the first set.

Finishing targets had been estimated so as to result in final shrinkage figures of approximately 10% in both length and width. They proved to be obtainable in the case of the unmercerised materials, but much more difficult to achieve for the mercerised fabrics.

The finished fabrics were returned to TRD and were tested by our standard methods. Test results were available by November 1984 and the first analysis of the data was completed in January 1985.

Results

The basic test data are presented in *Tables 1 to 6*. *Tables 1 and 2* show the results from the greige fabrics, *Tables 3 and 4* are those from the dyed and finished fabrics, and *Tables 5 and 6* are those from the mercerised and dyed and finished materials.

The shrinkage results on the dyed and finished fabrics (*Table 4*) confirm that the calculated finishing targets were mostly reasonable ones and were actually attained more often than not. Fabrics made from the two-fold yarns generally show slightly higher width shrinkages but lower shrinkages in length.

The shrinkage results on the mercerised, dyed and finished fabrics (*Table 6*) confirm that the calculated finishing targets were either inaccurate or were not obtainable in practice. In this case, the differences in shrinkages between singles-yarn and two-fold-yarn fabrics are even more striking.

In both sets of finished fabrics it seems that, for a given level of width shrinkage, the length shrinkage tends to be lower with the tighter fabrics (shorter stitch lengths).

Figure 1 shows the test results from greige fabrics for relaxed courses /3cm, wales /3cm, stitches /sq. cm and weight per sq. metre as a function of the relaxed stitch length in a way which compares the results for single-yarn fabrics against the two-fold fabrics. *Figures 2 and 3* show the corresponding test data for the dyed and finished, and for the mercerised, dyed and finished fabrics respectively.

Looking at these three sets of graphs we can see that, for a given yarn count and stitch length, fabrics made from two-fold yarns will always have:-

- fewer courses per unit length
- fewer stitches per square cm.

- a lower weight per square metre

So far as the wale density is concerned the picture is not quite so clear. In the greige and the dyed and finished fabrics there is a tendency for the two-fold fabrics to have fewer wales per unit width than the singles fabrics. However, in the mercerised material, the reverse is the case.

These differences in Reference course and wale spacings mean that separate finishing targets must be issued for singles and two-fold fabrics. For example, if nominally identical qualities are made and finished to exactly the same width and weight, then the two-fold fabric would have significantly lower shrinkages in both length and width, provided it were not mercerised. If the fabrics were mercerised then the single-yarn fabric would have better width shrinkage but the length shrinkage would be drastically worse.

This simple example illustrates the importance of being able to predict or calculate the reference dimensions in advance, e.g. by using the STARFISH equations, so that the proper finishing targets can be set.

Comparison of *Figures 2 and 3* or *Tables 4 and 6* confirm that the relaxed mercerised materials have fewer courses but more wales per 3cm than the unmercerised ones. The percentage increase in the wales is greater than the reduction in the courses so the stitch density per square cm. is about 10% greater in the relaxed mercerised than in the unmercerised fabrics. Similarly, the weight per unit area is greater by about 15%. The mercerised fabrics are only marginally thicker than the unmercerised ones but they are significantly stronger. However the increase in strength is mostly accounted for by the increased weight as shown in one of the charts of *Figure 4* where the bursting strength is plotted against the weight per square metre.

Elsewhere in *Figure 4*, we can see that the increase in weight and stitch density caused by mercerising seems to be at least partly caused by the changes which have been brought about in the yarn count and the stitch length (mercerising caused the yarn Tex to increase by about 6½%, relative to the dyed material, and the stitch length to reduce by about 5%).

Finally, *Figure 4* also shows the spirality angles in the greige, the dyed, and the mercerised fabrics. In both greige and dyed samples, spirality is affected markedly by the tightness factor (square root of Tex divided by stitch length in cm). The tighter the fabric, the lower the spirality in the fabric. Dyed fabrics show spiral angles of about 5 degrees or so lower than greige fabrics. Most of the mercerised fabrics have spiral angles significantly less than those of the dyed fabrics, but there is considerable scatter in the data and no clear trend has emerged.

For the fabrics made from two-fold yarns, (not plotted) the spiral angle in the greige relaxed fabrics is close to zero and is negative (i.e. spiralling to the left). This means, presumably, that the residual torque in the folded yarn was in the 'S' direction. After dyeing, the spirality is still negative and has increased in size by one to three degrees. After mercerising the spirality has increased even further and is now at about the same absolute level as in the singles fabrics, but in the opposite direction! (See *Table 6*).

Regression Analysis

The STARFISH equations are of two types named STEP ONE and STEP TWO equations after the way that they are used in the STARFISH models.

STEP ONE equations deal with the change in yarn count and stitch length which is caused by the finishing (and relaxation) process. The current form of these equations is as follows:-

$$Rtex = a \cdot Gtex$$

$$RL = a' \cdot GL$$

where:

Rtex and *RL* are the tex and stitch length in the finished relaxed fabric;

Gtex and *GL* are the tex and stitch length in the greige, as knitted fabric;

a and *a'* are constants which depend upon the wet processing treatment.

STEP TWO equations are those which describe the finished relaxed reference state of the fabric in terms of the reference tex and the reference stitch length, thus:-

$$Rc = a + b / RL + c \cdot \sqrt{Rtex}$$

$$Rw = a' + b' / RL + c' \cdot \sqrt{Rtex}$$

$$Rs = a''' + b''' / RL^2 + c''' \cdot Rtex$$

$$Rwt = a'' + b'' \cdot Rtex / RL$$

where:

Rc = courses /cm in the relaxed reference state;

Rw = wales /cm in the relaxed reference state;

Rs = stitches /sq.cm in the relaxed reference state;

Rwt = weight in g/sq. metre in the relaxed reference state.

a, a', b, b', c, c' , etc. are constants which depend upon the wet processing treatment.

For the present data, the coefficients of the STEP ONE tex equations (a) were estimated using simple linear regression analysis on the average yarn tex values established before knitting by sampling from the cones, and the average yarn tex in the reference state established by averaging over the five different stitch lengths for yarns taken from the relaxed fabrics.

Because of our experience with earlier single jersey trials, singles and two fold yarns were pooled for this analysis so there were six data pairs in all.

For the STEP ONE stitch length equations, no averaging was carried out and the coefficients (a') were estimated by simple linear regression analysis on the individual data pairs - as knitted and relaxed. Data for singles and two-fold yarns were combined making 30 data pairs in all.

For the STEP TWO equations the reference tex values used were the averages but the reference stitch lengths were the individual measured values. For all STEP TWO equations, the singles-yarn fabrics were treated separately from the two-folds, so there were 15 data pairs in each case.

Table 7 shows the values of the coefficients which resulted from this analysis, together with the square of the correlation coefficient. In most cases, R-squared is 0.99 or greater which means that the equations account for about 99% of the variation in the data. The few exceptions are almost all in the mercerised material so that the predictions for these may be somewhat less reliable. However, the lowest value for R-squared was 0.94 which is still a very acceptable result.

The regression curves have been plotted alongside the data in *Figures 5 to 11* where it can be seen that the STARFISH equations do model the measured values remarkably well.

Table 1

IIC/TEBE TRIALS 1984

Test Results on GREIGE Fabrics - as recieved

Fabric ID	Ave Tex	Av StL cm	Crses 3cm	Wales 3cm	Weight gsm	Burst Kn/sm	Distn mm	Spiral deg	Y Str g	Extn %	Thkns mic
18 Gauge : Singles											
20Ne 327	29	0.329	54.6	27.4	156	726	19.6	3.2	370	7	732
20Ne 344	29	0.345	49.3	26.9	150	667	20.8	4.1	371	7.3	707
20Ne 362	29	0.362	44.7	27.3	143	636	21	4.7	372	7	695
20Ne 380	29	0.38	41.4	27.5	139	619	21.7	5.3	364	7.2	712
20Ne 399	29	0.399	37.1	27.1	132	592	20.1	6.1	346	7	690
18 Gauge : Twofold											
2/40Ne 327	28.7	0.328	53.4	27.5	153	953	21.2	-0.3	651	7.6	683
2/40Ne 344	28.7	0.343	48.1	27	141	909	20.1	-0.1	656	7.7	651
2/40Ne 362	28.7	0.362	43.1	27.1	134	821	20.1	-0.5	648	7.6	655
2/40Ne 380	28.7	0.38	38.6	26.6	123	814	22.2	-0.7	647	7.5	635
2/40Ne 399	28.7	0.4	35.5	27.2	116	815	20.2	1.1	661	7.8	621
24 Gauge : Singles											
28Ne 291	20.9	0.294	61.2	33.2	135	n.a.	n.a.	13.1	271	9.1	618
28Ne 306	20.9	0.307	49.2	32.3	120	n.a.	n.a.	7.7	266	7.6	593
28Ne 321	20.9	0.322	47.1	33.1	134	n.a.	n.a.	17.5	272	8.1	668
28Ne 337	20.9	0.34	42.9	33.2	116	n.a.	n.a.	15.3	266	7.8	650
28Ne 354	20.9	0.357	37.6	32	121	n.a.	n.a.	11.5	253	6.7	628
24 Gauge : Twofold											
2/56Ne 291	21.5	0.291	56.8	32.4	133	n.a.	n.a.	2.3	466	7.2	621
2/56Ne 306	21.5	0.31	49.9	31.6	125	n.a.	n.a.	2.6	488	7.4	585
2/56Ne 321	21.5	0.322	45.5	31.4	113	n.a.	n.a.	2.7	497	6.9	574
2/56Ne 337	21.5	0.337	41.1	32.2	111	n.a.	n.a.	-0.4	516	6.9	587
2/56Ne 354	21.5	0.354	38.8	31.5	105	n.a.	n.a.	-1.4	473	6.7	604
28 Gauge : Singles											
36Ne 259	16	0.261	56.4	38.1	105	n.a.	n.a.	12.7	191	7.8	537
36Ne 273	16	0.277	51.6	37.8	101	n.a.	n.a.	11.9	205	8.1	517
36Ne 287	16	0.287	48.5	37.3	101	n.a.	n.a.	18	191	7.1	571
36Ne 301	16	0.305	44.8	38.4	109	n.a.	n.a.	20	198	8.3	528
36Ne 316	16	0.319	42.8	37.9	98	n.a.	n.a.	15.4	209	9.3	578
28 Gauge : Twofold											
2/72Ne 259	16.5	0.255	59.1	37.4	109	n.a.	n.a.	2.8	376	9	559
2/72Ne 273	16.5	0.273	53.4	37.7	107	n.a.	n.a.	3.6	355	7.4	521
2/72Ne 287	16.5	0.284	44.6	38.2	94	n.a.	n.a.	2.8	364	8.7	520
2/72Ne 301	16.5	0.302	43.6	36.7	94	n.a.	n.a.	1.4	353	6.3	498
2/72Ne 316	16.5	0.319	41	37	90	n.a.	n.a.	-1.2	365	6.7	521

Burst strength not carried out on Greige fabrics as recieved

Table 2

IIC/TEBE TRIALS 1984

Test Results on GREIGE Fabrics - Reference state

Fabric ID	Yarn Tex	St Len cm	Crses 3cm	Wales 3cm	Weight gsm	Burst Kn/sm	Distn mm	Spiral deg	Y Str g	Extn %	Thkns mic	Shr L %	Shr W %
18 Gauge : Singles													
20Ne 327	28.9	0.323	54.9	38.1	212	710	22.2	9.5	355	7.9	973	1.4	27.1
20Ne 344	28.9	0.338	51.9	36.6	202	681	22.2	11.8	355	7.8	994	5.8	24.2
20Ne 362	28.8	0.355	47.9	35.9	194	669	22.6	13.3	336	7.6	988	9.6	21.7
20Ne 380	29	0.374	46.4	34.3	185	618	22.9	14.9	345	8.1	1000	11.3	17.6
20Ne 399	28.8	0.393	43.9	33.1	177	574	22.5	18	341	8	1038	16.1	16.5
18 Gauge : Twofold													
2/40Ne 327	28.3	0.324	52.5	38.8	202	897	21.5	-1.1	653	8.1	885	-0.4	28.2
2/40Ne 344	28.4	0.338	49.8	36.5	193	856	22.5	-0.5	650	8.1	909	5.1	25.6
2/40Ne 362	28.6	0.356	47.1	35.8	182	822	22.5	-0.9	633	8.1	916	8.5	22.3
2/40Ne 380	28.1	0.375	44.7	33.5	170	791	22.2	0.2	647	8.2	918	14.5	19.1
2/40Ne 399	28.5	0.393	42.9	32.6	163	747	22.1	-0.1	633	7.8	909	17.4	17
24 Gauge : Singles													
28Ne 291	20	0.289	61.4	43.8	170	608	15.8	17	276	9.5	867	2.7	25.6
28Ne 306	20.2	0.301	56.9	42.1	159	576	18.5	18.9	257	8.9	952	15	21.2
28Ne 321	20.4	0.32	54.1	40.7	158	535	18.8	20.1	236	7.1	965	13.9	19.4
28Ne 337	20.3	0.335	50.8	39.9	148	494	19.3	21.8	252	10	957	18.2	18.3
28Ne 354	20.4	0.35	48.6	39	146	471	19.5	25.3	249	7.8	849	23.1	14.8
24 Gauge : Twofold													
2/56Ne 291	21.4	0.291	58.9	42.8	169	762	15.1	-0.6	453	8.9	789	6.8	24.7
2/56Ne 306	21.1	0.304	56.3	41.3	158	712	14.8	-2.1	469	7.8	774	11.2	21.7
2/56Ne 321	21.2	0.315	53	40.4	157	703	18.8	-2.3	441	9.8	882	14.1	21.8
2/56Ne 337	21	0.332	49.3	38.6	150	685	19	-3.5	447	9.5	888	17.1	16.1
2/56Ne 354	21.9	0.351	46.9	36.3	133	653	18.2	-4.2	470	9.4	836	20.9	13.6
28 Gauge : Singles													
36Ne 259	15.7	0.261	66.2	50.2	147	484	15	20.1	183	9.4	787	15.8	22.7
36Ne 273	15.9	0.274	63.6	48.4	137	484	18.6	21.3	198	9.4	796	19.7	20
36Ne 287	15.6	0.281	59.1	46.9	132	456	18	24.5	188	9.3	876	20	15.8
36Ne 301	15.5	0.298	56.6	46	134	412	18.9	26.6	184	9.7	869	19.5	15.7
36Ne 316	15.4	0.315	53.8	44.4	123	391	18.8	26.5	190	11.1	860	22	14.8
28 Gauge : Twofold													
2/72Ne 259	16.3	0.256	64.4	49	146	642	14.9	0.6	326	9.4	719	11.4	23.6
2/72Ne 273	15.9	0.273	61.8	47.3	137	625	14.4	-1.2	350	7.3	682	14.4	19.5
2/72Ne 287	16.3	0.283	58.1	45.2	128	621	19.2	-2.4	335	9.5	812	23	15.7
2/72Ne 301	16.2	0.296	55.5	42.4	124	560	18.7	-2.9	339	10	809	21.7	15.9
2/72Ne 316	15.8	0.311	51.3	41.4	115	544	17.6	-3.2	354	9.1	757	21.5	13.1

Table 3

IIC/TEBE TRIALS 1984

Test Results on DYED & FINISHED Fabrics - as recieved

Fabric ID		Yarn Tex	St Len cm	Crses 3cm	Wales 3cm	Weight gsm	Burst Kn/sm	Distn mm	Spiral deg	Y Str g	Extn %	Thkns mic
18 Gauge : Singles												
20Ne	327	28.4	0.324	50	33	175	635	18.1	4.3	378	6.8	647
20Ne	344	28.4	0.34	46.4	32.5	161	647	17.3	1.3	342	7.4	643
20Ne	362	28.4	0.357	43	32.3	154	570	18	3.2	373	6.3	669
20Ne	380	28.8	0.374	40.2	29.9	141	595	17.6	1.9	356	6.6	631
20Ne	399	28.3	0.393	36.8	29.6	129	569	17.6	2.8	361	7.3	641
18 Gauge : Twofold												
2/40Ne	327	28.5	0.323	49.4	32.7	164	868	18.7	-0.7	642	7.8	606
2/40Ne	344	28.4	0.338	46	32.7	159	821	18.4	0.8	635	7.2	612
2/40Ne	362	28.7	0.354	43.1	31.2	143	808	18.7	0.4	647	8.0	616
2/40Ne	380	27.9	0.376	39.4	28.6	127	771	18.4	1.5	633	7.1	595
2/40Ne	399	27.6	0.395	36.6	27.8	122	755	17.3	0.2	641	10.1	591
24 Gauge : Singles												
28Ne	291	20.3	0.29	54.5	38.6	138	560	17.8	3.8	253	6.1	563
28Ne	306	19.7	0.305	49.8	37.3	123	520	17.6	4.8	277	7.4	559
28Ne	321	20.1	0.318	46.5	36.4	115	511	17.8	3.1	255	7.3	525
28Ne	337	20.3	0.335	43	35.2	114	486	18.5	3.4	260	7.3	534
28Ne	354	20.3	0.352	41.6	33.3	105	448	17.6	3.4	259	7	543
24 Gauge : Twofold												
2/56Ne	291	20.6	0.288	54.1	37.3	134	719	17.4	1.7	488	6.6	526
2/56Ne	306	20.3	0.304	50.1	36.5	124	666	17.3	1.5	471	7.5	522
2/56Ne	321	20.8	0.318	46.5	35.3	117	674	17.7	0.1	456	8.1	519
2/56Ne	337	20.6	0.334	43.1	33.9	110	641	17.5	0.5	495	8.8	526
2/56Ne	354	20.5	0.349	40.1	33.1	99	620	17	0.4	490	7.4	517
28 Gauge : Singles												
36Ne	259	15.3	0.258	59.6	43.4	108	428	17.4	2	204	5.9	497
36Ne	273	15.7	0.274	53.5	41.4	103	400	17.8	4.4	183	6.5	480
36Ne	287	15.2	0.287	50.8	39	95	429	18.2	3.1	184	5.9	468
36Ne	301	15.2	0.301	47.4	38.8	93	376	17.6	2.9	203	6.5	490
36Ne	316	15.3	0.315	43.1	37.6	86	354	17.2	5.2	198	7.3	475
28 Gauge : Twofold												
2/72Ne	259	15.8	0.253	60.4	42.6	116	606	17.2	1.3	363	6.3	471
2/72Ne	273	15.9	0.269	54.8	40.6	104	602	17.4	1.7	373	7.1	460
2/72Ne	287	15.9	0.284	51.1	39.4	96	577	17.8	2.4	356	6.2	467
2/72Ne	301	15.9	0.297	48.7	38	92	573	17.1	1.6	339	7.4	466
2/72Ne	316	16	0.312	44.3	36.1	85	497	16.5	3.2	369	7.6	455

Table 4

IIC/TEBE TRIALS 1984

Test Results on DYED & FINISHED Fabrics - Reference State

Fabric ID	Yarn Tex	St Len cm	Crses 3cm	Wales 3cm	Weight gsm	Burst Kn/sm	Distn mm	Spiral deg	Y Str g	Extn %	Thkns mic	Shr L %	Shr W %
18 Gauge : Singles													
20Ne 327	28.5	0.321	54.1	36.7	198	630	19.2	10.3	381	6.1	830	7.7	10.2
20Ne 344	28.3	0.337	50.4	35.3	190	608	19	10.4	361	7.3	818	8.2	7.4
20Ne 362	28.3	0.357	47.8	34.6	176	594	19.3	12.2	434	6.5	844	10.9	5.6
20Ne 380	28.8	0.374	44.4	33.4	173	592	19.3	13	456	7.7	831	9.7	8.1
20Ne 399	28.3	0.392	42.1	32.2	165	567	20.1	14.5	448	7.4	865	14	5.5
18 Gauge : Twofold													
2/40Ne 327	28	0.322	51.6	37.1	189	840	18.5	-1.6	665	7.9	732	4.9	10.3
2/40Ne 344	28.7	0.337	48.5	36.2	180	822	19.8	-2.9	646	7.5	760	7.7	9.7
2/40Ne 362	28.3	0.352	45.9	34.6	172	764	19.1	-1.1	666	7.4	766	5.9	9.7
2/40Ne 380	27.9	0.374	44	32.7	158	721	19.4	-1	645	7.2	758	11.2	12.8
2/40Ne 399	28	0.391	41.7	31.6	154	742	20.4	-1.5	602	7.4	757	11.1	11.1
24 Gauge : Singles													
28Ne 291	20	0.29	57.9	43.1	160	537	19.3	12.3	291	7.3	704	7.8	7
28Ne 306	20.2	0.303	55.2	42.1	151	510	18.9	12.9	312	7.3	723	10.5	7.6
28Ne 321	19.8	0.32	52.6	40	145	488	19.9	15.2	287	7.5	721	11.7	8.8
28Ne 337	20.2	0.332	49.8	39	140	463	19.5	17.6	300	6.7	753	14.2	8.6
28Ne 354	20.1	0.35	47.2	37.6	133	430	19.6	19.6	280	7.6	749	12.7	6.7
24 Gauge : Twofold													
2/56Ne 291	20.6	0.285	57.1	42.5	156	680	18.3	-2.9	513	7.8	637	6.2	10.1
2/56Ne 306	20.8	0.301	53.4	41.1	151	668	19.5	-4.4	463	7.2	672	6.8	11.4
2/56Ne 321	20.6	0.314	51.3	39.3	141	667	19.8	-4.6	483	7.5	664	8.9	10.4
2/56Ne 337	20.9	0.33	47.9	37.9	134	634	20	-4.3	474	7.5	673	10.1	9.8
2/56Ne 354	20.8	0.348	45.8	36.6	128	631	20.4	-5.3	467	7	676	12.4	10.5
28 Gauge : Singles													
36Ne 259	15.1	0.257	65.7	48.6	134	443	19.2	13.1	217	5.7	652	9.1	10.1
36Ne 273	15.3	0.273	61.5	46.3	130	415	19.3	14.9	199	5.6	663	13	9.3
36Ne 287	15.3	0.285	57.6	45.7	125	402	19.7	16.6	204	6.3	662	13.6	12
36Ne 301	15.4	0.298	55.1	44.8	121	398	19.6	18.8	213	7	688	14.5	9.7
36Ne 316	15.4	0.313	50.3	43.5	115	362	19.2	21.9	205	7.1	679	15.5	6.8
28 Gauge : Twofold													
2/72Ne 259	15.9	0.253	62.4	48.1	135	599	18	-3.6	400	7.4	574	6.2	9.9
2/72Ne 273	15.9	0.268	60	47.7	128	603	19.2	-3.9	373	6.3	604	8.8	13.4
2/72Ne 287	15.7	0.283	56.5	45.7	121	582	19.3	-4.5	358	6.1	609	10.4	11.9
2/72Ne 301	15.8	0.295	53.2	43.6	116	542	20	-4.2	361	7.1	601	9.5	11.2
2/72Ne 316	15.8	0.31	49	41	108	532	19	-4.2	356	7.3	598	11.1	10.6

Table 5

IIC/TEBE TRIALS 1984

Test Results on MERCERISED,DYED & FINISHED Fabrics - as recieved

Fabric ID		Yarn Tex	St Len cm	Crses 3cm	Wales 3cm	Weight gsm	Burst Kn/sm	Distn mm	Spiral deg	Y Str g	Extn %	Thkns mic
18 Gauge : Singles												
20Ne	327	30.1	0.309	42.5	40	169	865	14.7	0.3	471	9	620
20Ne	344	30.5	0.321	40.5	39.1	171	855	16.2	0.4	455	8	603
20Ne	362	30.4	0.337	37.4	38.4	152	804	15	-0.2	475	7.3	611
20Ne	380	30.4	0.352	35.9	35.7	156	756	16	0.9	448	8.2	607
20Ne	399	30.5	0.373	33	36	143	793	16.1	2.4	482	9	604
18 Gauge : Twofold												
2/40Ne	327	30.2	0.303	42	40	168	1066	15.5	-2.2	710	9.4	543
2/40Ne	344	30.2	0.315	41.3	38.4	163	988	15.4	-2.7	727	9	599
2/40Ne	362	30.2	0.331	38.9	36.7	153	991	16.3	-1.4	716	11	596
2/40Ne	380	30.7	0.348	35.7	35.6	146	974	15.2	-1.5	733	11.1	592
2/40Ne	399	30.1	0.369	31.1	35	125	899	13	-1.6	723	10.2	576
24 Gauge : Singles												
28Ne	291	21.2	0.276	47.9	46.1	141	652	16.4	0.5	299	8.2	532
28Ne	306	21.6	0.289	42.8	46	126	627	14.7	0.8	295	6.5	543
28Ne	321	21.3	0.305	38.5	42.7	118	588	14.3	0.8	313	7.8	491
28Ne	337	21.1	0.321	35.8	41.5	112	574	14.9	0.6	301	7.5	498
28Ne	354	21.2	0.338	33.1	41	100	517	12.9	0.3	300	7.6	503
24 Gauge : Twofold												
2/56Ne	291	22.2	0.267	49.9	45.6	144	892	15.1	2	537	11.4	508
2/56Ne	306	22.4	0.28	42.9	44.2	125	799	15.8	-3.1	535	8.3	501
2/56Ne	321	22.4	0.293	39.9	41.3	121	760	14.3	-2.2	539	8.8	504
2/56Ne	337	22.3	0.311	37.3	41.5	114	775	13.8	-0.5	564	9.5	498
2/56Ne	354	22.5	0.327	34.5	38.9	109	727	13.6	-0.6	551	10.4	487
28 Gauge : Singles												
36Ne	259	15.9	0.25	48.5	51.9	106	531	14.5	2.2	230	7.2	442
36Ne	273	16.1	0.26	46.3	50.6	111	523	14.5	0.6	236	7.5	479
36Ne	287	16.7	0.274	41.1	46.9	97	489	13.2	1	232	6.5	435
36Ne	301	15.9	0.29	37.4	49.1	90	425	11.6	0	234	6.3	454
36Ne	316	16.2	0.306	35.2	44.6	85	426	11.1	1.3	239	6.1	433
28 Gauge : Twofold												
2/72Ne	259	17.2	0.239	54.2	51.9	123	775	15.2	-0.7	399	10.1	451
2/72Ne	273	17.3	0.249	48.9	49.1	113	719	14.9	-1.6	407	10.1	459
2/72Ne	287	16.9	0.267	42.8	48.7	102	647	12.5	0.2	401	8.6	432
2/72Ne	301	16.9	0.281	41	44.7	97	654	14.1	0.4	399	8.4	426
2/72Ne	316	17	0.296	37.8	45.8	89	630	12.1	-0.7	406	8.7	450

Table 6

IIC/TEBE TRIALS 1984

Test Results on MERCERISED,DYED & FINISHED Fabrics - Reference State

Fabric ID	Yarn Tex	St Len cm	Crses 3cm	Wales 3cm	Weight gsm	Burst Kn/sm	Distn mm	Spiral deg	Y Str g	Extn %	Thkns mic	Shr L %	Shr W %
18 Gauge : Singles													
20Ne 327	30.1	0.309	49.4	42.9	213	810	18.5	2.9	477	8.8	873	14.6	7.5
20Ne 344	30.4	0.323	48.4	41.5	212	805	20.1	9.1	463	7.6	825	16.7	4.9
20Ne 362	30.3	0.339	45	40.4	197	780	19.5	6.3	472	7.2	891	17.9	8
20Ne 380	30.9	0.355	44.3	39.6	200	764	21.1	10.6	451	7.3	859	18.6	8.4
20Ne 399	30.5	0.373	41	38.4	193	735	20.5	12.5	447	7.5	859	20.9	6
18 Gauge : Twofold													
2/40Ne 327	29.8	0.305	47.2	44.9	209	1109	17.7	-5.6	708	9.2	718	10.1	12
2/40Ne 344	30.2	0.315	45.4	43.6	199	1065	18.1	-5.6	720	8.9	779	10.8	11.2
2/40Ne 362	30.2	0.33	42.9	42.2	195	1029	19.2	-7.5	725	11.2	810	10.9	12.9
2/40Ne 380	30.4	0.349	39.4	42.2	187	1016	18.4	-9.1	735	10.3	817	10.4	14.7
2/40Ne 399	29.7	0.369	33.9	42.5	171	1009	17.8	-9.9	735	10.4	784	10.6	18.2
24 Gauge : Singles													
28Ne 291	21.3	0.275	56.2	50.1	181	617	20	9.4	308	7.4	720	15.7	8.2
28Ne 306	21.3	0.289	51.8	49.2	168	646	19.7	6.9	336	7	774	18.2	7.2
28Ne 321	21.1	0.303	49.4	49.4	169	600	20.1	12.8	321	7.1	728	21.4	11
28Ne 337	21.1	0.317	47	47.3	164	573	20.5	13.4	311	7.1	755	24	10.8
28Ne 354	21.1	0.335	44.3	48.2	156	533	19.9	10.3	319	8.1	873	26.1	12.8
24 Gauge : Twofold													
2/56Ne 291	22.4	0.265	54.8	50.7	182	899	18.5	-7.4	532	9	665	10.4	10.9
2/56Ne 306	22.2	0.28	45.3	52.9	159	948	17.4	-8.3	536	8.5	697	6.6	17
2/56Ne 321	22.4	0.294	43.8	51.8	157	911	16.9	-6.7	557	8.7	711	7.7	16.1
2/56Ne 337	22.3	0.311	40.8	51.4	155	932	18.1	-9.6	550	9.6	729	8.7	19.2
2/56Ne 354	22.2	0.326	38.9	49	145	846	17.5	-11.8	563	8.2	702	11	16.9
28 Gauge : Singles													
36Ne 259	16	0.249	59.1	59.1	151	492	18.8	10.5	221	6.1	644	17.2	12.3
36Ne 273	16.2	0.258	55.2	58.4	145	567	19.4	4.7	226	7.8	725	17.9	12.4
36Ne 287	16.5	0.273	50.3	57	135	560	19	5.7	249	6.6	720	18.6	15.2
36Ne 301	15.8	0.291	47.7	57.5	134	502	18.5	4.9	227	7	769	23.2	16.1
36Ne 316	15.9	0.303	44	54.5	125	462	19.6	8	234	6	729	23.8	16.2
28 Gauge : Twofold													
2/72Ne 259	17	0.238	59.2	59.4	156	787	18.1	-7.9	383	8.7	592	9.1	12.4
2/72Ne 273	17.5	0.25	54.6	58.7	147	786	18.4	-9.7	395	9.8	648	9.8	14.8
2/72Ne 287	17	0.268	46.6	59.6	134	776	16.9	-8.4	398	9	652	8.1	18.5
2/72Ne 301	17	0.279	46.7	57.7	138	731	18.7	-10.4	388	7.4	615	13.1	20.4
2/72Ne 316	16.7	0.295	42.2	57.3	127	747	17	-10.5	413	8.9	671	10.5	21.2

Table 7

IIC/TEBE TRIALS 1984

Coefficients of the STARFISH Equations

	SINGLES Coef a	Coef b	Coef c	Corel Rsq	TWOFOLD Coef a	Coef b	Coef c	Corel Rsq
GREIGE								
Tex	0.986	n.a.	n.a.	0.998	0.986	n.a.	n.a.	0.998
St Length	0.986	n.a.	n.a.	0.998	0.986	n.a.	n.a.	0.998
Courses	-5.585	6.598	0.643	0.983	-5.937	6.352	0.738	0.989
Wales	10.226	2.955	-1.254	0.995	3.136	3.769	-0.364	0.994
Stitches	51.589	23.035	-1.416	0.996	-9.239	23.73	0.305	0.996
Weight	15.411	2.198	n.a.	0.991	-4.364	2.344	n.a.	0.989
DYED								
Tex	0.972	n.a.	n.a.	0.998	0.972	n.a.	n.a.	0.998
St Length	0.981	n.a.	n.a.	0.998	0.981	n.a.	n.a.	0.998
Courses	-7.773	6.735	0.889	0.992	-5.626	5.945	0.806	0.99
Wales	11.076	2.671	-1.339	0.996	6.5	3.334	-0.847	0.989
Stitches	44.083	21.746	-1.208	0.999	20.478	21.125	-0.454	0.989
Weight	13.011	2.091	n.a.	0.996	0.63	2.139	n.a.	0.996
MERCERISED								
Tex	1.037	n.a.	n.a.	0.996	1.037	n.a.	n.a.	0.996
St Length	0.93	n.a.	n.a.	0.987	0.93	n.a.	n.a.	0.987
Courses	-9.665	5.855	1.401	0.94	-18.839	7.106	2.058	0.954
Wales	23.05	1.91	-2.774	0.981	29.231	0.96	-3.248	0.982
Stitches	97.952	19.643	-2.102	0.99	58.074	19.966	-1.393	0.991
Weight	24.664	1.987	n.a.	0.97	10.383	1.999	n.a.	0.974

Figure 1

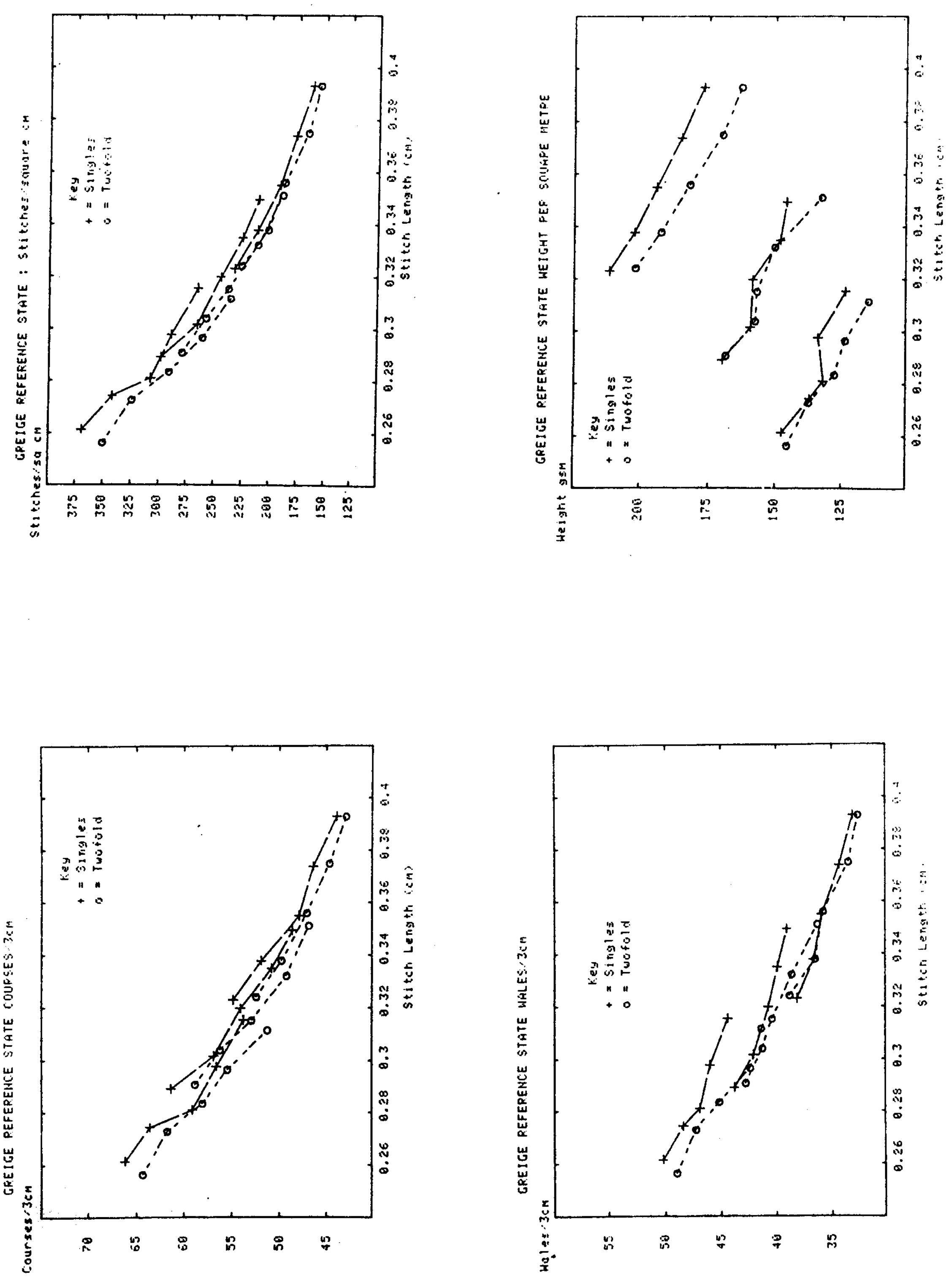

GREIGE REFERENCE STATE : Stitches/square cm
Stitches/sq cm
Key
+ = Singles
o = Twofold
Stitch Length (cm)
GREIGE REFERENCE STATE WEIGHT PER SQUARE METRE
Weight gsm
GREIGE REFERENCE STATE COURSES/3cm
Courses/3cm
GREIGE REFERENCE STATE WALES/3cm
Wales/3cm

Figure 2

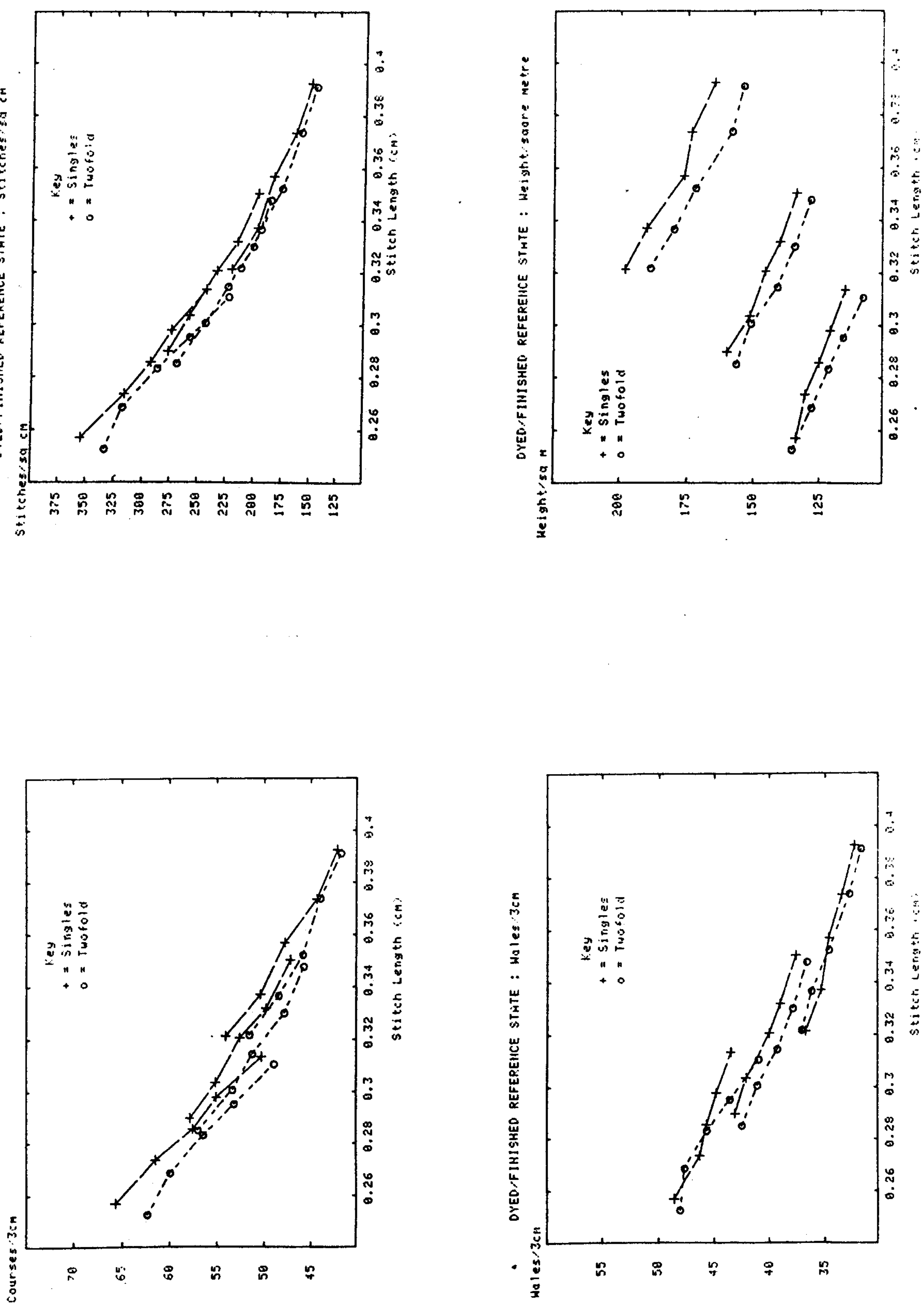

DYED/FINISHED REFERENCE STATE : Stitches/sq cm
Stitches/sq cm
Key
+ = Singles
o = Twofold
Stitch Length (cm)
DYED/FINISHED REFERENCE STATE : Weight/sqare metre
Weight/sq m
Key
+ = Singles
o = Twofold
Stitch Length (cm)
DYED/FINISHED REFERENCE STATE : Courses/3cm
Courses/3cm
Key
+ = Singles
o = Twofold
Stitch Length (cm)
DYED/FINISHED REFERENCE STATE : Wales/3cm
Wales/3cm
Key
+ = Singles
o = Twofold
Stitch Length (cm)

Figure 3

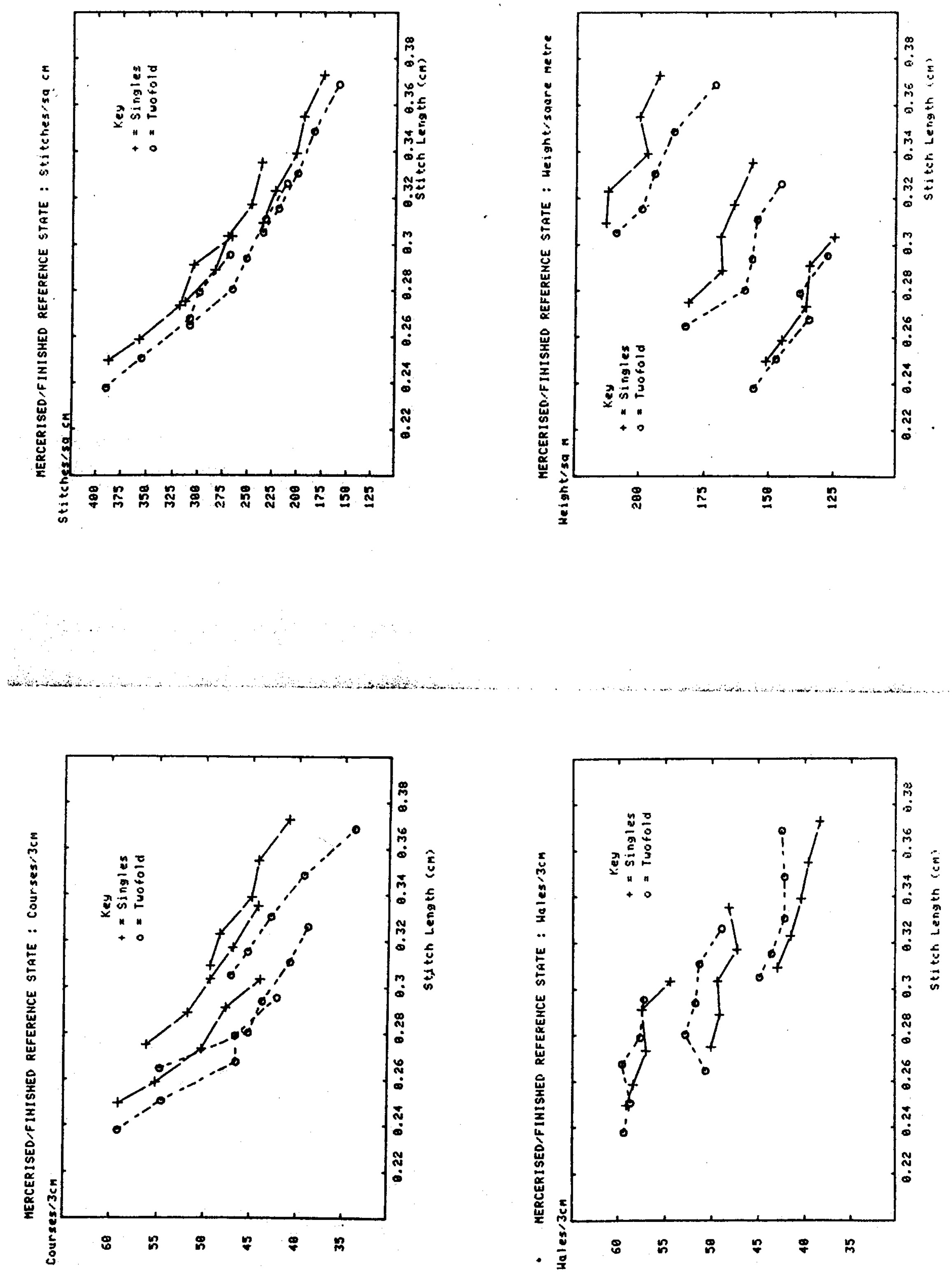

MERCERISED/FINISHED REFERENCE STATE : Stitches/sq cm
Stitches/sq cm
Stitch Length (cm)
Key
+ = Singles
o = Twofold
MERCERISED/FINISHED REFERENCE STATE : Weight/sqare metre
Weight/sq m
Stitch Length (cm)
Key
+ = Singles
o = Twofold
MERCERISED/FINISHED REFERENCE STATE : Courses/3cm
Courses/3cm
Stitch Length (cm)
Key
+ = Singles
o = Twofold
MERCERISED/FINISHED REFERENCE STATE : Wales/3cm
Wales/3cm
Stitch Length (cm)
Key
+ = Singles
o = Twofold

Figure 4

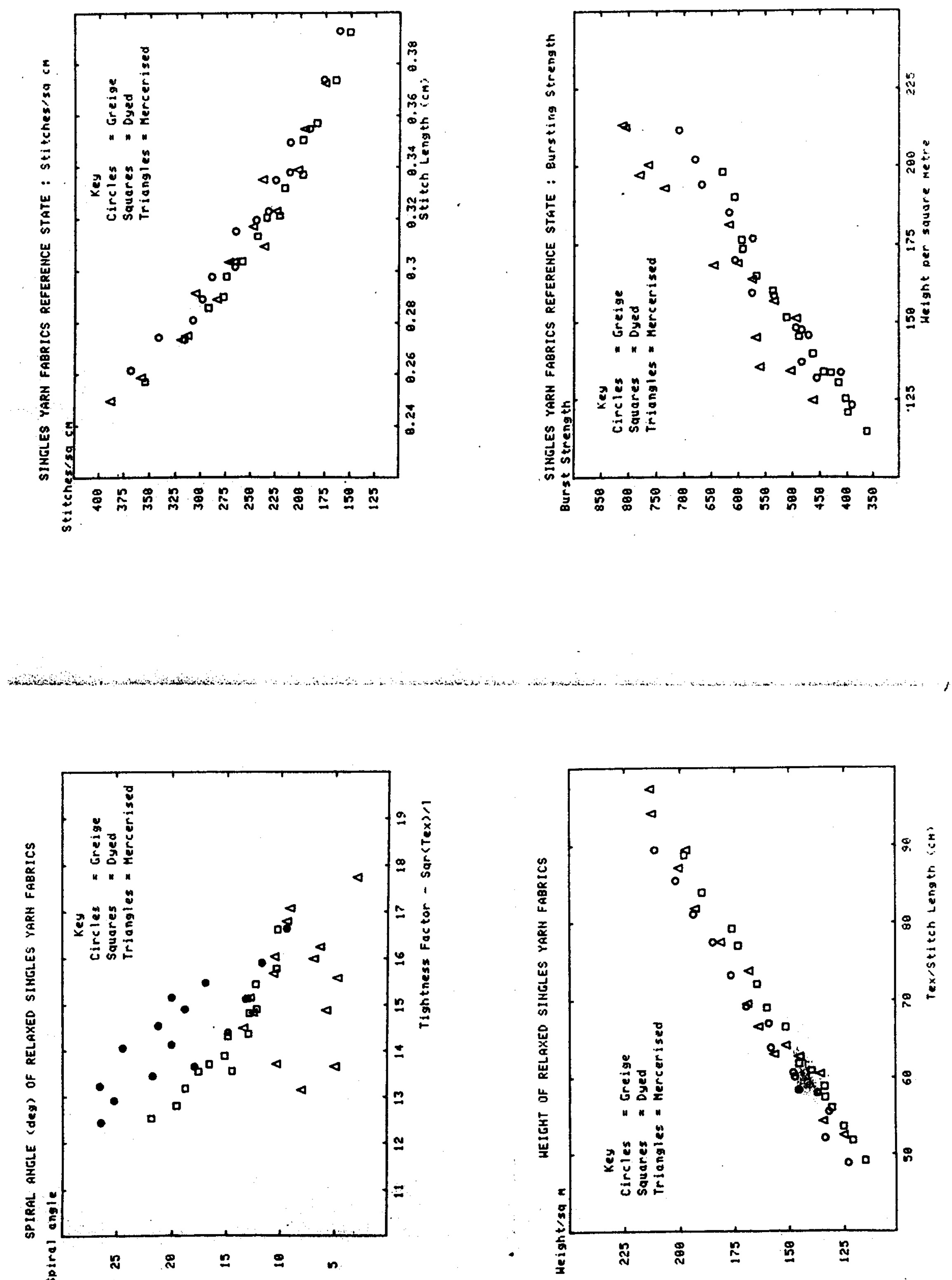
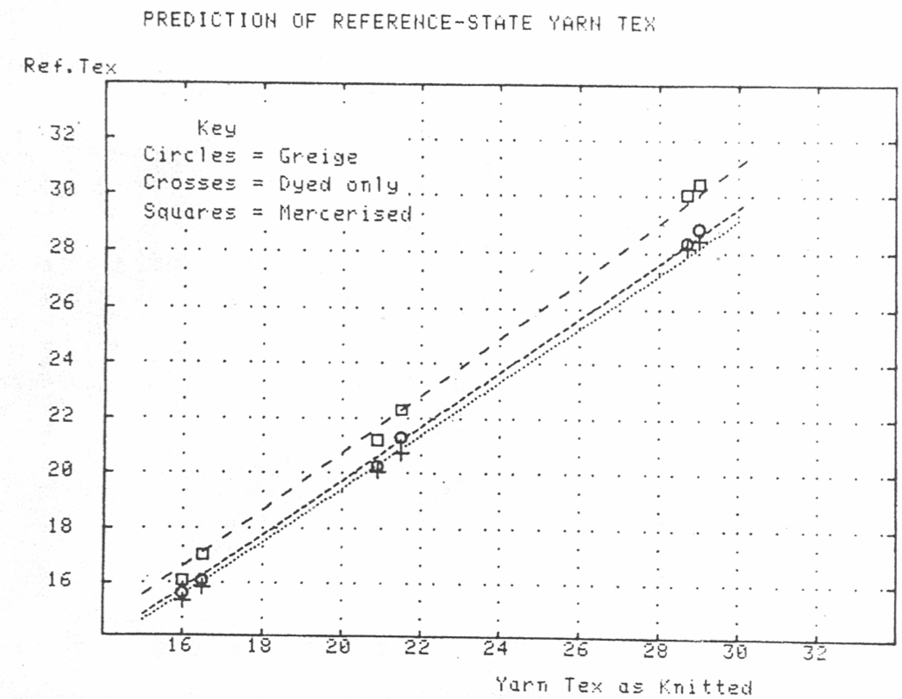

SINGLES YARN FABRICS REFERENCE STATE : Stitches/sq cm
Stitches/sq cm
Key
Circles = Greige
Squares = Dyed
Triangles = Mercerised
Stitch Length (cm)
SINGLES YARN FABRICS REFERENCE STATE : Bursting Strength
Burst Strength
Weight per square metre
SPIRAL ANGLE (deg) OF RELAXED SINGLES YARN FABRICS
Spiral angle
Tightness Factor - Sqr(Tex)/l
WEIGHT OF RELAXED SINGLES YARN FABRICS
Weight/sq m
Tex/Stitch Length (cm)

Figure 5


PREDICTION OF REFERENCE-STATE YARN TEX
Ref.Tex
Key
Circles = Greige
Crosses = Dyed only
Squares = Mercerised
32
30
28
26
24
22
20
18
16
16
18
20
22
24
26
28
30
32
Yarn Tex as Knitted

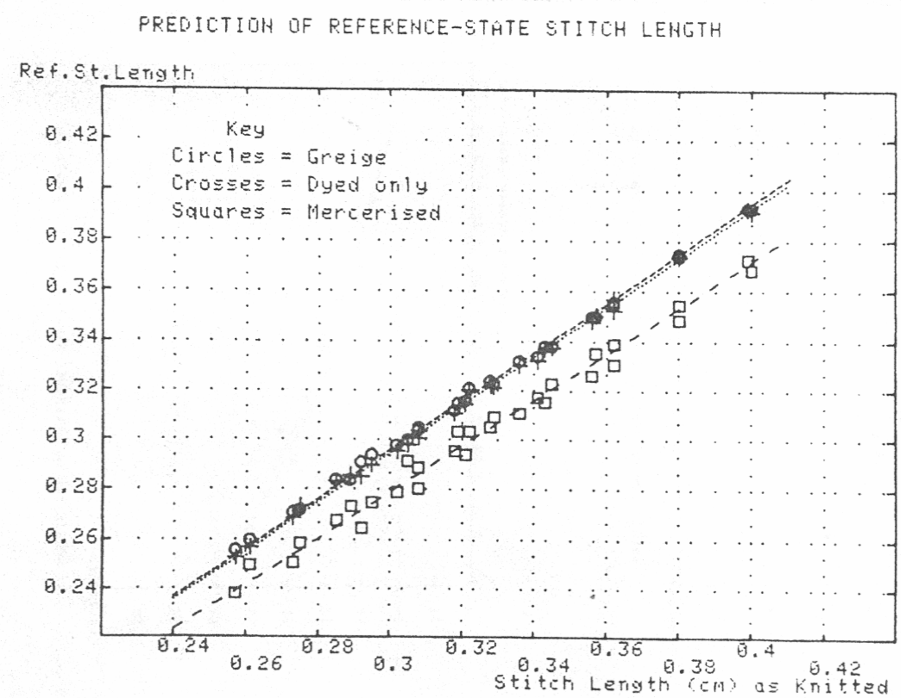

PREDICTION OF REFERENCE-STATE STITCH LENGTH
Ref.St.Length
Key
Circles = Greige
Crosses = Dyed only
Squares = Mercerised
0.42
0.4
0.38
0.36
0.34
0.32
0.3
0.28
0.26
0.24
0.24
0.26
0.28
0.3
0.32
0.34
0.36
0.38
0.4
0.42
Stitch Length (cm) as Knitted

Figure 6

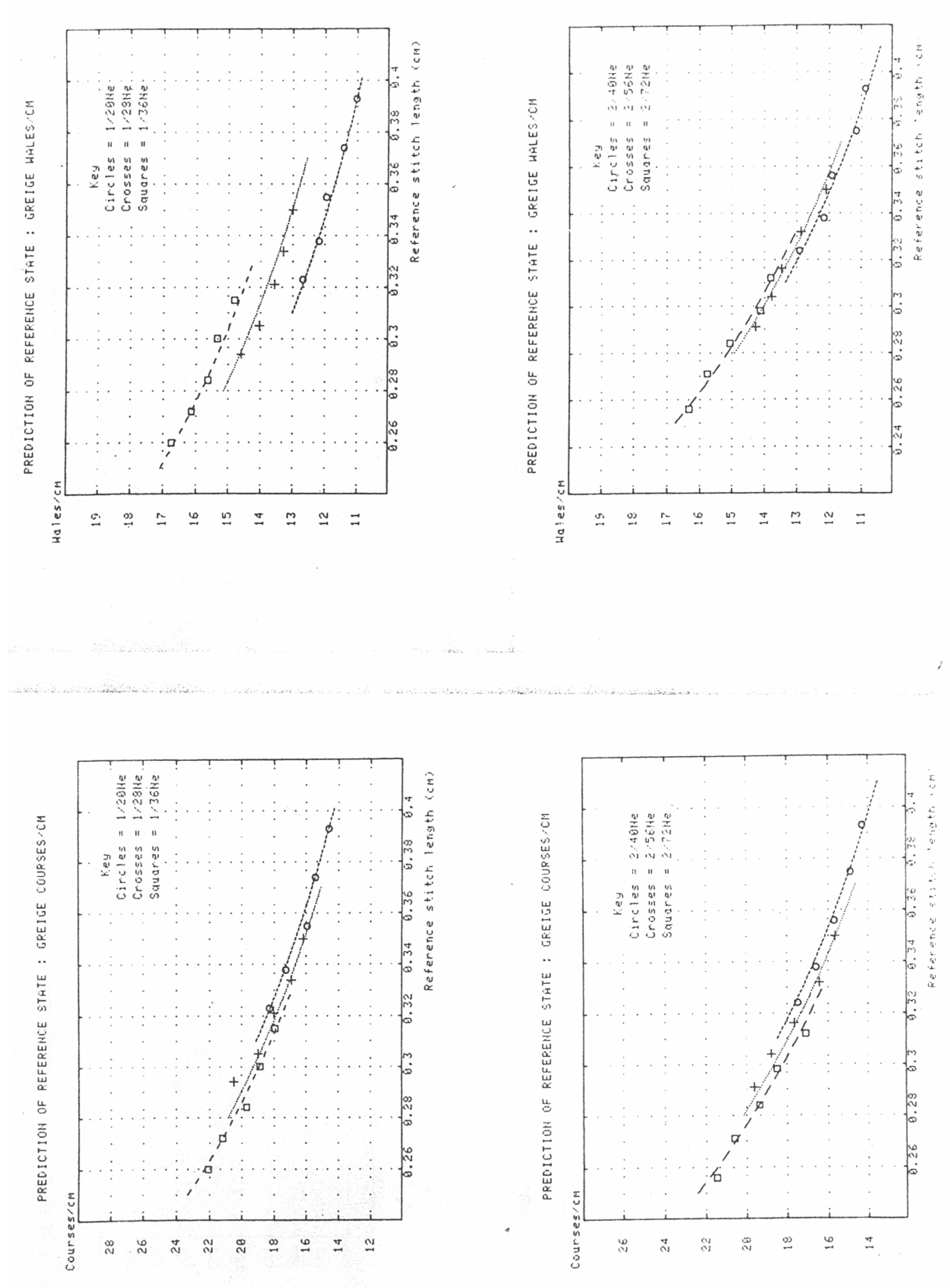
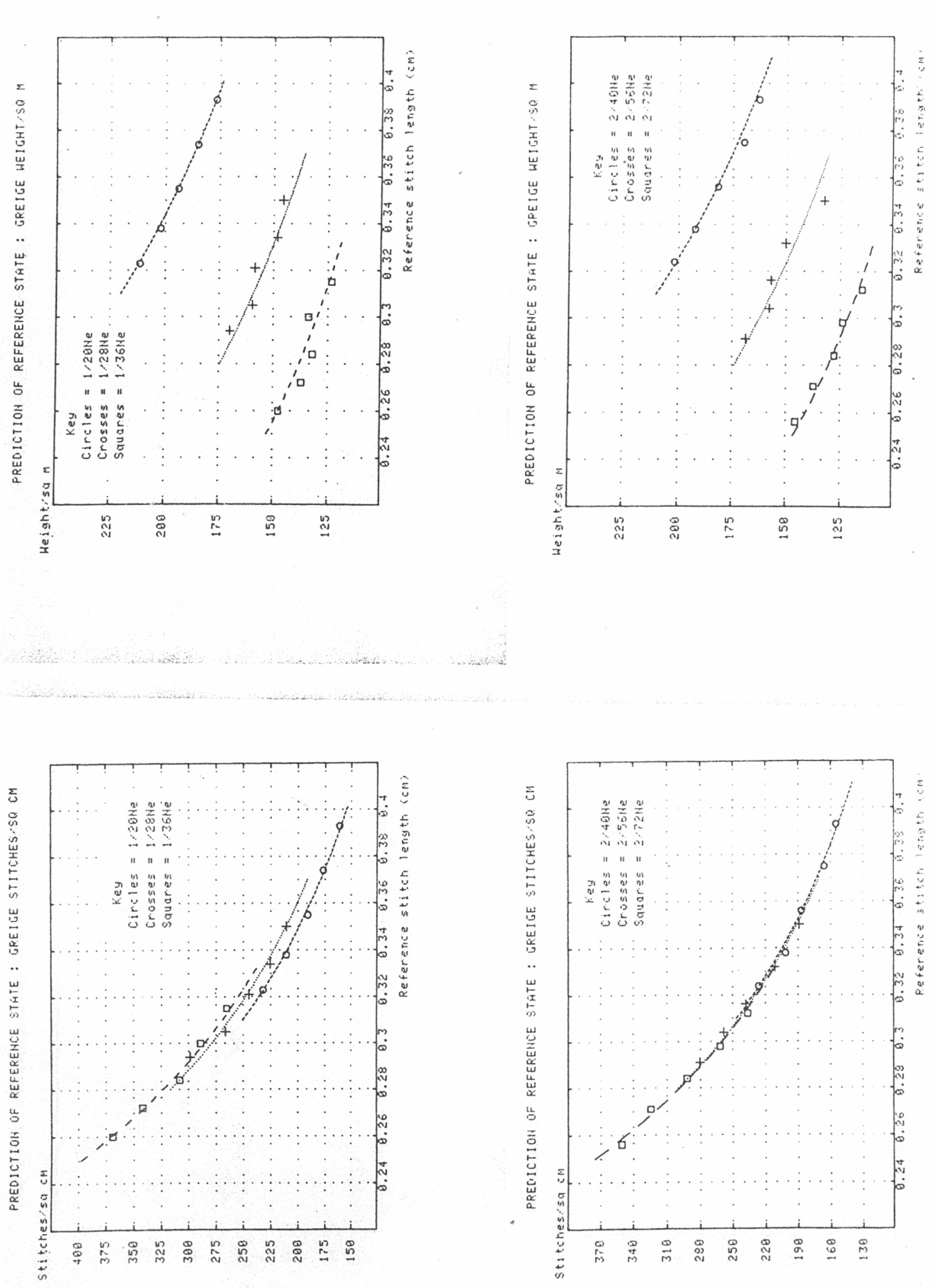

PREDICTION OF REFERENCE STATE : GREIGE WALES/CM
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
Wales/cm
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : GREIGE WALES/CM
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne
Wales/cm
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : GREIGE COURSES/CM
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
Courses/cm
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : GREIGE COURSES/CM
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne
Courses/cm
Reference stitch length (cm)

Figure 7



PREDICTION OF REFERENCE STATE : GREIGE WEIGHT/SQ M
Weight/sq m
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : GREIGE WEIGHT/SQ M
Weight/sq m
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : GREIGE STITCHES/SQ CM
Stitches/sq cm
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : GREIGE STITCHES/SQ CM
Stitches/sq cm
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne
Reference stitch length (cm)

Figure 8

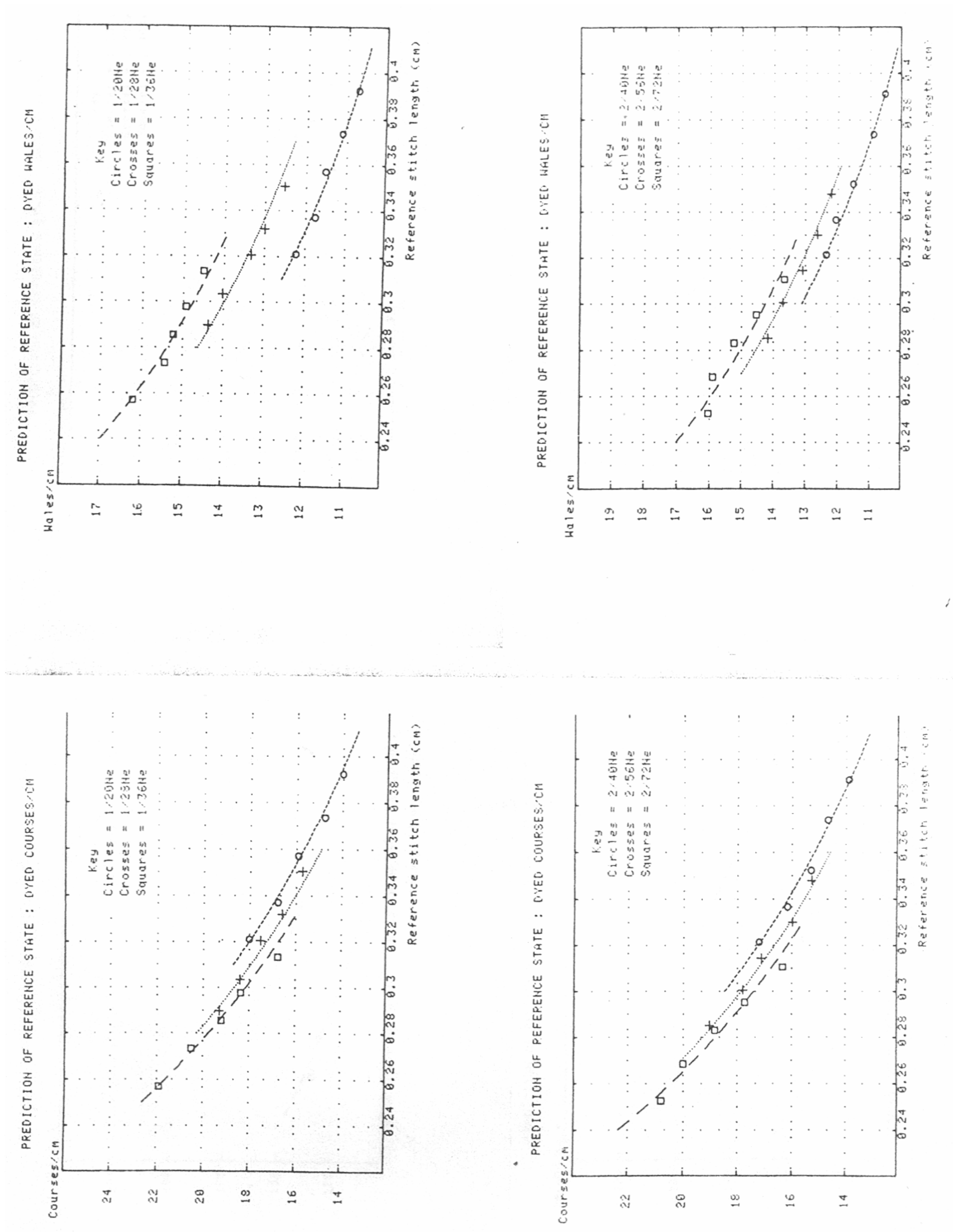
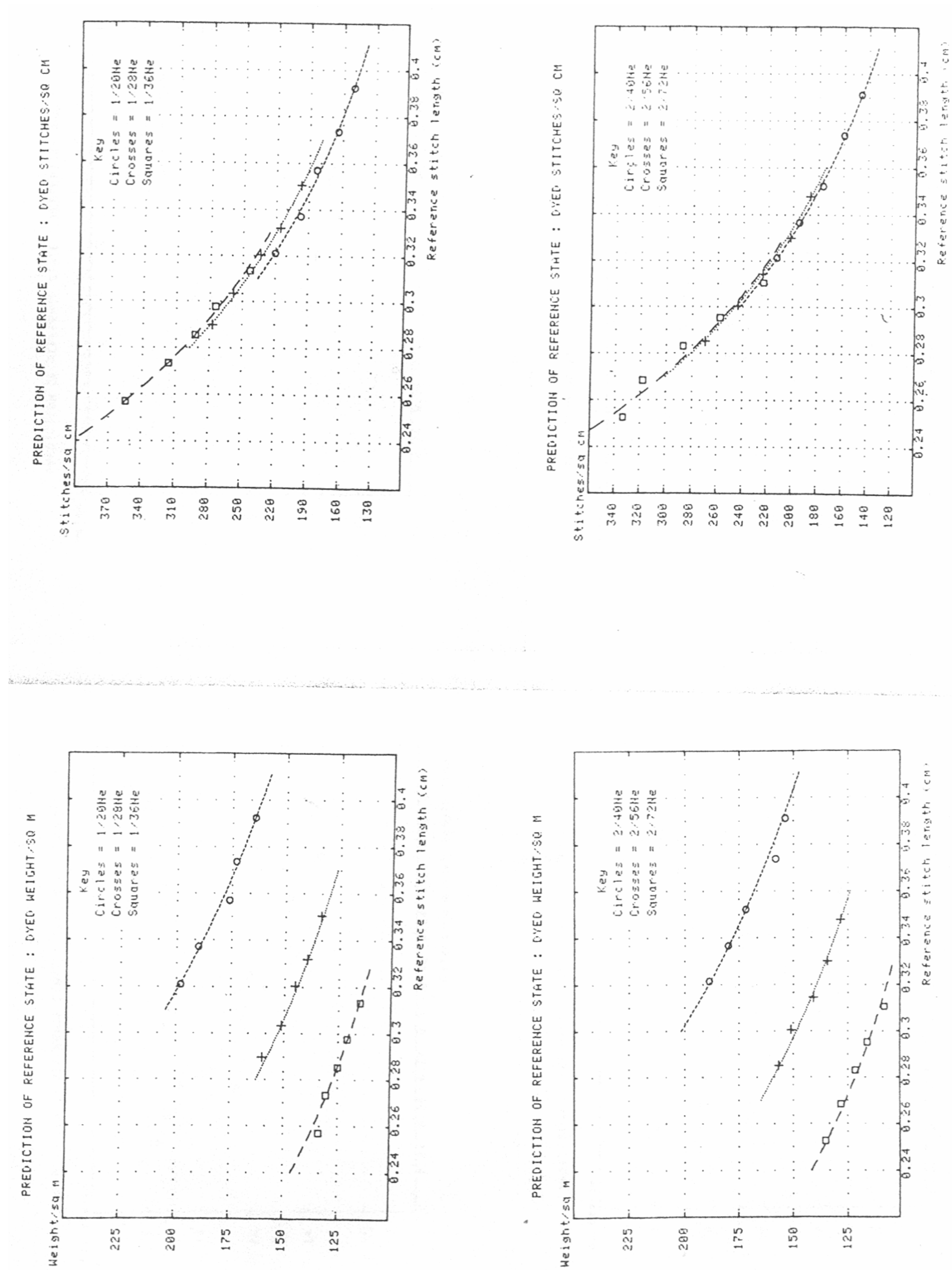
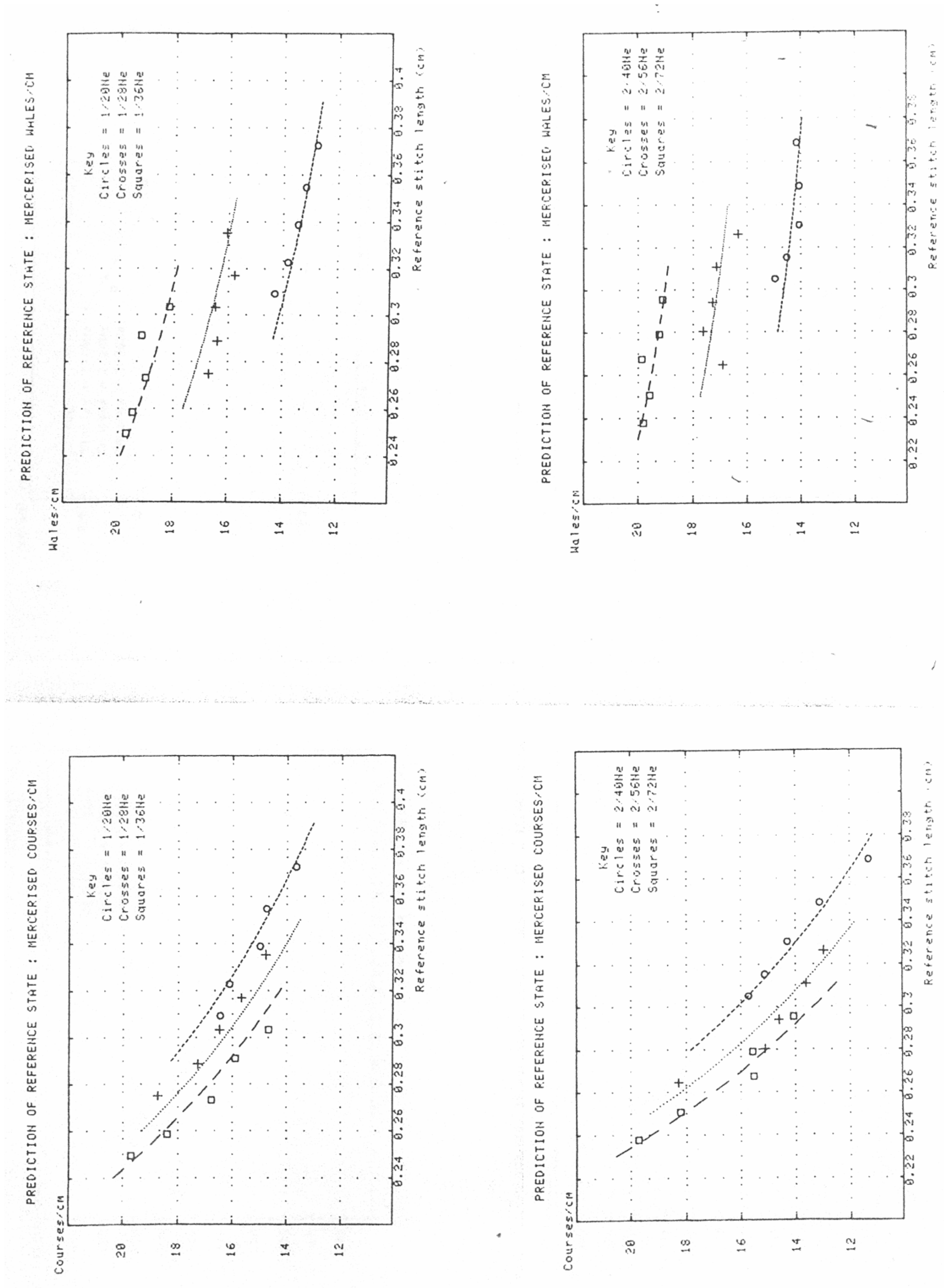

PREDICTION OF REFERENCE STATE : DYED WALES/CM
Wales/cm
Reference stitch length (cm)
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
PREDICTION OF REFERENCE STATE : DYED WALES/CM
Wales/cm
Reference stitch length (cm)
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne
PREDICTION OF REFERENCE STATE : DYED COURSES/CM
Courses/cm
Reference stitch length (cm)
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
PREDICTION OF PEFEPENCE STATE : DYED COURSES/CM
Courses/cm
Reference stitch length (cm)
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne

Figure 9



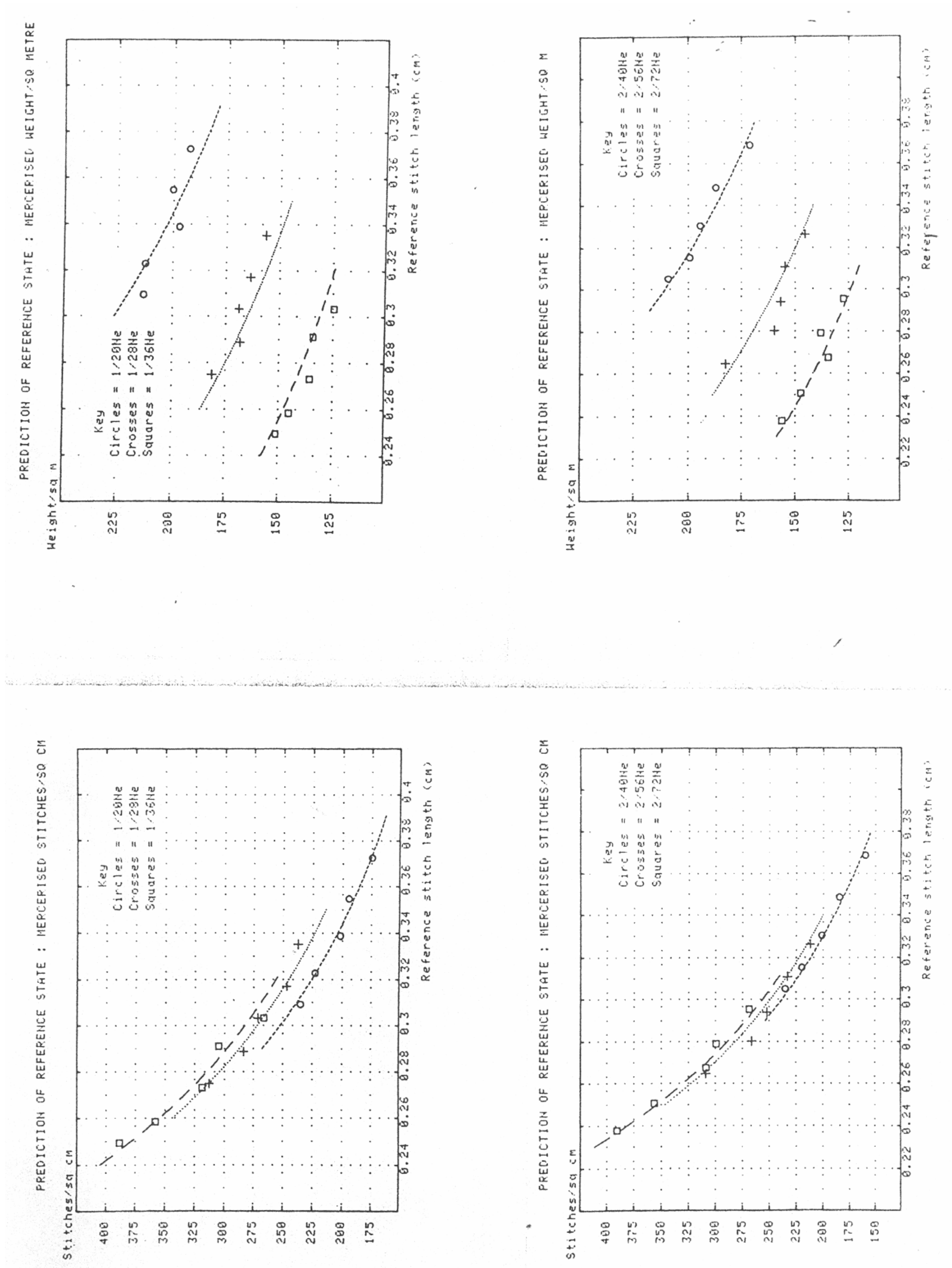
PREDICTION OF REFERENCE STATE : DYED STITCHES/SQ CM
Stitches/sq cm
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : DYED STITCHES/SQ CM
Stitches/sq cm
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : DYED WEIGHT/SQ M
Weight/sq m
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : DYED WEIGHT/SQ M
Weight/sq m
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne
Reference stitch length (cm)

Figure 10



PREDICTION OF REFERENCE STATE : MERCERISED WALES/CM
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
Wales/cm
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : MERCERISED WALES/CM
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne
Wales/cm
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : MERCERISED COURSES/CM
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
Courses/cm
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : MERCERISED COURSES/CM
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne
Courses/cm
Reference stitch length (cm)

Figure 11


PREDICTION OF REFERENCE STATE : MERCERISED WEIGHT/SQ METRE
Weight/sq m
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : MERCERISED WEIGHT/SQ M
Weight/sq m
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : MERCERISED STITCHES/SQ CM
Stitches/sq cm
Key
Circles = 1/20Ne
Crosses = 1/28Ne
Squares = 1/36Ne
Reference stitch length (cm)
PREDICTION OF REFERENCE STATE : MERCERISED STITCHES/SQ CM
Stitches/sq cm
Key
Circles = 2/40Ne
Crosses = 2/56Ne
Squares = 2/72Ne
Reference stitch length (cm)