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International Institute For Cotton

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Project K1 & Spirality Trial

The Influence Of Yarn Count, Twist And Machine Gauge Upon The Dimensional Properties Of Single Jersey Fabrics

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Contents

1. Introduction

In *Research Record No. 130* the fabrics produced for the projects Kl and K2 were assessed in the grey fully-relaxed state as a preliminary to the analysis of the finished fabric results. This firstly enabled general trends and relationships indicated by earlier studies to be established and, secondly, allowed a closer examination of certain other important areas of interaction, which had not previously been assessed, *i.e.*

1. The effect of twist and twist direction on spirality and relaxed dimensions
2. The effect of machine gauge.
3. The effect of using singles or two-fold yarns

From the assessment of the grey relaxed fabrics certain general conclusions were made.

1. The general trends (*i.e.* interaction of yarn count and stitch length and their effect on relaxed dimensions) established in earlier studies were reconfirmed.
2. Yarn twist factor, and the mixing of yarns of opposite twist in a fabric can affect the fully relaxed dimensions, other than spirality.
3. The fully relaxed dimensions of similar fabrics knitted from singles and two-fold yarns may be different.
4. The possibility of an independent effect of machine gauge on relaxed dimensions can not be discounted on the evidence of the grey relaxed dimensions alone.

Previous experience, particularly with the interlock and rib fabrics of Project CP78, has shown that the fully-relaxed dimensions of finished fabrics are different from their grey relaxed dimensions and that the individual finishing route can also independently affect the fully relaxed structure. Consequently, before the detailed mathematical analysis of the results of Projects Kl and K2 is carried out, it is useful to look at the various interactions of count, gauge, finish etc. in more general terms. On the one hand to establish whether single jersey fabrics are similarly affected by, for example, finishing route, as interlock and rib, but also, if possible, to clarify, confirm, or negate, in terms of finished fabrics, the conclusions drawn from the assessment of grey relaxed fabrics, as this may assist the more detailed analysis which is to follow. To do this, a series of assessments is being carried out which will each look at certain specific aspects of the results. The object of this report is to look in particular at:

- the influence of yarn twist and twist direction on dimensional properties, and
- the influence of machine gauge on dimensional properties, with reference to the fabrics produced for Project K1, including the supplementary spirality trial, through both tubular and open-width finishing.

As the details of the fabric production and processing have been reported previously, these will not be included.

2. Results

The results of this general analysis are presented as a series of graphs which show the main dimensional properties, courses, wales, weight, spirality and thickness, plotted against the main structural parameters or some function of them *viz*. reciprocal stitch length (*1/l*), Tex/stitch length ratio (*Tex/l*), tightness factor ($\sqrt{Tex}/l$), and the square root of Tex ($\sqrt{Tex}$).

All of the data included relate to the “fully relaxed” fabric, *i.e.* relaxed by the IIC standard procedure: 1 wash and tumble-dry cycle, followed by 4 rinse and tumble-dry cycles.

Tex is the average Tex for the particular finishing route averaged over stitch length.

Mean weight is the average, for the particular finishing route, of the β-gauge measurement and the value calculated from courses, wales, Tex and stitch length.

3. Influence Of Machine Gauge

The overall knitting plan for Kl allowed for 15 fabric constructions (3 yarns x 5 stitch lengths) to be knitted on each of 3 gauges of machine for singles yarns, and the equivalent number using the same stitch lengths and resultant counts in two-fold yarns. Included in the plan, to allow for an investigation of gauge influence, four of the yarns (2 singles and their two-fold equivalents) were duplicated on two gauges of machine. These were:

Ne 1/24 & Ne 2/48 on 18G and 24G, and

Ne 1/32 & Ne 2/64 on 24G and 28G

A full set of all the fabrics was processed through two “standard” finishing routes:

1) Jet dye in a Thies R-Jet 95, tubular finish R-95
2) Jet dye in a Thies RotoStream, open-width finish RS-OW.

The graphs applicable to this discussion are arranged in sets according to finishing route. In each case, the first two graphs illustrate the overall general behaviour of the full 90 fabrics with the 45 singles and 45 two-fold yarns treated separately. These are followed by the detail of the gauge interaction.

3.1. Courses (*Figures 1-10*)

Finish RS-OW (*Figures 1-5*)

Figures 1 and 2 illustrate the same general relationship for both singles and two-fold yarn, *i.e.* relaxed courses increase proportionally to the reciprocal of stitch length. The spread in the data would, however, suggest that an additional independent influence, probably of yarn tex or yarn diameter, is present. *Figure 3* illustrates the particular areas of overlap between the gauges, singles and two-fold shown together. *Figures 4 and 5* treat them separately.

There is a suggestion of a gauge effect between the 1/24's on 18G and 1/24's on 24G; four out of five points for 18G lie below the 24G results. This, however, is not repeated in the behaviour of the 1/32's on 24G and 28G or the two-fold yarns.

Finish R-95 (*Figures 6-10*)

A similar picture emerges from *Figures 6-10* for the tubular finished fabrics. There is evidence to suggest a yarn count/diameter influence and also a difference between single and two-fold yarn, but an independent effect of gauge is not apparent.

3.2. Wales (*Figures 11-20*)

Finish RS-OW (*Figures 11-15*)

Figures 11 and 12 show a similar overall relationship between wales and *1/l* for both singles and two-fold yarns and there is evidence to support an additional yarn count/diameter influence. Also, it appears that two-fold yarns produce fewer wales in the fabric than singles yarns.

Figure 14 illustrates the gauge interaction for singles yarns. It does not indicate a gauge effect but clearly illustrates a tex effect.

Figure 15 showing two-fold yarns, however, does pose a slight contradiction. The 2/48's on 18G lie below the 2/48's on 24G which would seem to indicate a gauge influence but, again, this trend is not repeated by the behaviour of the 2/64's on 24G and 28G between which there is no obvious influence of machine gauge.

Finish R-95 (*Figures 16-20*)

For singles and two-fold yarns the same general trends apply and the two-fold yarns again tend to produce fewer wales than singles yarns (*Figure 18*).

In *Figure 19*, however, there is perhaps some evidence to suggest a gauge effect particularly between the 1/32's on 24G and 28G but, again, this trend is not repeated by the two-fold yarns.

3.3. Weight (*Figures 21-30*)

Finish RS-OW (*Figures 21-25*)

The same general trend applies to both singles and two-fold yarns: fabric weight increases proportionally to the tex/stitch length ratio and, in addition, *Figure 23* indicates that fabric produced from two-fold yarn tends to be lighter than the equivalent produced from singles yarns.

However, while the singles yarns (*Figure 24*) do not show any evidence of a gauge effect, the behaviour of the 2/48's on 18G and 24G does suggest a possible influence. This is not repeated by 2/64's on 24G and 28G.

Finish R-95 (*Figures 26-30*)

The same overall trends emerge from the tubular finished fabrics but there is no evidence of a gauge effect in the individual graphs (*Figures 29-30*).

3.4. Spirality (*Figures 31-36*)

Finish RS-OW (*Figures 31-33*)

There is, of course, a big difference between spirality angles developed by singles and two-fold yarns. The singles yarns all spiral positively, the angle increasing as tightness factor decreases (stitch length increases) and the two-fold yarns spiral negatively with no obvious tightness influence.

Figure 33 indicates that there is no obvious gauge influence.

Finish R-95 (*Figures 34-36*)

The R-95 tubular finished fabrics follow a similar pattern to the RS-OW finished fabrics, with regard to the main differences between singles and two-fold yarn. However, there is a suggestion of a gauge effect between the 1/24's on 18G and 24G. The 18G fabrics tend to spiral slightly more than the 24G fabrics. Also, the 1/32's on 24G tend to spiral slightly more than 1/32's on 28G. There is no evidence of a gauge effect in the two-fold yarns.

3.5. Thickness (*Figures 37-52*)

This particular fabric property is perhaps one of the most difficult to measure reliably and reproducibly as the scatter in the data would seem to bear out. In addition, our test method for determining fabric thickness has not yet been fully evaluated and this may also be a contributing factor.

Nevertheless, on the basis of the data so far available, it is possible to make some observations.

Finish RS-OW (*Figures 37-44*)

The structural parameter which so far appears to have the most dominant influence on fabric thickness is yarn diameter, approximated by $\sqrt{Tex}$, with a secondary influence exerted by *1/l* (the combination of Tex and *1/l* as Tightness Factor $\sqrt{Tex}/l$ did not seem to reveal any obvious trends).

Generally, the fabric thickness increases with an increase in $\sqrt{Tex}$ and an increase in loop length, (reduction in *1/l*) Thus 18G 1/16's fabric are the thickest and 28G 1/40's are the thinnest. A similar trend applies to two-fold yarns but they produce considerably thinner fabrics than the equivalent singles yarns. It is, however, difficult to detect an effect of machine gauge.

Figures 42-44 show thickness plotted against *1/l* and although the difference between singles and two-fold yarns is clear, and ignoring the obviously stray data points, a gauge effect is not apparent.

Finish R-95 (*Figures 45-52*)

The behaviour of the fabrics through tubular finishing is not quite the same, however. There is a less steady progression of thickness increasing with yarn diameter than is shown through open-width finishing. In addition, there is a very marked difference between the 18G and 24G fabrics and to a lesser extent between the 24G and 28G fabrics. The two-fold fabrics are still, however, much thinner than the equivalent singles fabrics.

This trend is reconfirmed when thickness is plotted against *1/l*, where the gauge effect is predominant in the singles yarns and between the two-fold yarn on 18G and 24G, but less obvious between 24G and 28G.

Some retesting may be necessary to clarify what, on the face of it, appears to be an anomalous situation.

4. The Influence Of Yarn Twist And Twist Direction

The fabrics pertinent to this aspect of the discussion are those included in the spirality trial knitted from combinations of yarns having different twist factors and twist directions. The middle “standard” (3.5 twist factor Z twist) singles yarn count on each gauge of machine is used as control against which similar fabrics knitted from alternate ends of S and Z twist yarn of equivalent twist factor 3.5 are compared.

The examination of the influence of twist level is confined to 24G fabrics where fabrics knitted from 3.0 twist factor Z twist and 4.0 twist factor Z twist are compared with the standard 3.5 twist factor Z twist and the 3.5 twist factor S twist.

All the fabrics were processed through an open-width finishing route after dyeing in a Thies

RotoStream (RS-OW) and are therefore directly comparable with the RS-OW singles yarn fabrics discussed in the first section.

The first graph in each set shows all the variables together before the individual interactions are dealt with separately.

4.1. Courses (*Figures 53-55*)

Although all the fabrics follow the same general trend (courses increase proportionally to *1/l*) the first, most obvious effect of mixing yarns of opposite twist direction (S&Z) in a fabric is that they develop more courses than standard Z twist fabrics. The effect of twist level and twist direction in isolation however is not so clear. There is perhaps a tendency for the fabrics from 3.0 twist factor yarn to develop fewer courses but the differences are small and the other variations are difficult to distinguish.

4.2. Wales (*Figures 56-58*)

Similarly to courses, there is a marked difference between fabrics knitted from alternate ends of S & Z twist yarn and those knitted from all Z twist. There are consistently fewer wales developed in S&Z fabrics than in all Z. Also similarly to courses, the influence of individual twist levels is less easy to distinguish, although generally there tends to be fewer wales produced from 3.0 twist factor yarns and more from 4.0 twist factor yarns, with the 3.5 twist factor S or Z twist yarns falling together, in between.

4.3. Weight (*Figures 59-61*)

There does not appear to be any real difference between the Z twist and S&Z alternate twist fabrics - probably because the differences shown in courses and wales balance out. If there is any effect it is that the Z twist fabrics tend towards the heavy side of the data scatter. The effect of twist level is again unclear although perhaps there is a tendency for the 4.0 twist factor fabrics to be heavier, and the 3.0 twist factor fabrics lighter than the 3.5 twist factor fabrics of either twist direction.

4.4. Spirality (*Figures 62-64*)

Spirality is the one fabric property which is known to be affected by twist direction and by the mixing of alternate ends of S and Z twist yarns. The S&Z twist fabrics develop very low levels of positive spirality with no apparent influence of tightness while the S twist fabrics spiral in the opposite direction (shown as negative spirality in *Figures 62 and 64*). They do, however, develop spirality angles very similar in degree to Z twist fabrics and both are influenced by fabric tightness. The slacker the fabric (low tightness factor, longer stitch length) the higher the angle of spirality that is developed. Once again, however, the influence of twist level is less clear cut, although generally fabrics produced from 3.0 twist factor yarn tend to develop lower angles of spirality than fabrics from 3.5 twist factor yarn, and 4.0 twist factor yarns tend to develop higher levels of spirality.

4.5. Thickness (*Figures 65-70*)

Figures 65-67 show fabric thickness plotted against $\sqrt{Tex}$ but it is difficult to detect any effect of twist direction or twist level in these comparisons.

Figures 68-70 showing thickness against *1/l*, similarly do not show any clear trend. *Figure 69* perhaps shows a tendency for the S&Z fabrics towards thinner fabric but this is really hard to justify due to the scatter in the data. Similarly in *Figure 70* the S twist fabrics tend towards the thin side but again the scatter in the data makes a sensible judgement impossible.

5. Conclusions

5.1. Gauge Effect

In the introduction it was recalled as a conclusion from the report on the grey relaxed dimensions that "*the possibility of an independent effect of machine gauge on relaxed dimensions cannot be discounted on the evidence of the grey relaxed dimensions alone*", and a similar statement must also be made regarding the finished fabrics but qualified in terms of the existing analysis.

In most cases it is only one yarn out of four in each group which is showing any tendency to being influenced by machine gauge. With the exception of fabric thickness the differences are generally small and probably insignificant in practical terms. However, it is perhaps interesting to note that, of the cases where differences can be seen, the majority are between 18 and 24 gauge - the exceptions being wales and thickness. Could this perhaps be due to the size of the gauge change? For example, 24G is finer by 33% than 18G, but 28G is only finer by 16% than 24G (a gauge fineness factor?).

In terms of spirality and thickness the influence may be a combination of finishing route/gauge effect rather than just gauge. The biggest differences are found in thickness through R-95 tubular finish while there does not appear to be any through the RS-OW open-width process. However, here again this must be qualified due to a certain amount of insecurity in the data.

With regard to the further, more detailed statistical analysis it may be justified to ignore, in the first instance, the possibility of a gauge influence on the grounds of the importance of establishing the major relationships and the overall scatter in the data. Moreover, the influence of gauge, if indeed there is one, is probably insignificant in practical terms. However, I feel it should not be totally discounted until at least some more detailed analysis is carried out.

Other points which have emerged which are not the main concern of this report are:

1. Fabrics made from two-fold yarns have different relaxed dimensions from fabrics made from singles yarns, *i.e.* fewer courses, fewer wales, lighter, thinner, and negative spirality.
2. Similarly to the interlock and rib fabrics, a further *Tex* term is probably required to completely explain/predict the changes in courses and wales.
3. With the exception of thickness, which obviously requires further study, there does not appear, in general terms, to be any major differences between the relaxed dimensions of open-width and tubular finished fabrics.

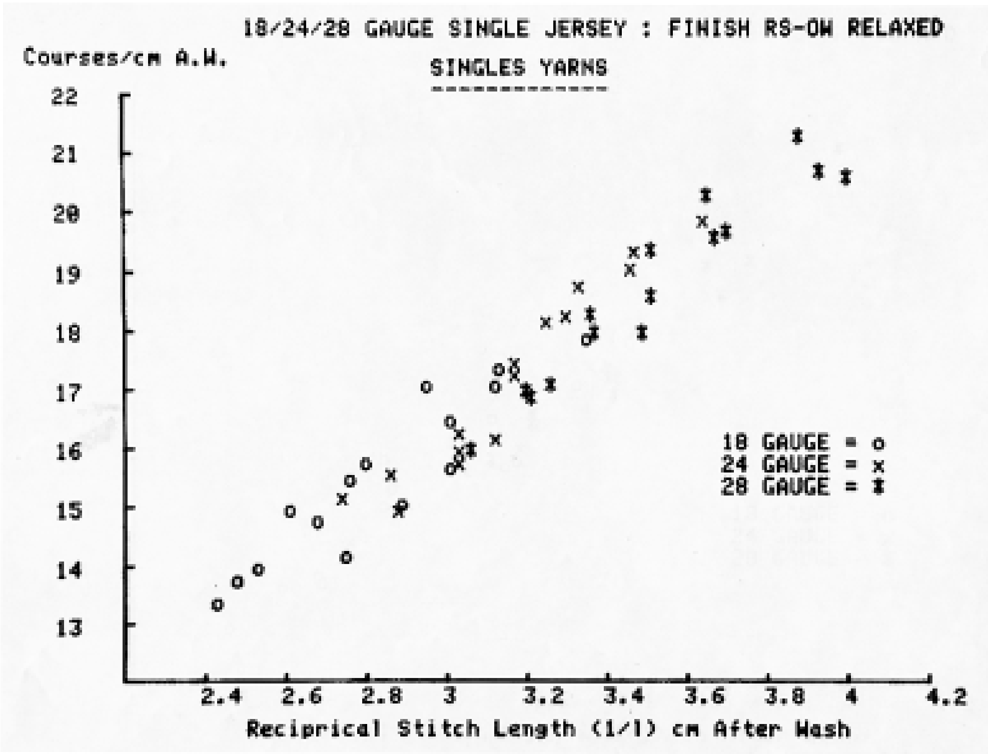
5.2. Effect of Twist

1. There is a definite and large effect on most of the relaxed dimensions of mixing alternate ends of S and Z twist yarns - courses, wales and spirality in particular. Weight is unclear

as the differences in courses and wales appear to balance out.

2. The use of S twist yarn changes the direction of spirality in the fabric but does not significantly alter the magnitude of the angles developed compared to standard Z twist yarn.
3. The effect of twist level cannot be conclusively identified, with the possible exception of spirality, due to the scatter in the data and the small size of the differences when they do appear. Any effect will, no doubt, be resolved after more detailed analysis but, as stated, the differences are small and in the main are probably insignificant in practical terms.

Figure 1



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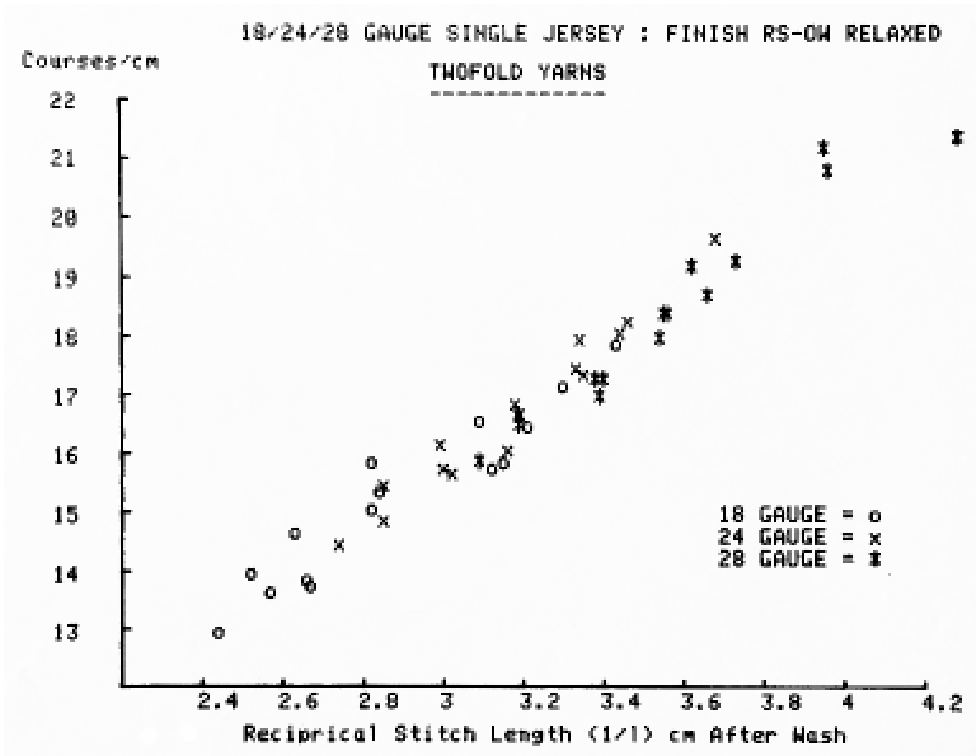

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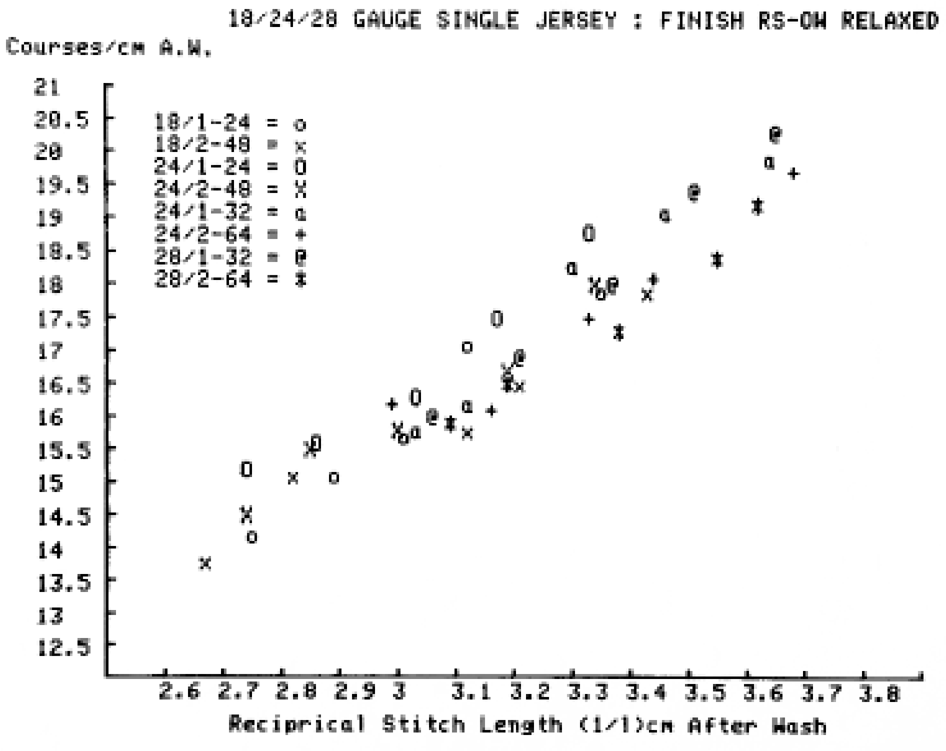

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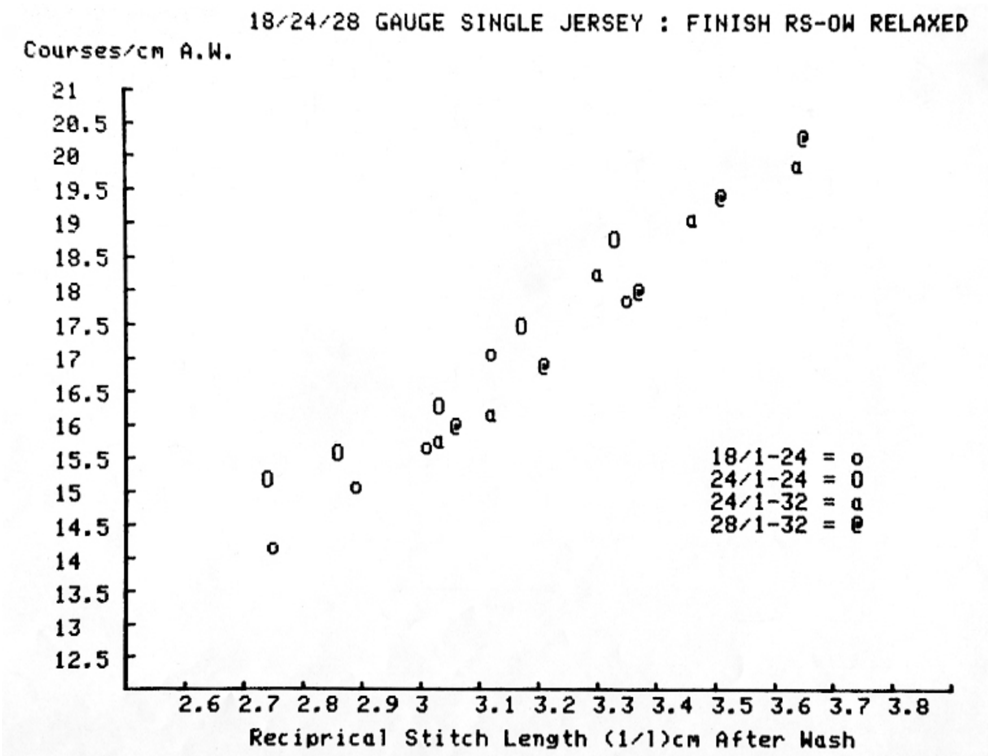

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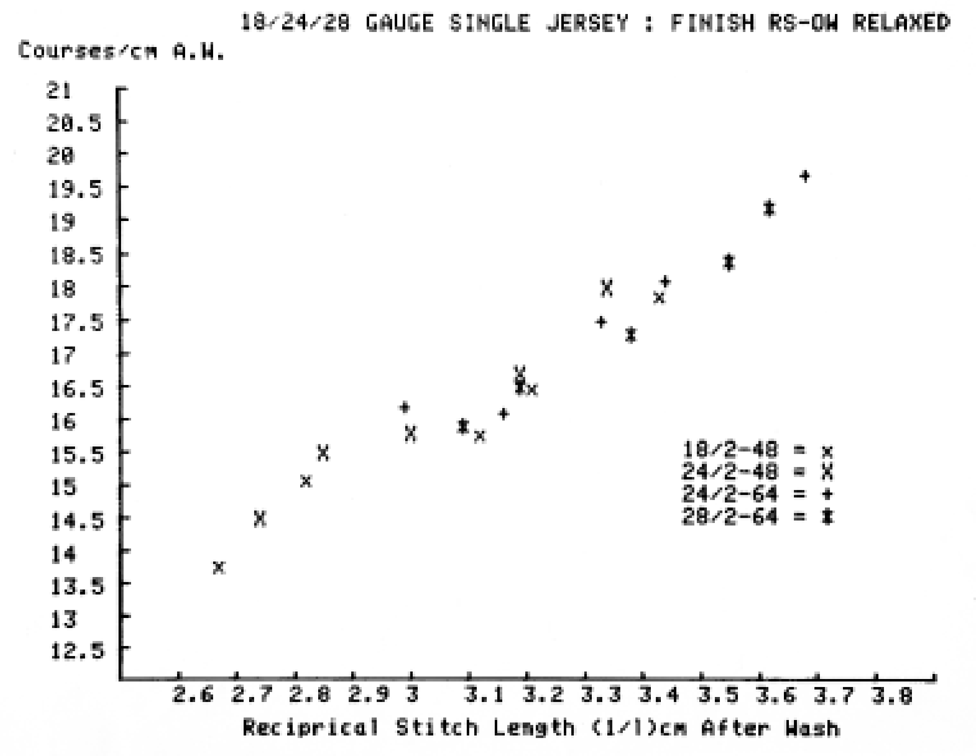

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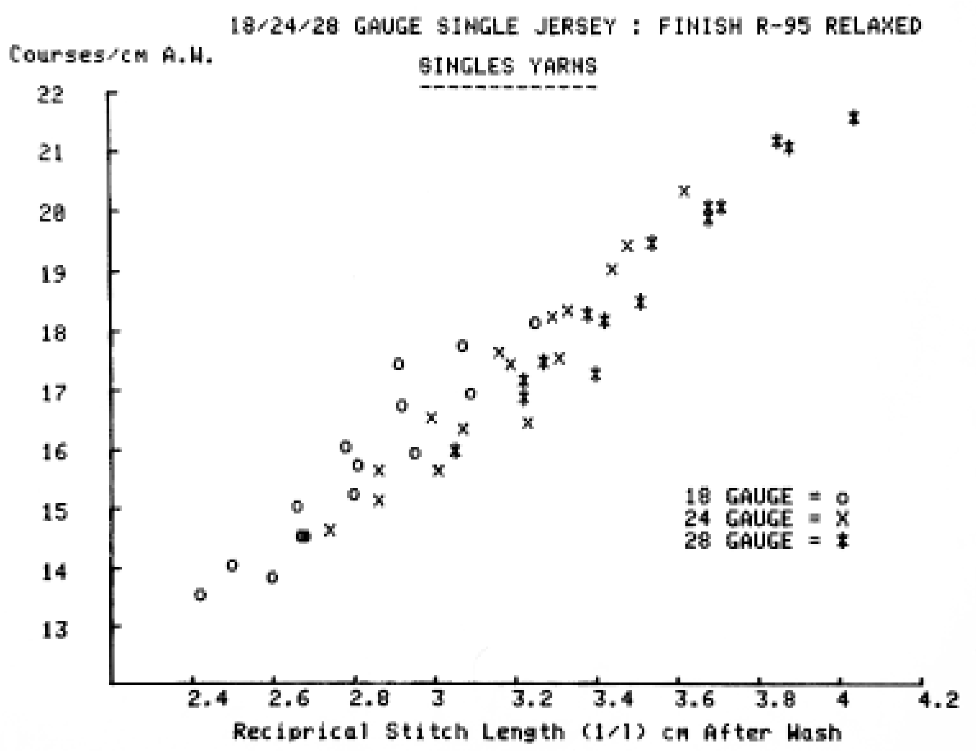

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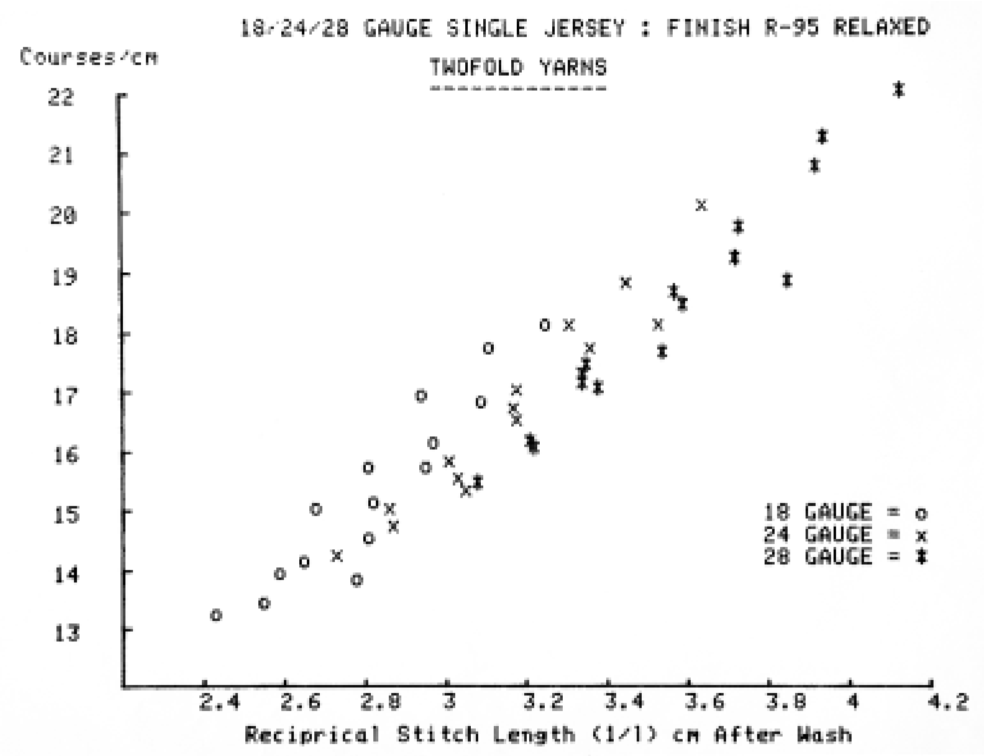

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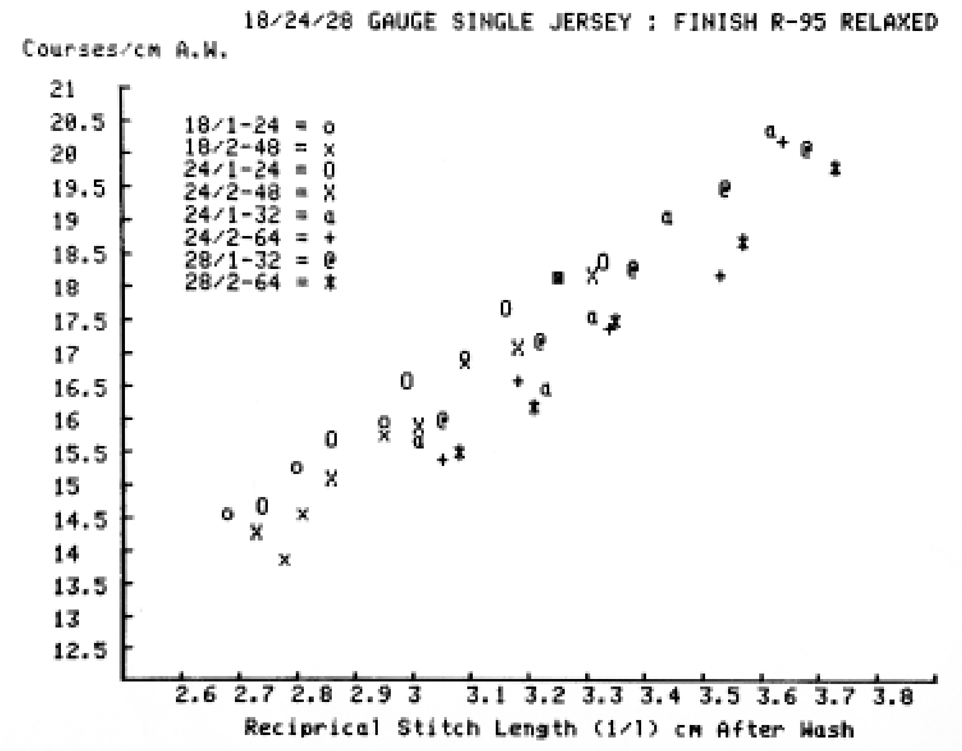

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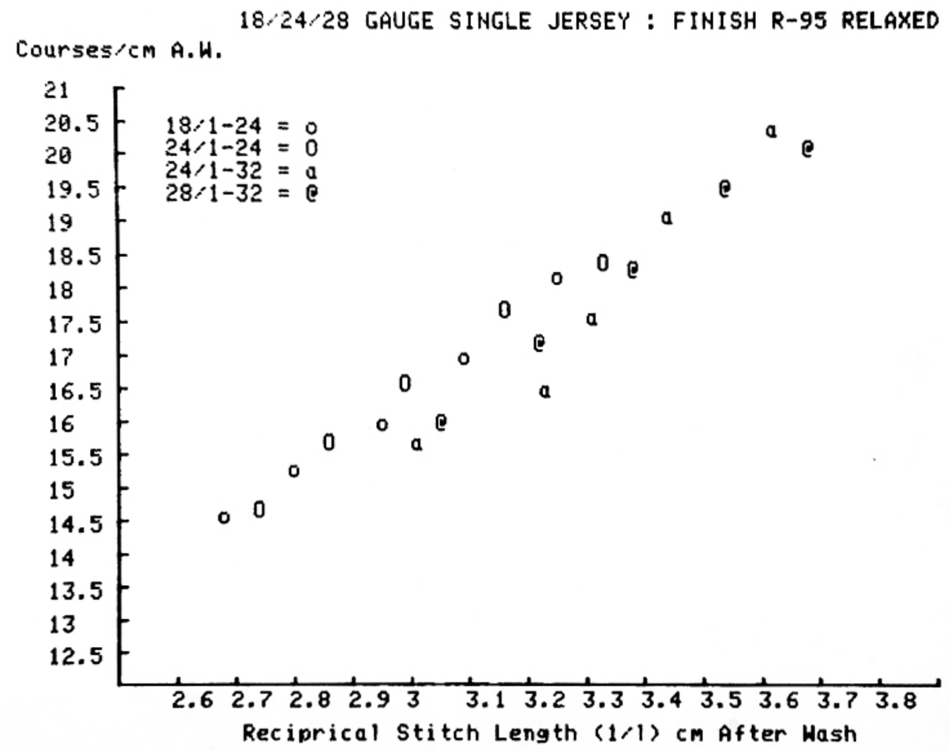

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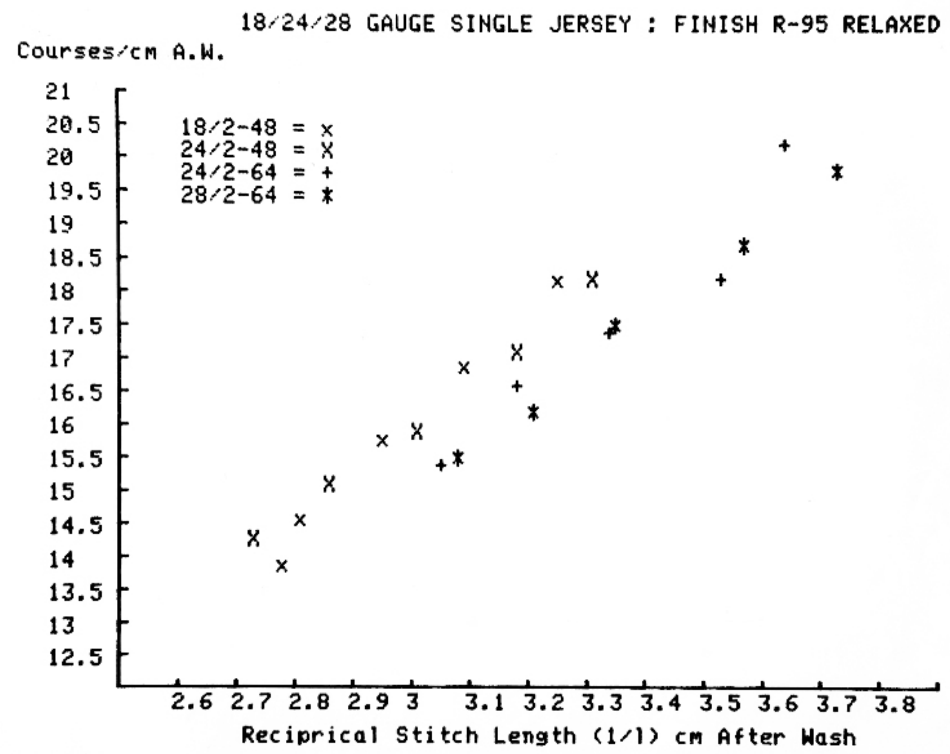

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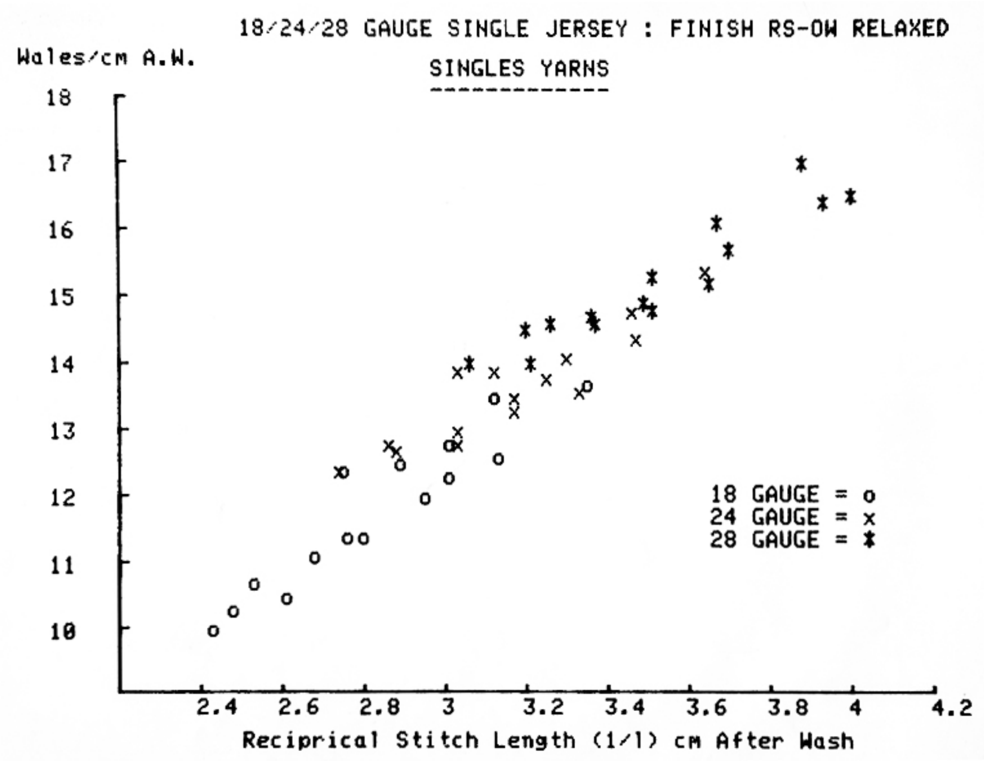

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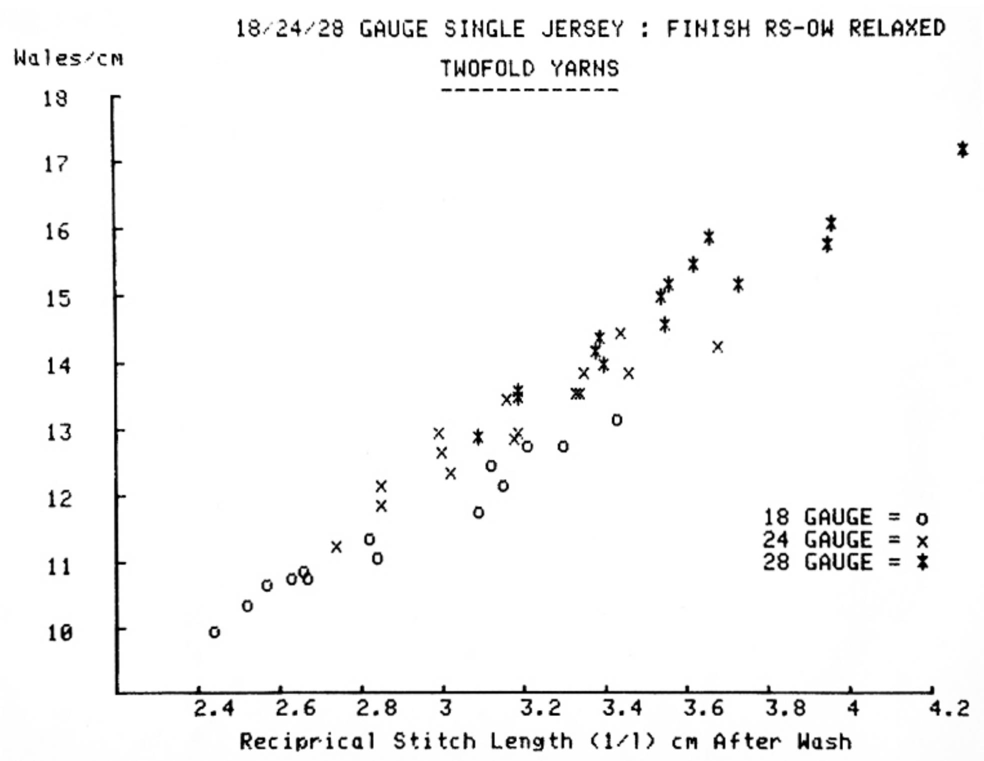

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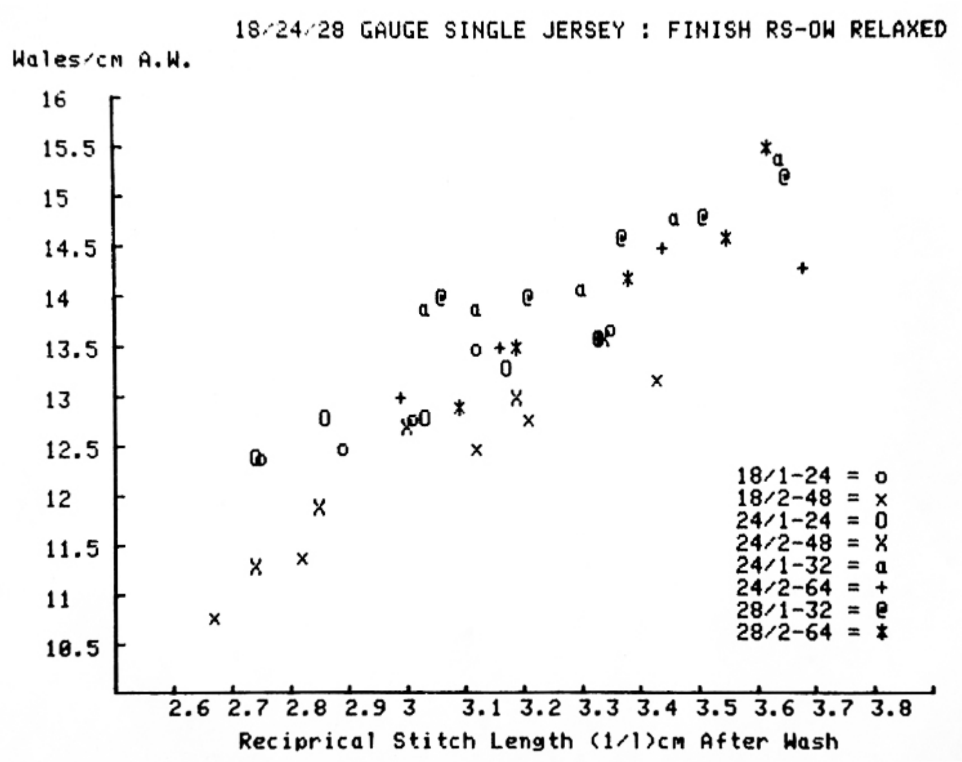

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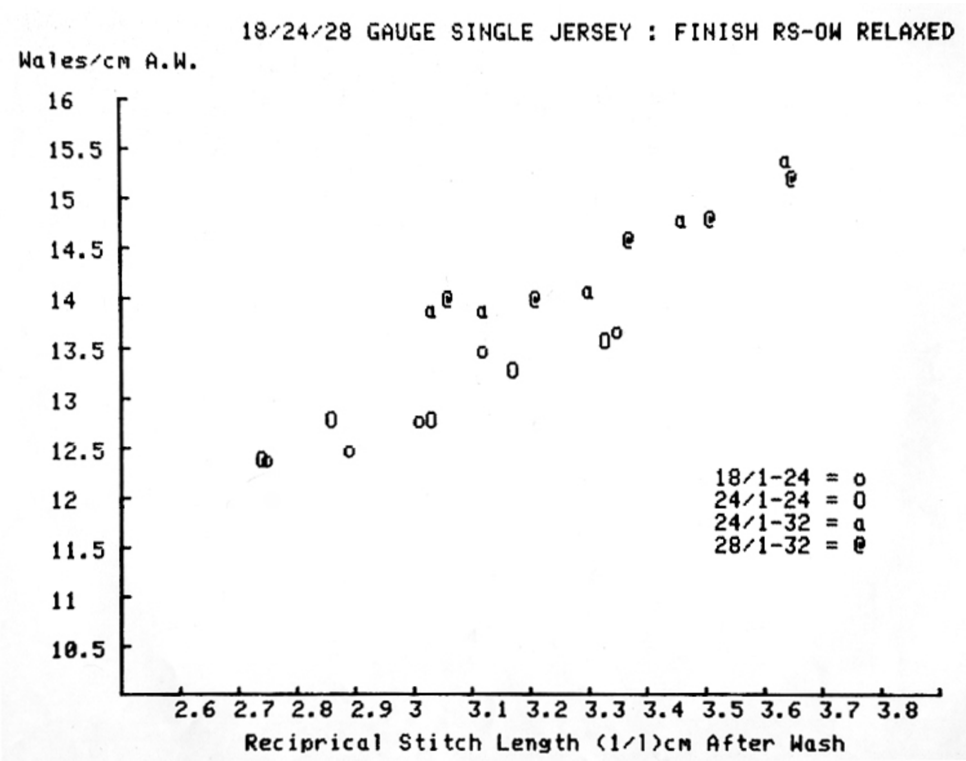

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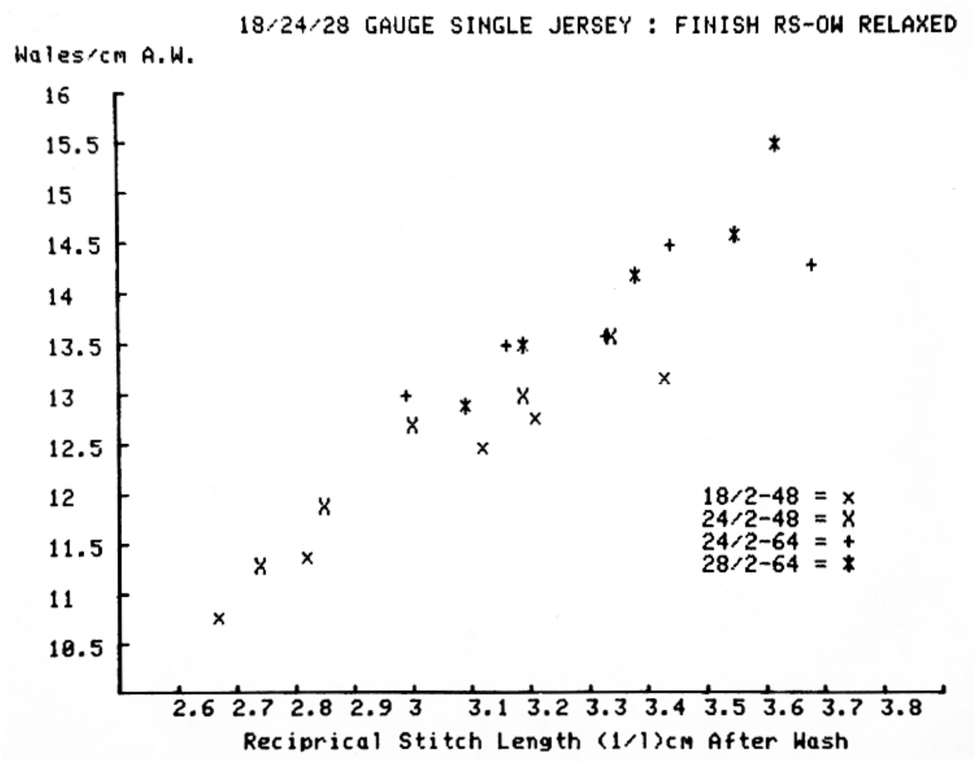

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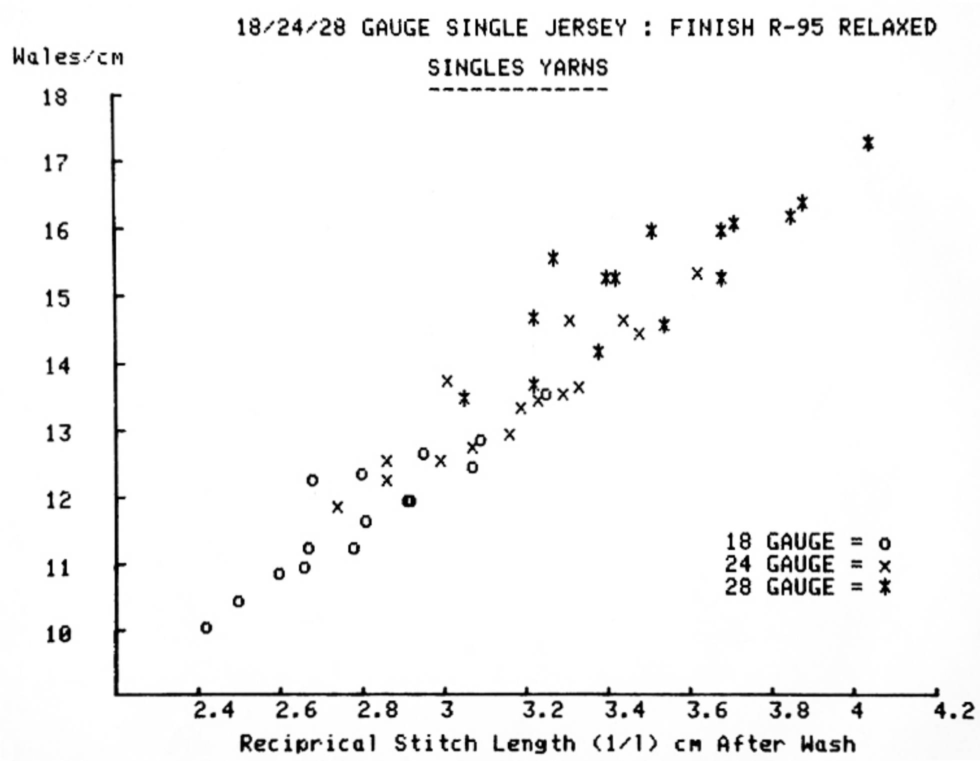

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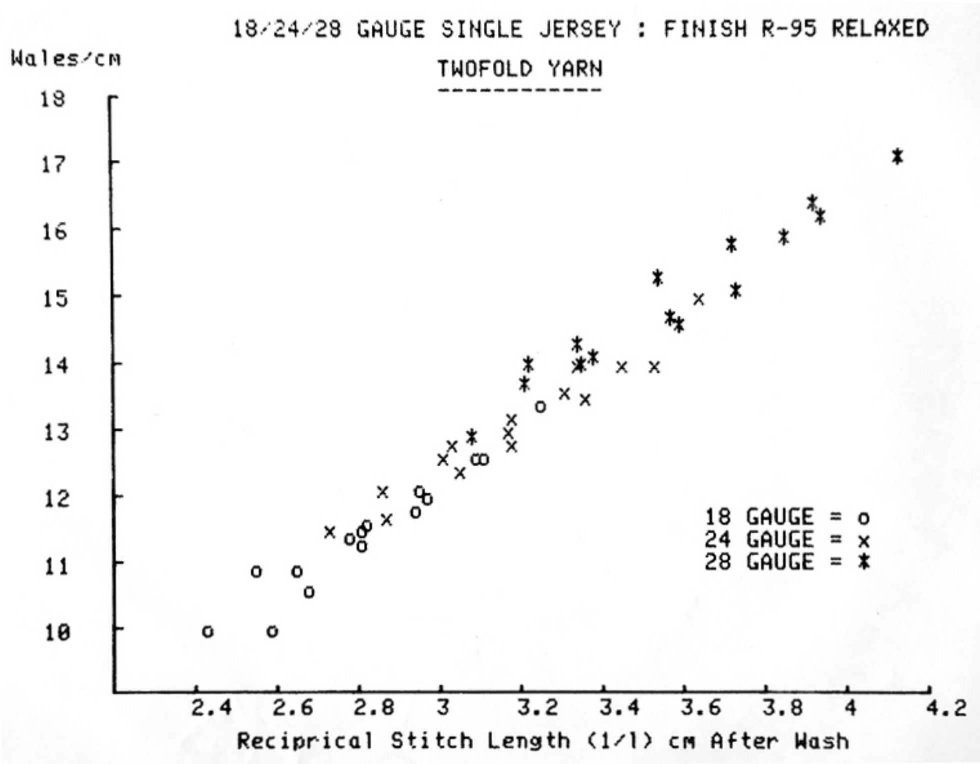

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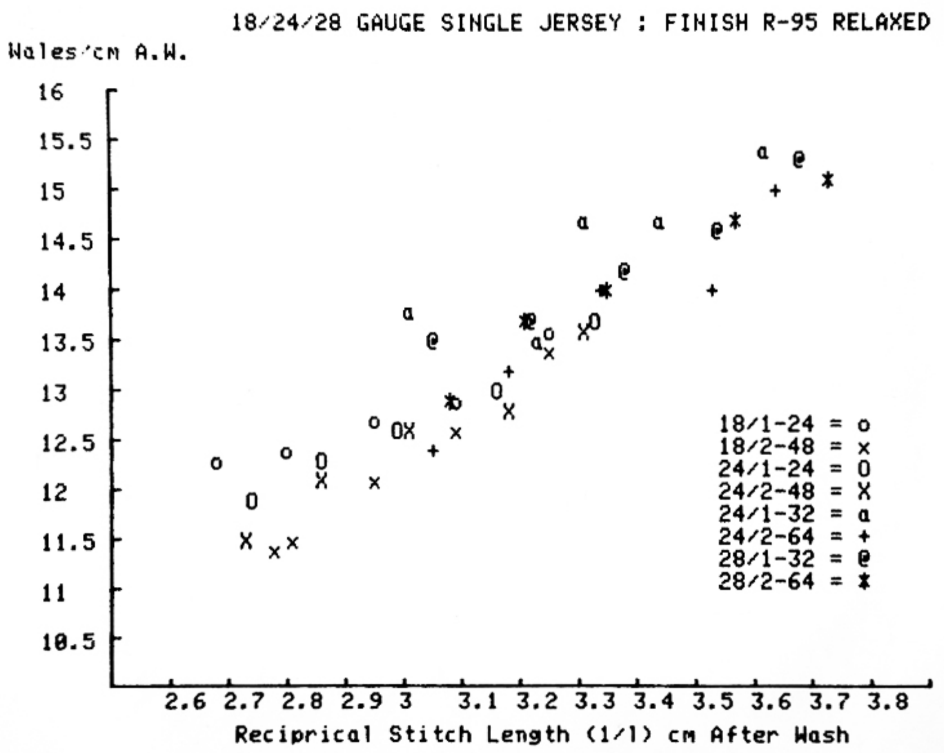

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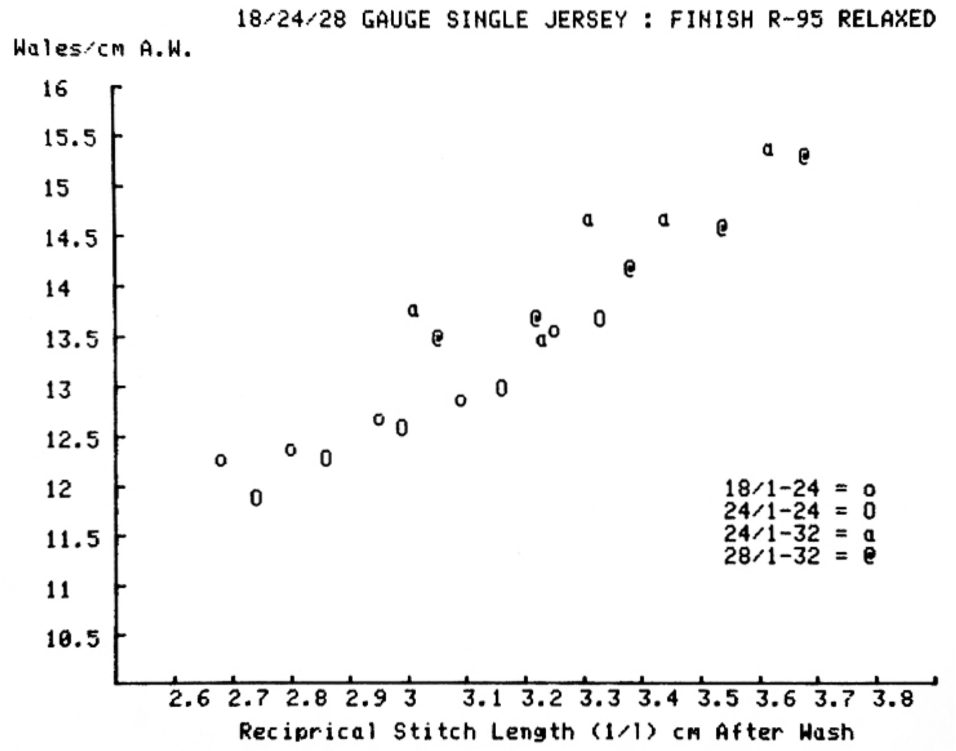

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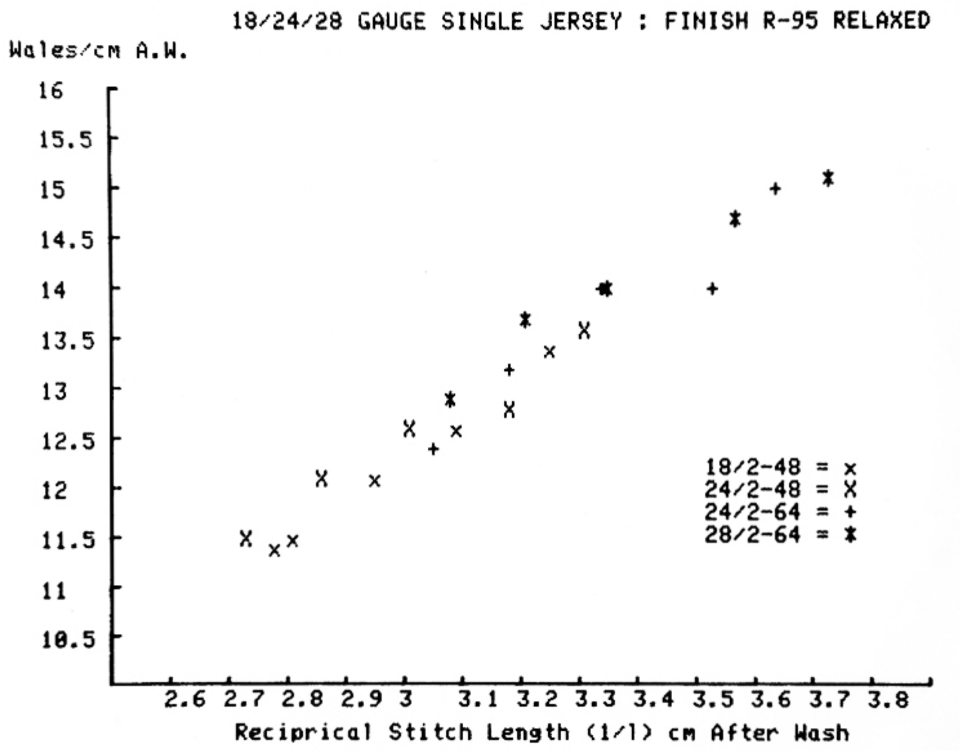

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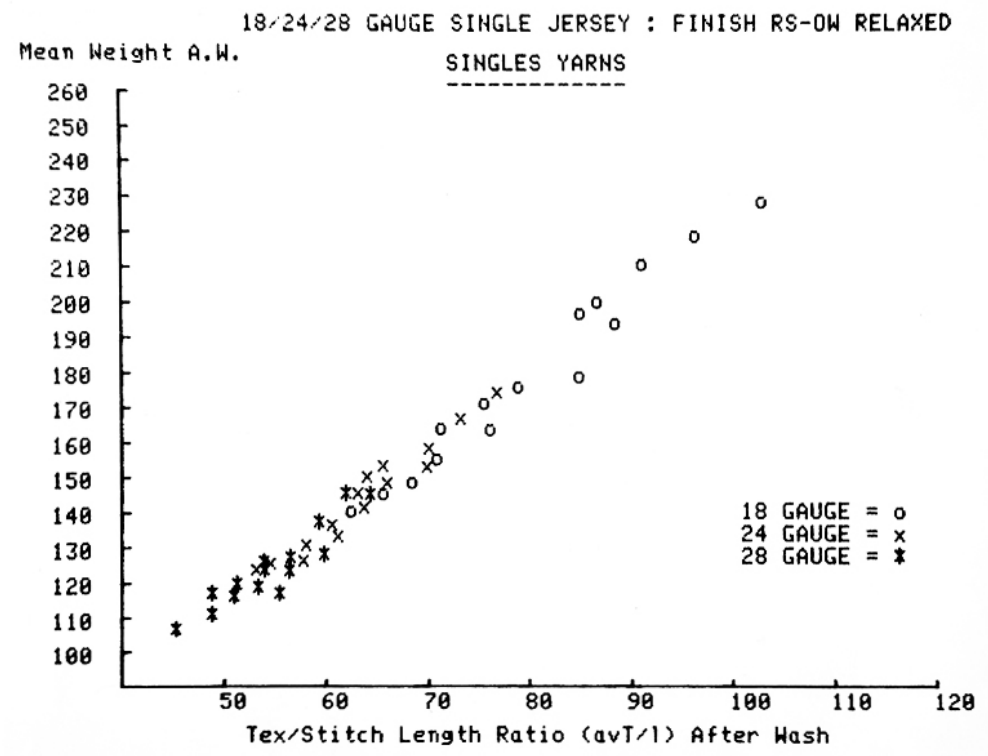

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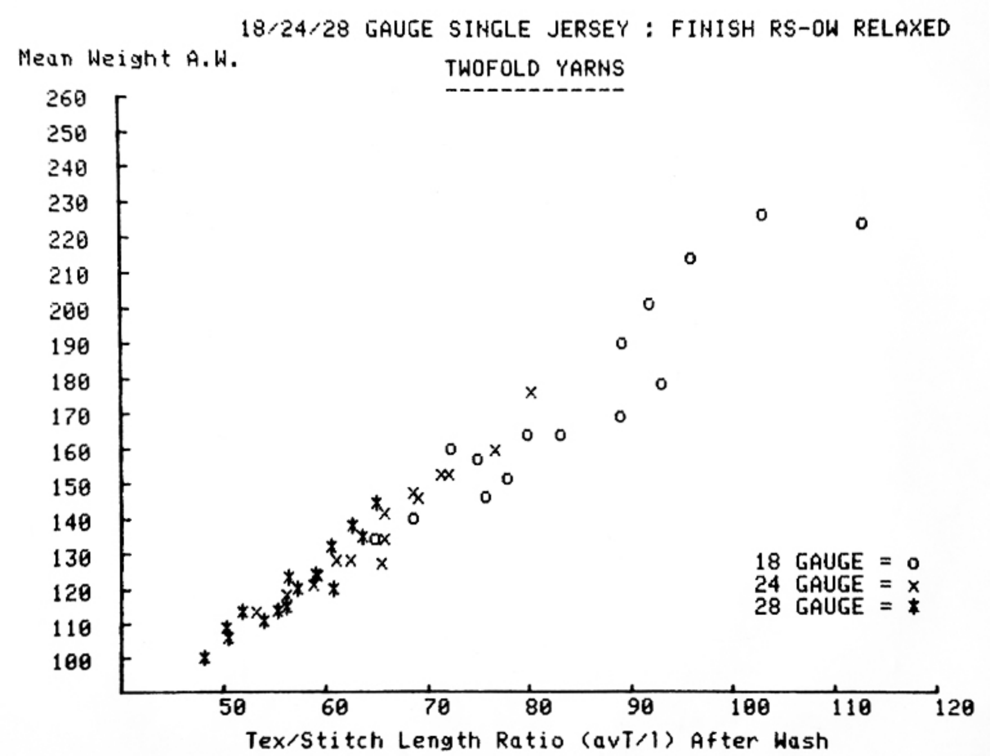

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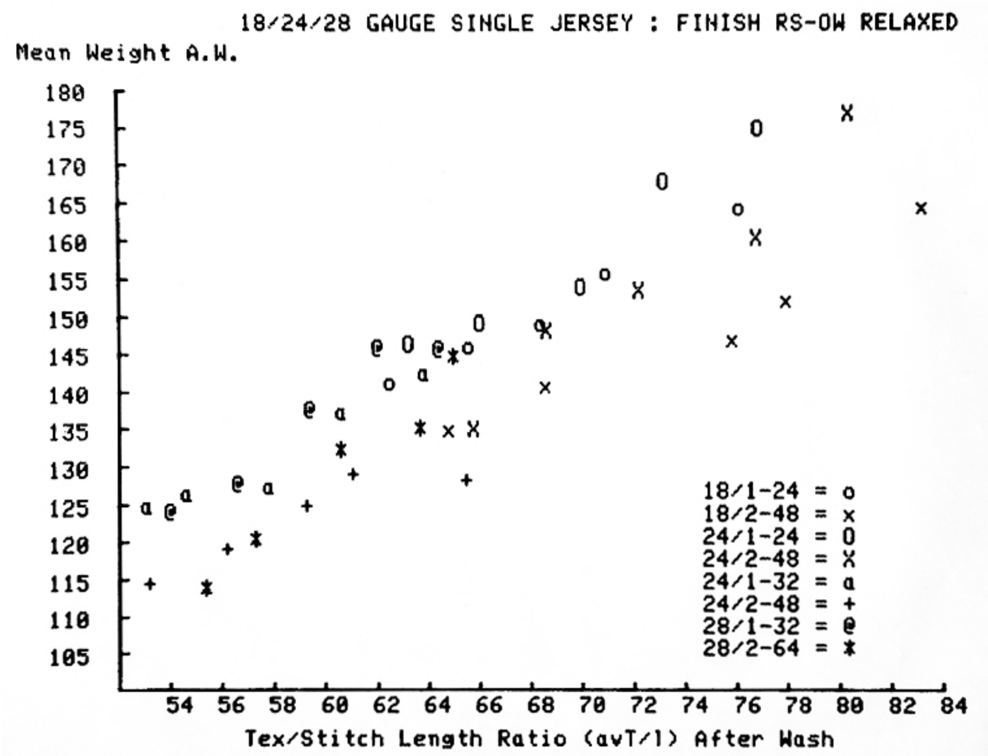

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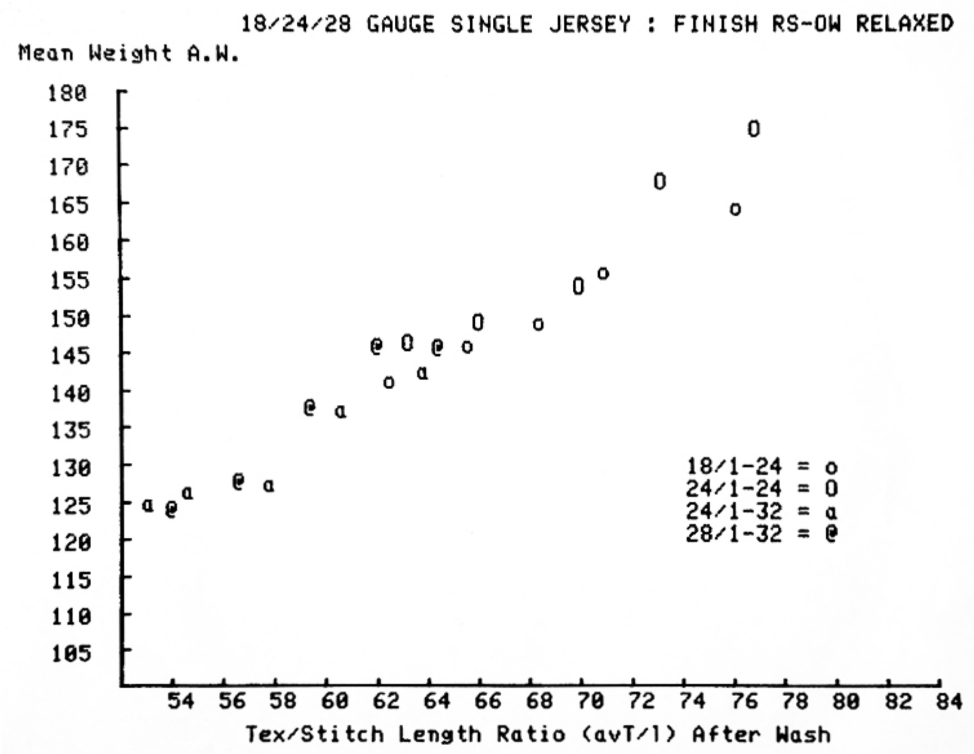

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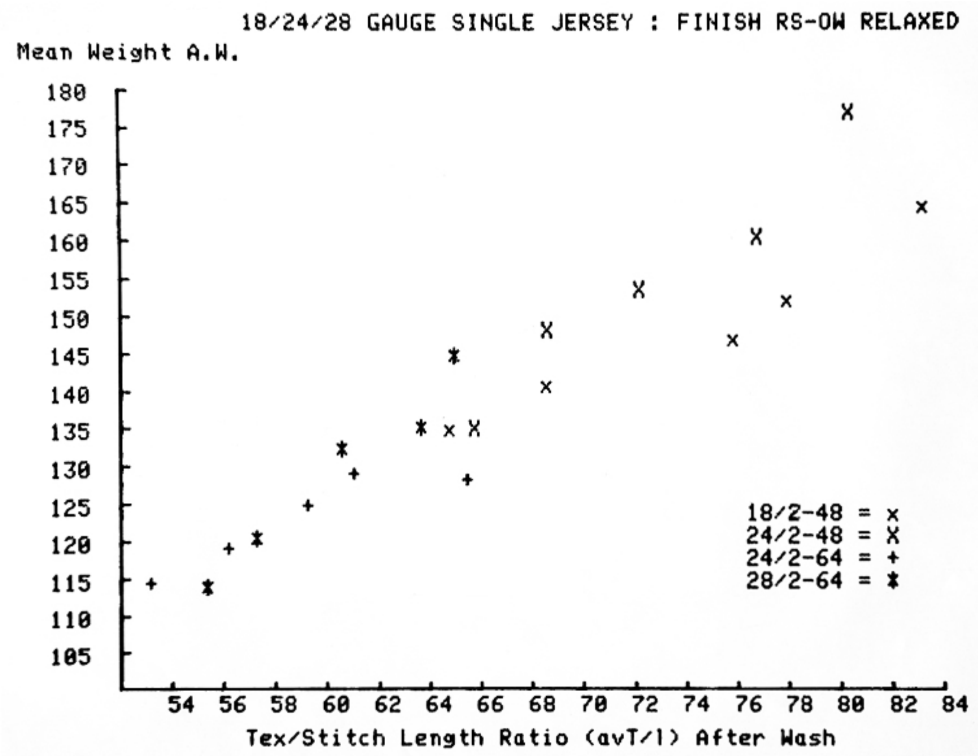

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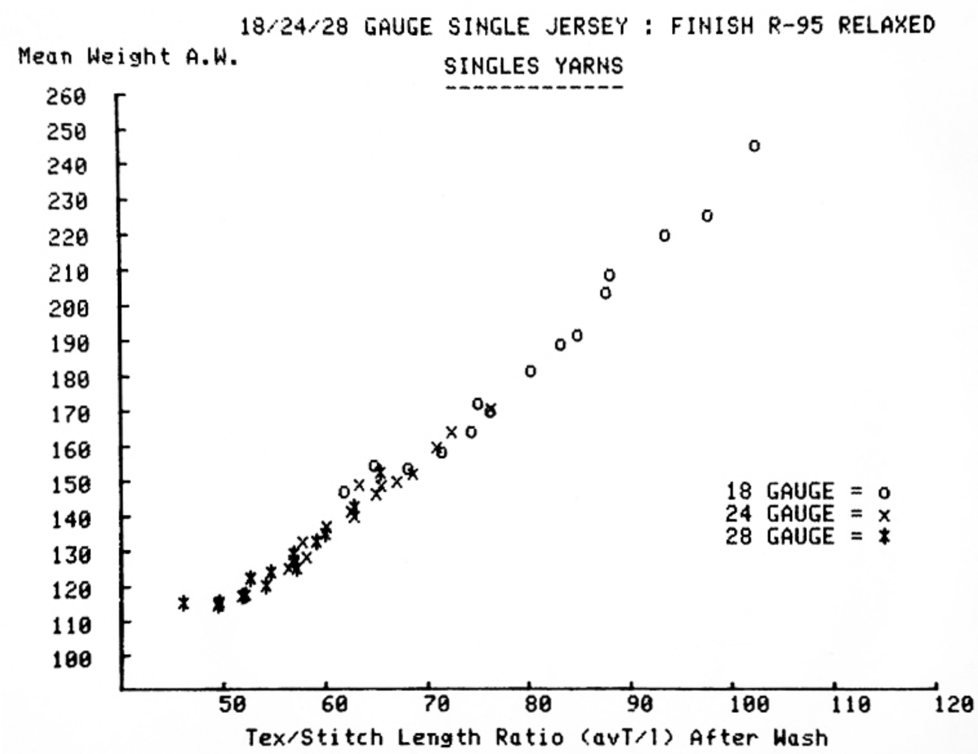

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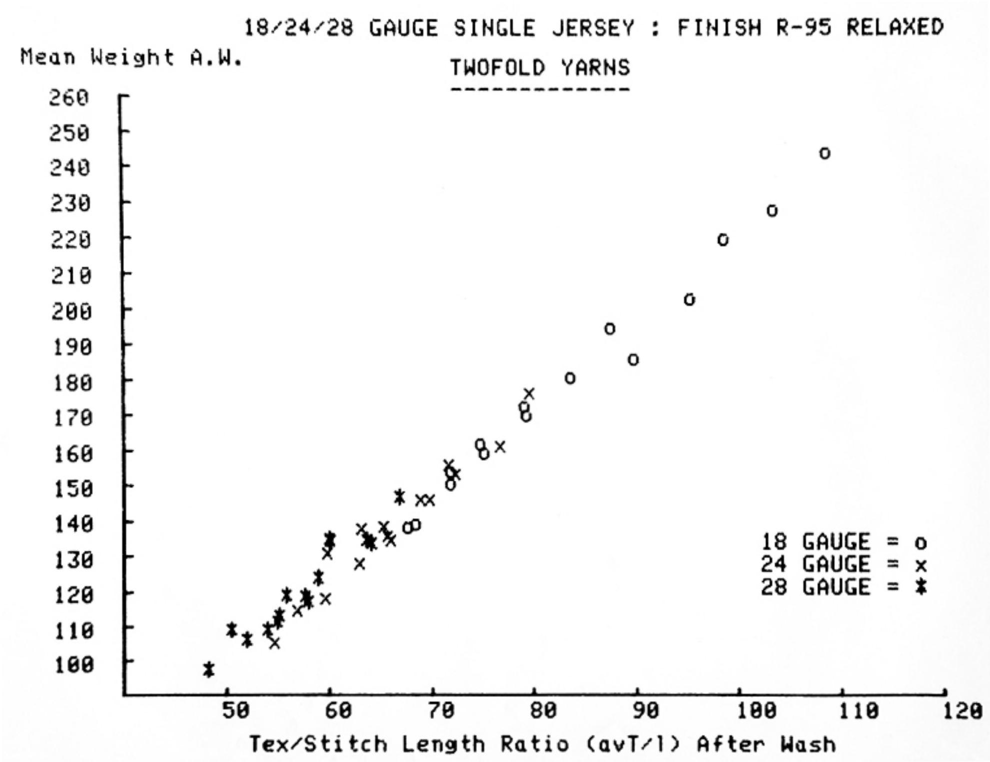

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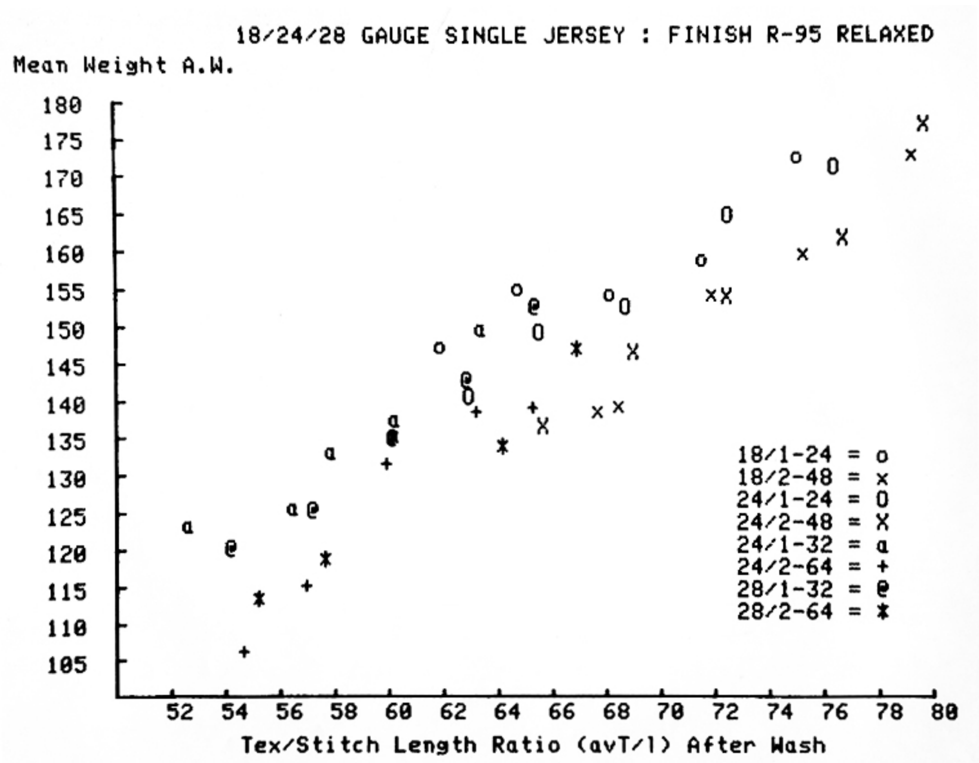

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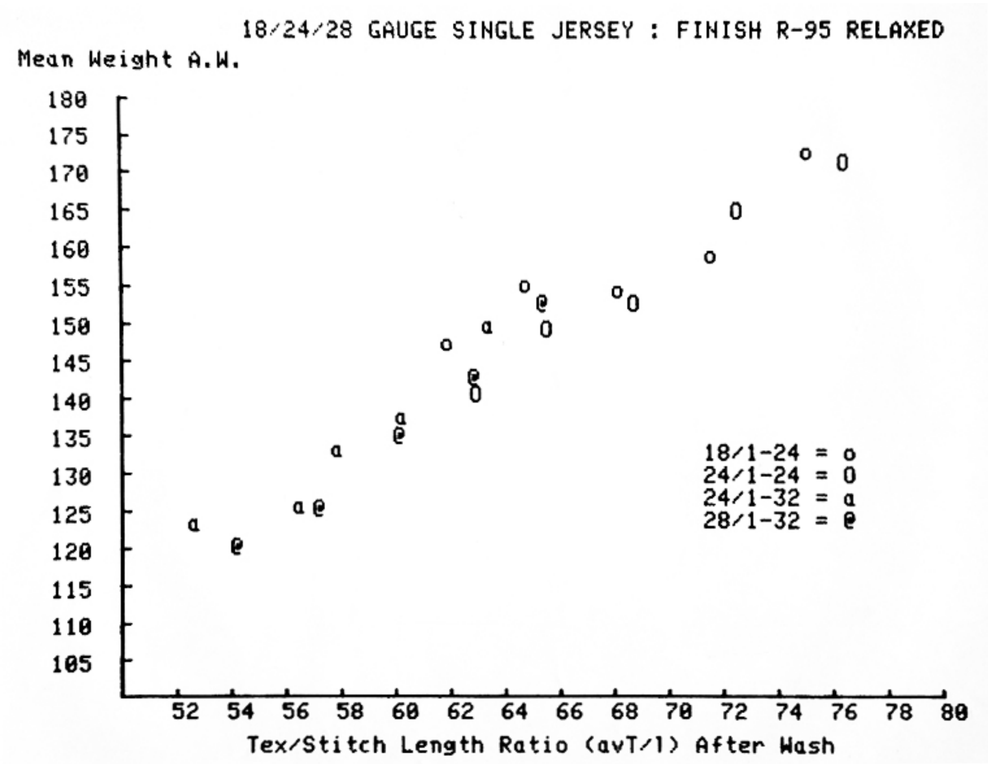

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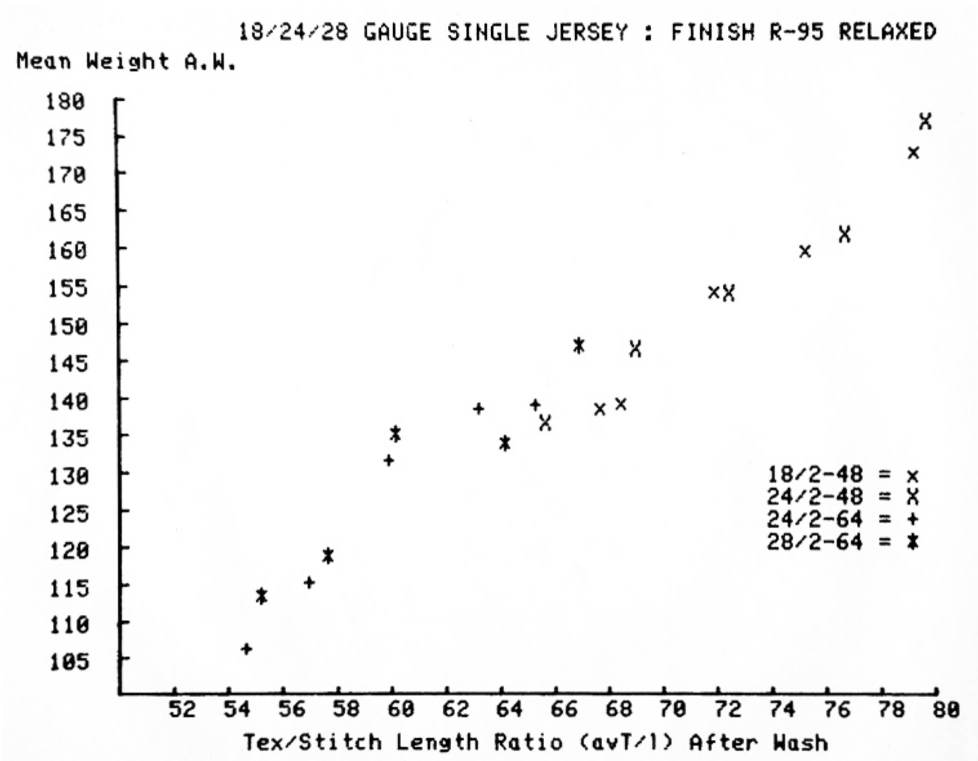

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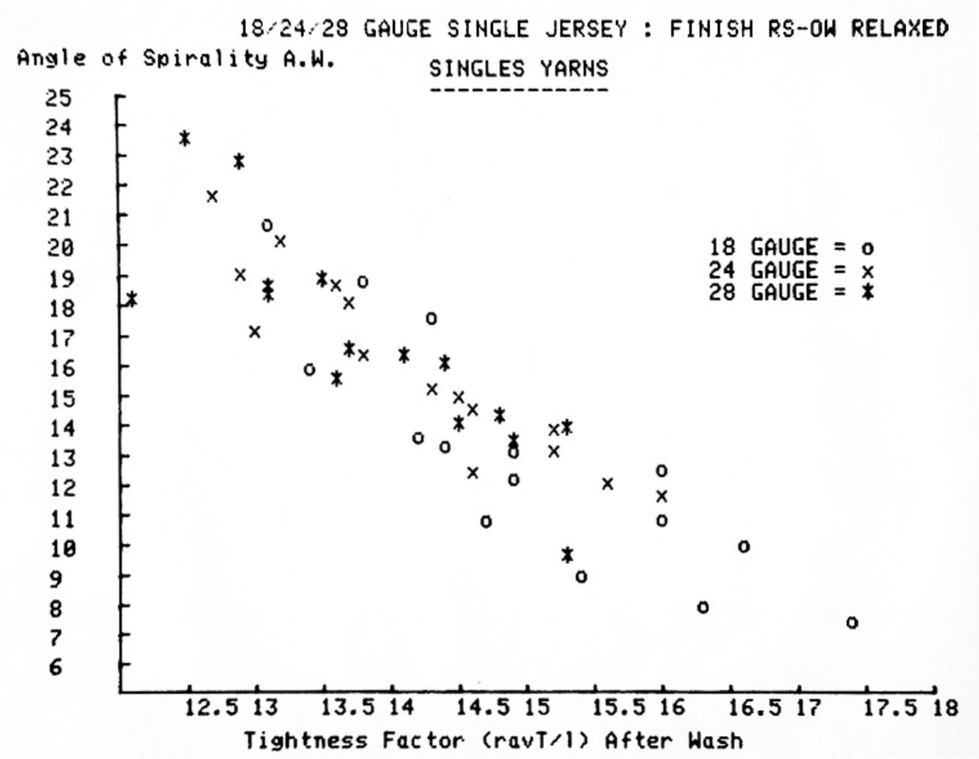

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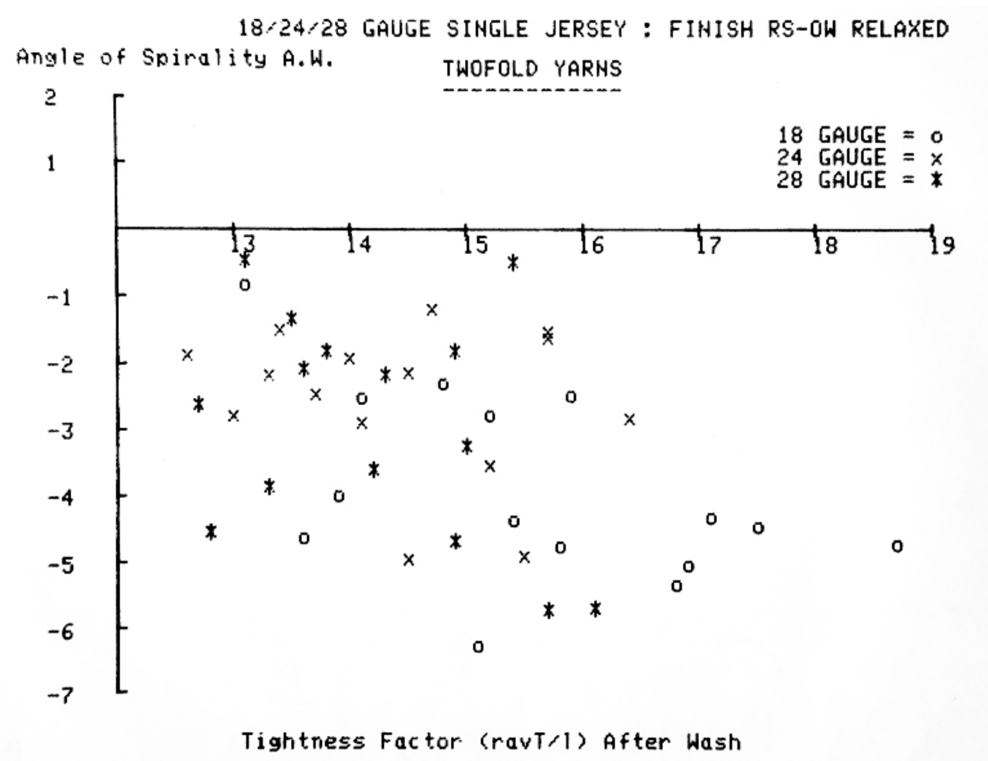

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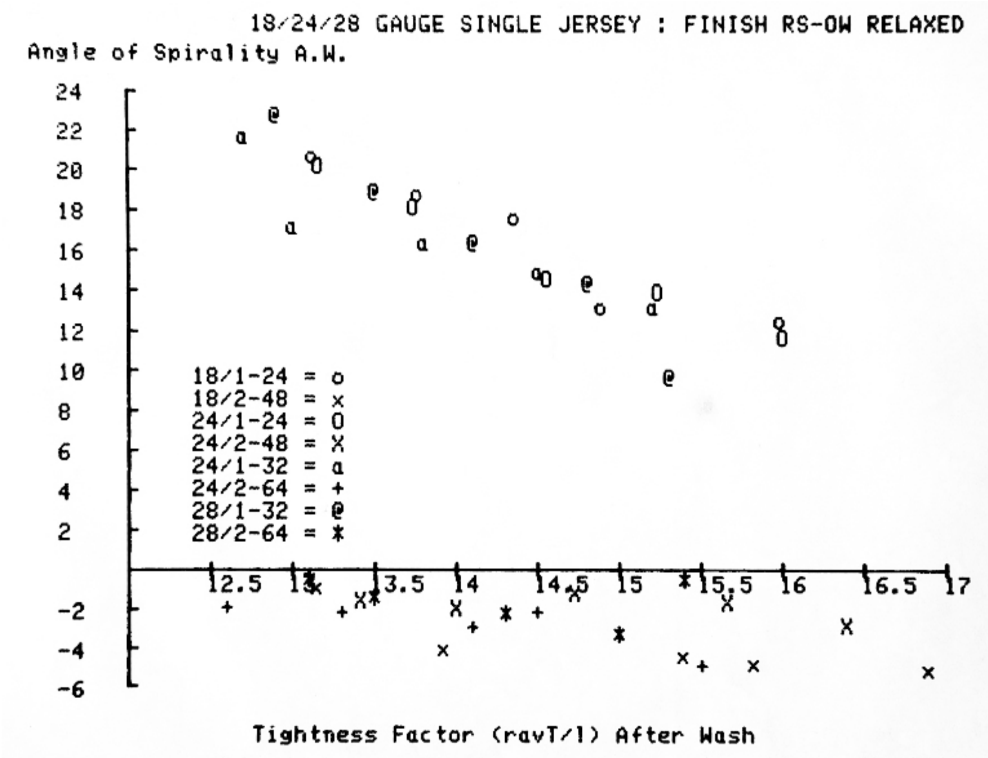

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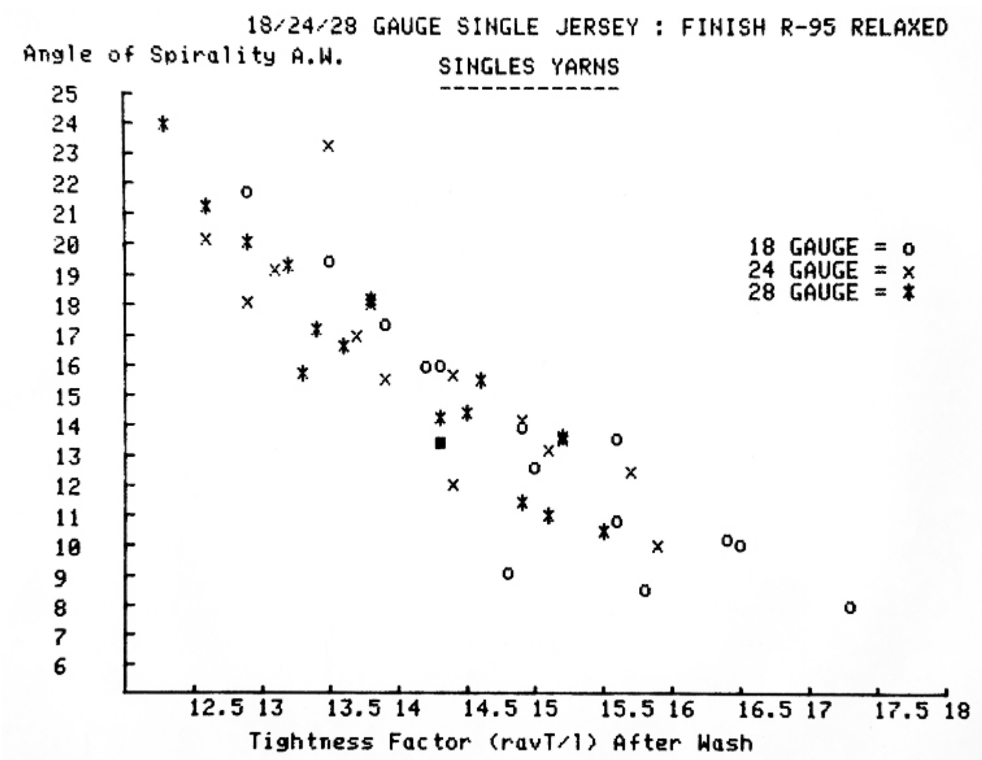

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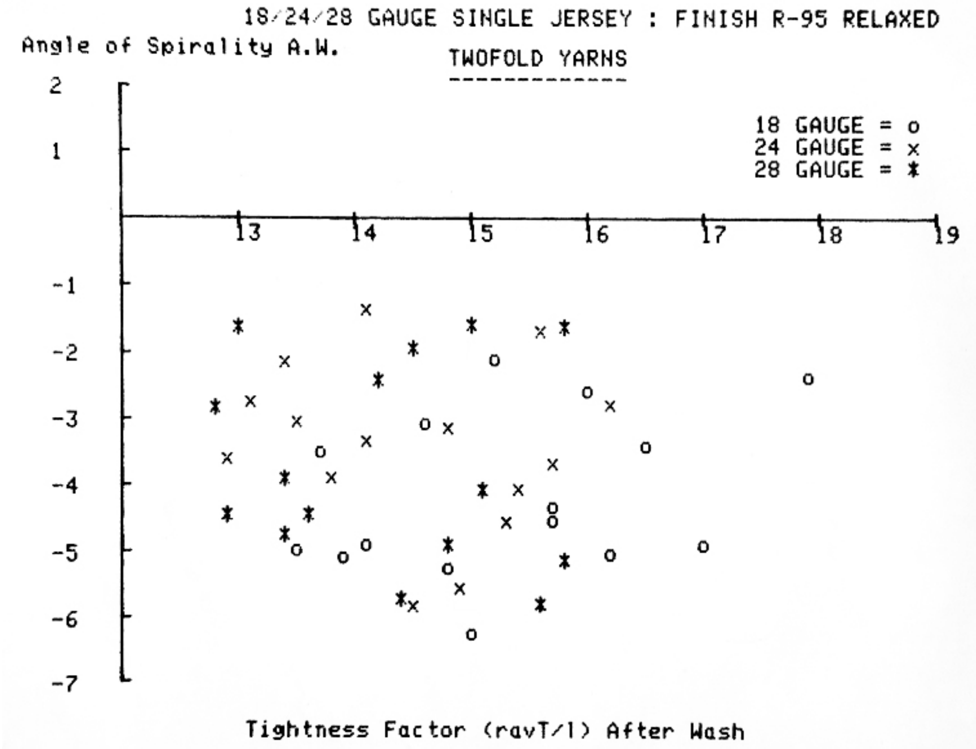

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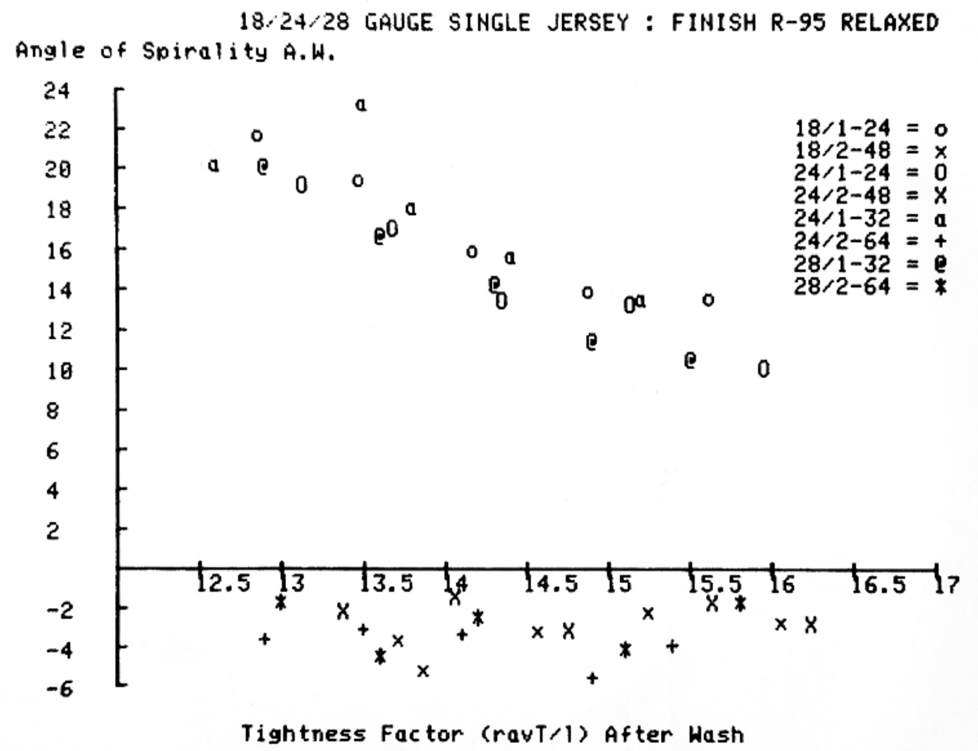
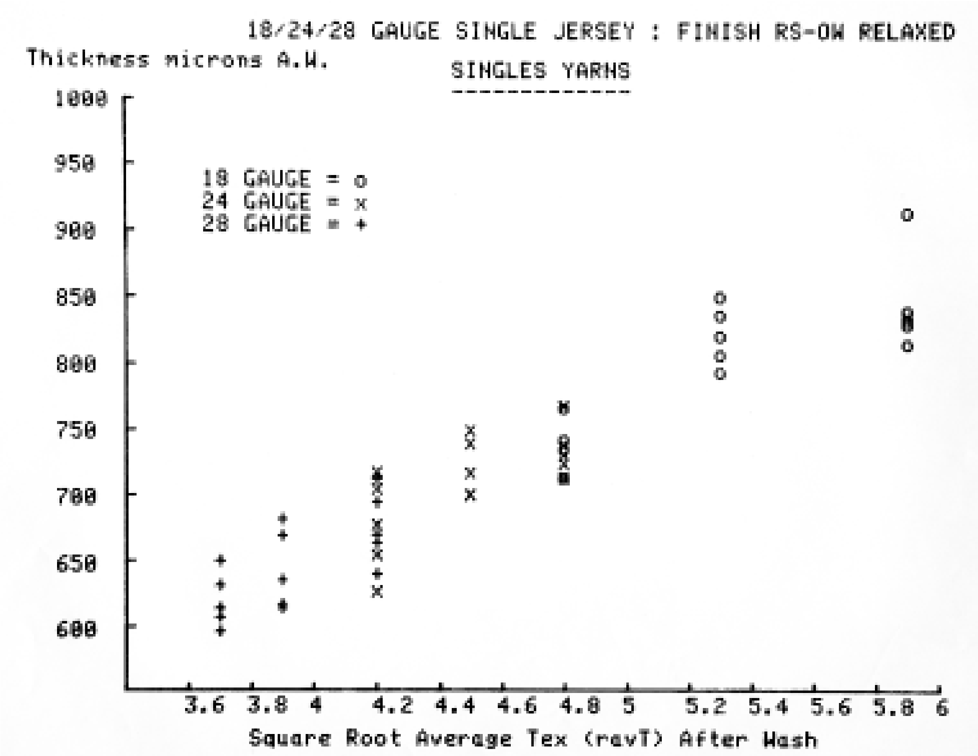


Figure 37



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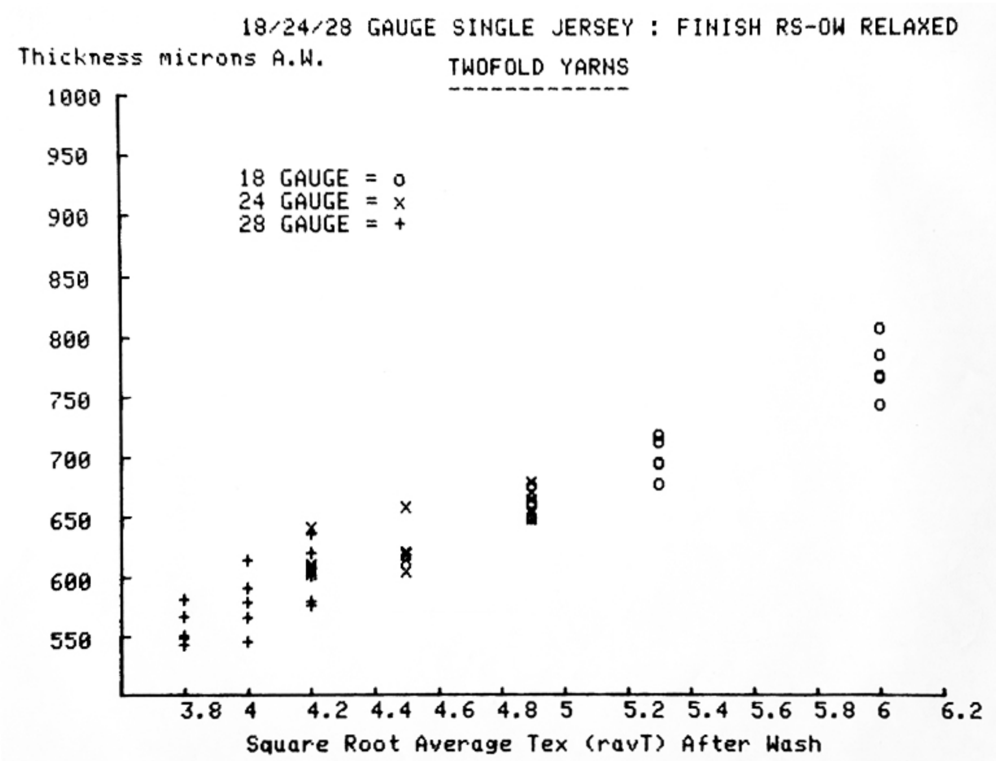

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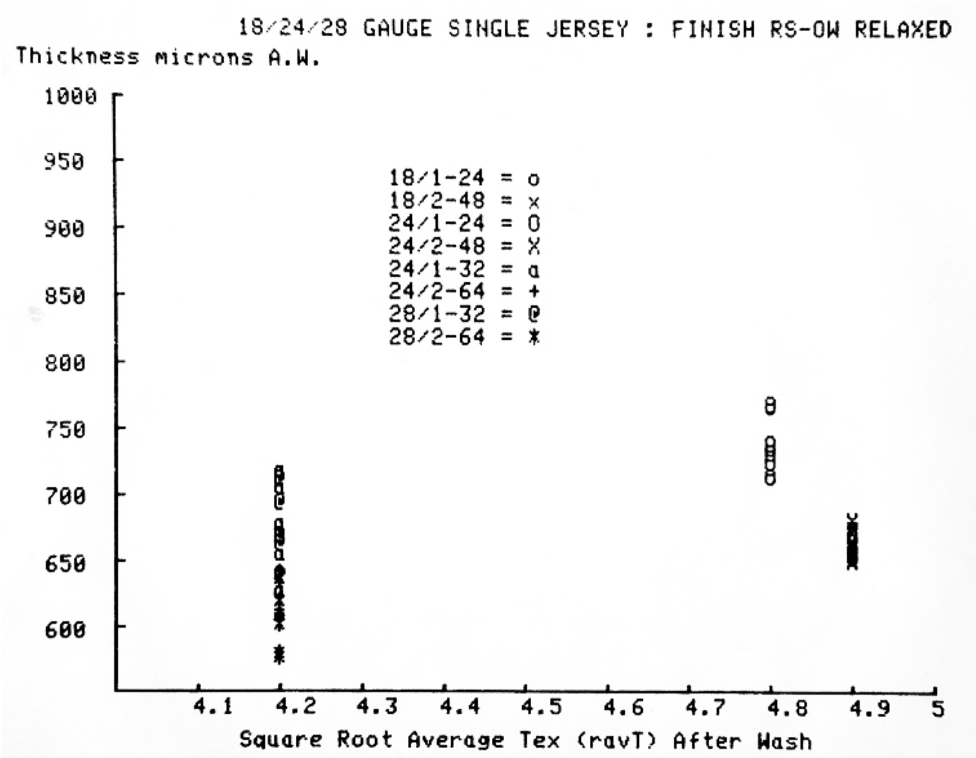

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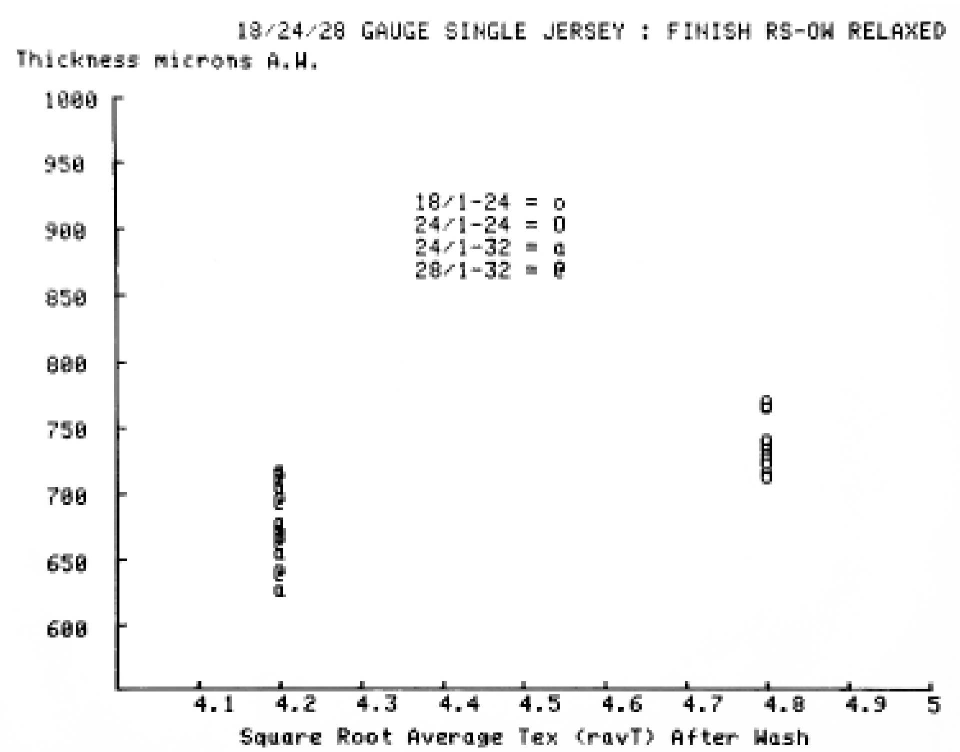

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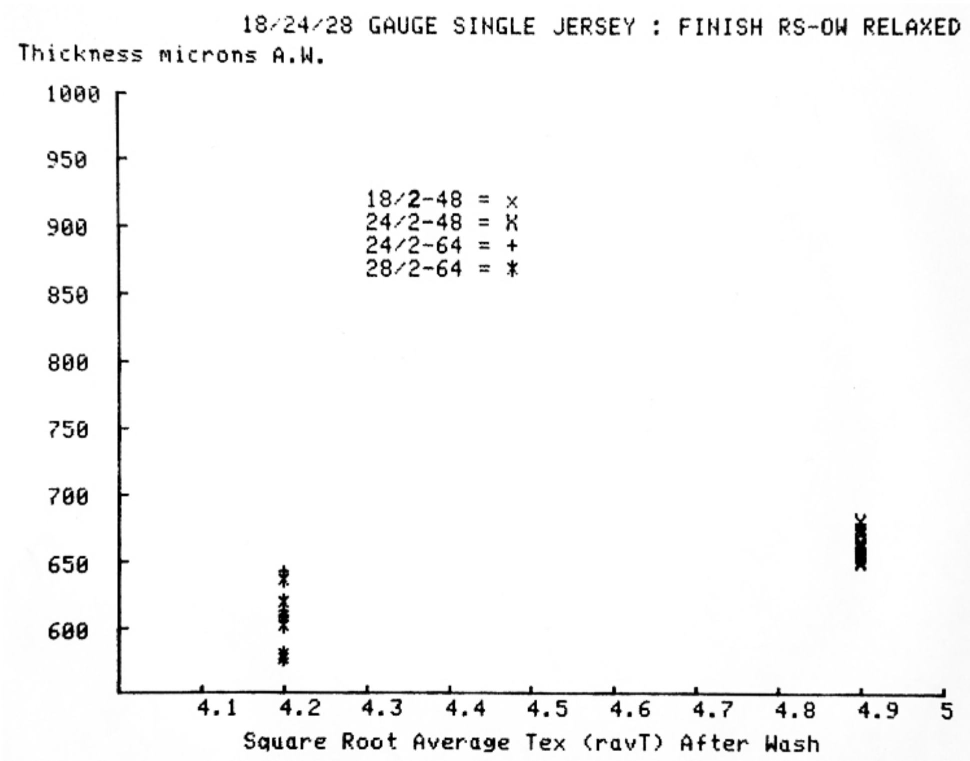

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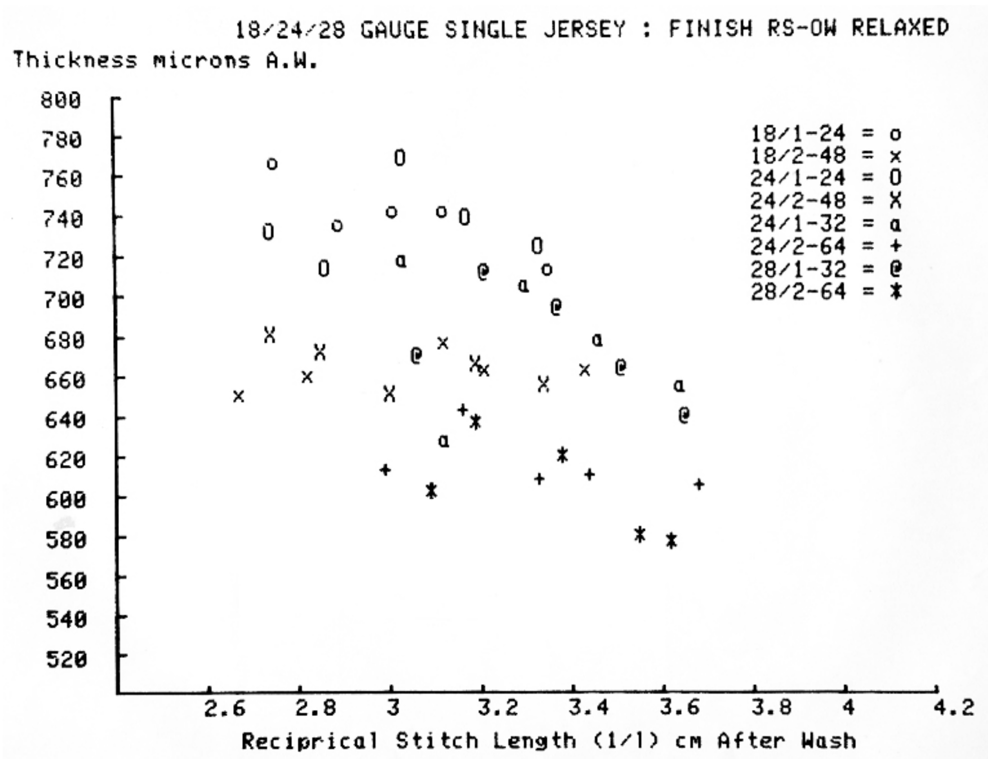

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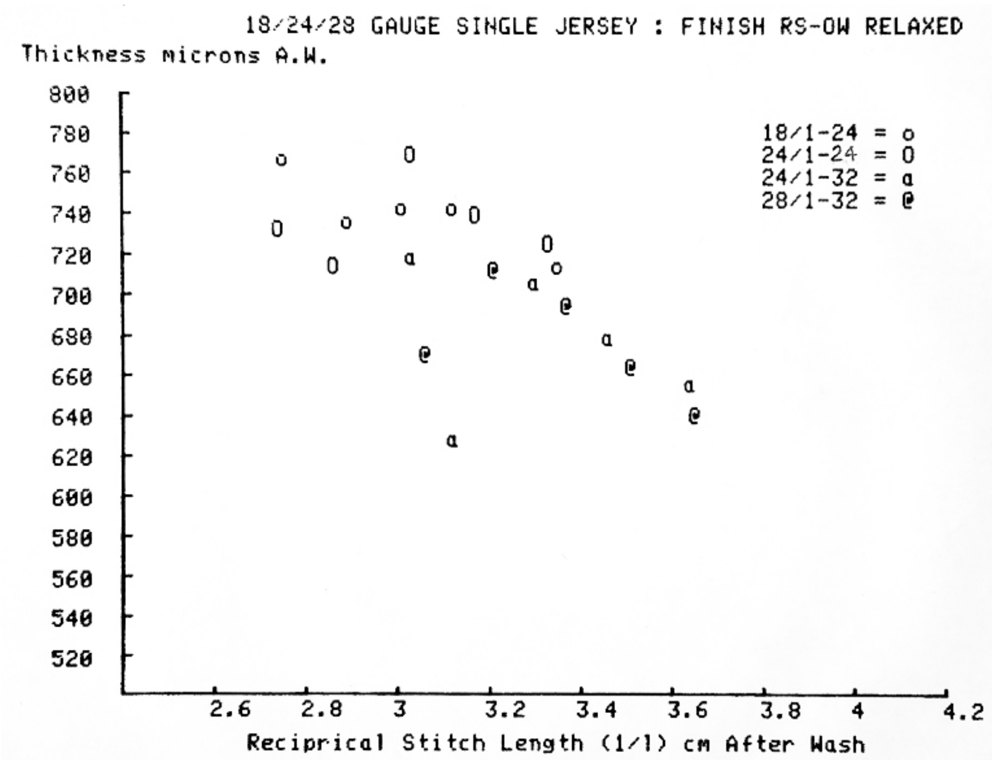

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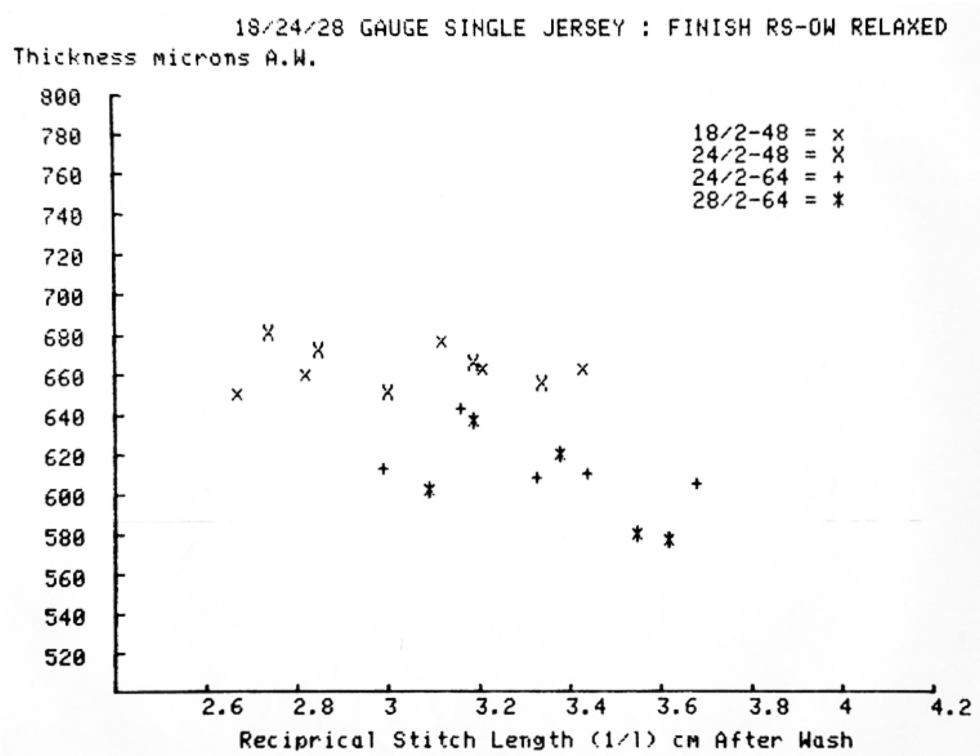

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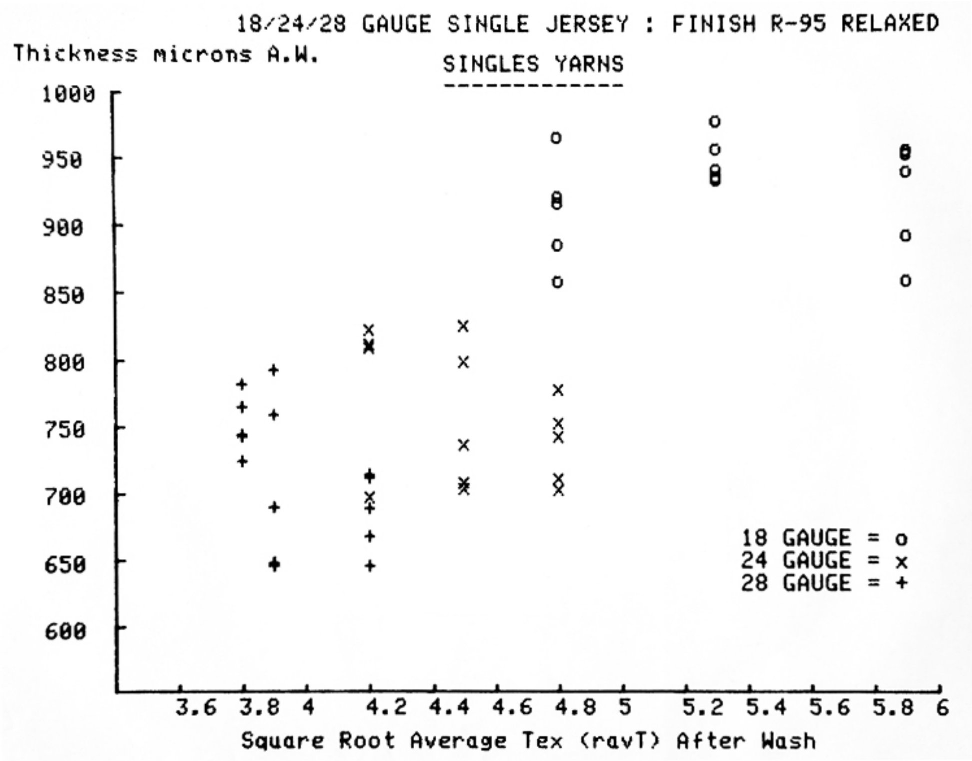

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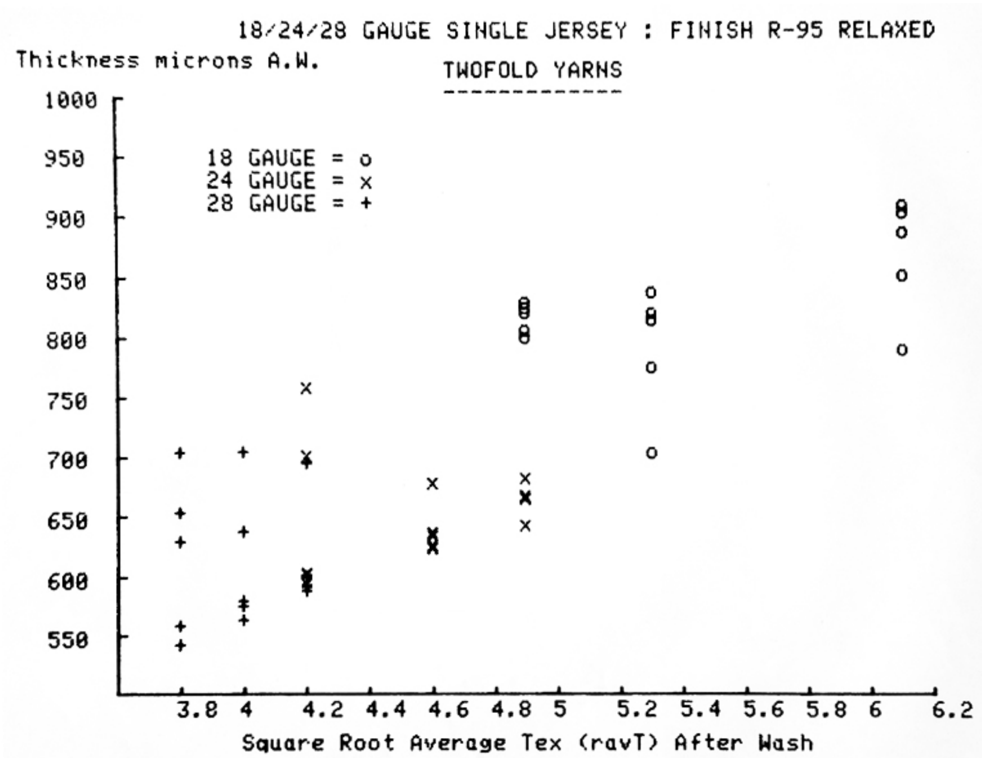

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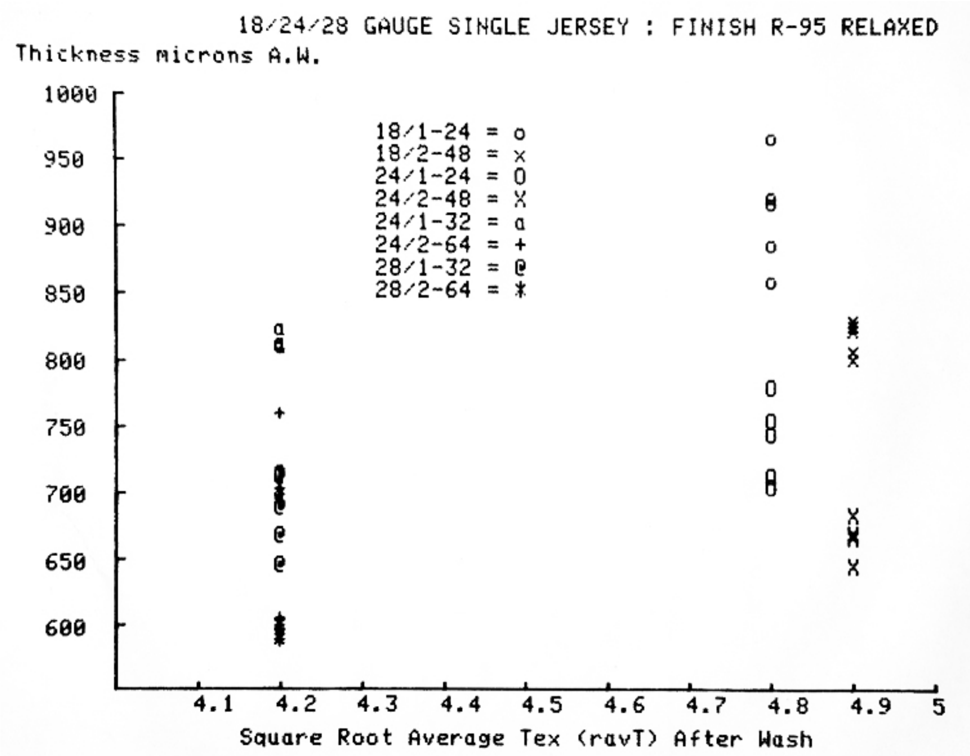

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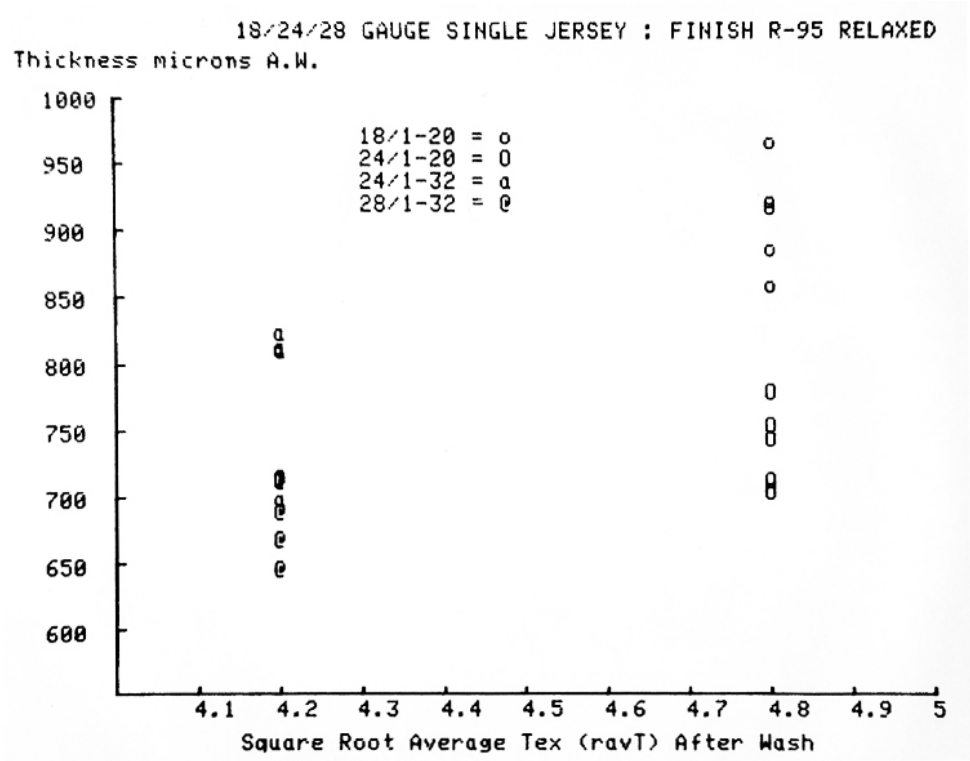

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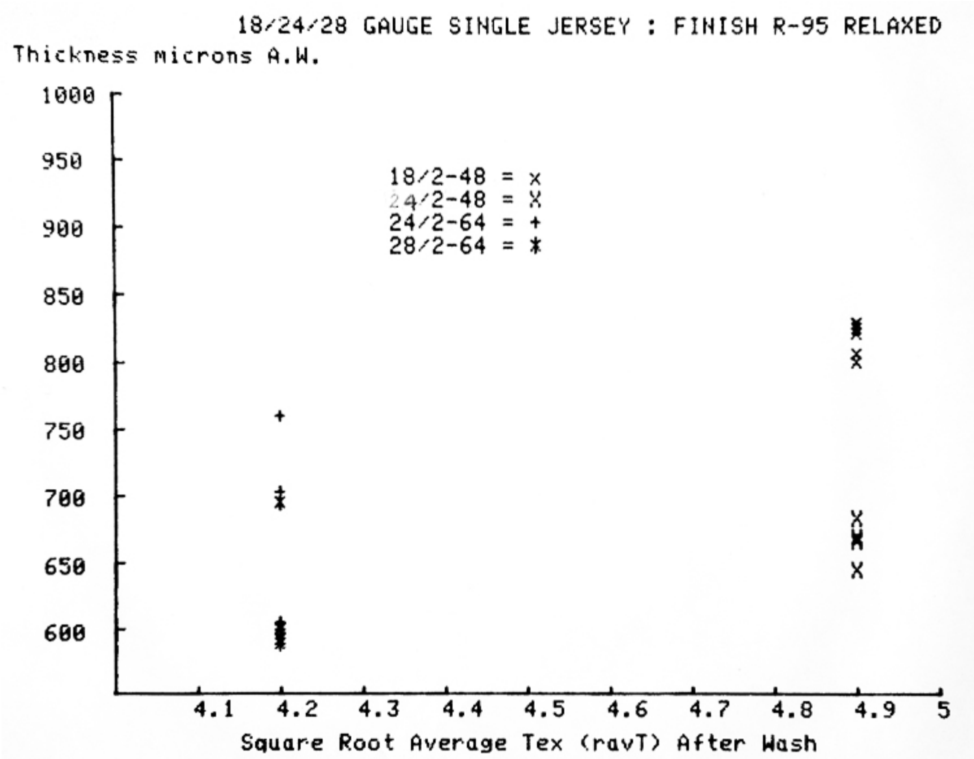

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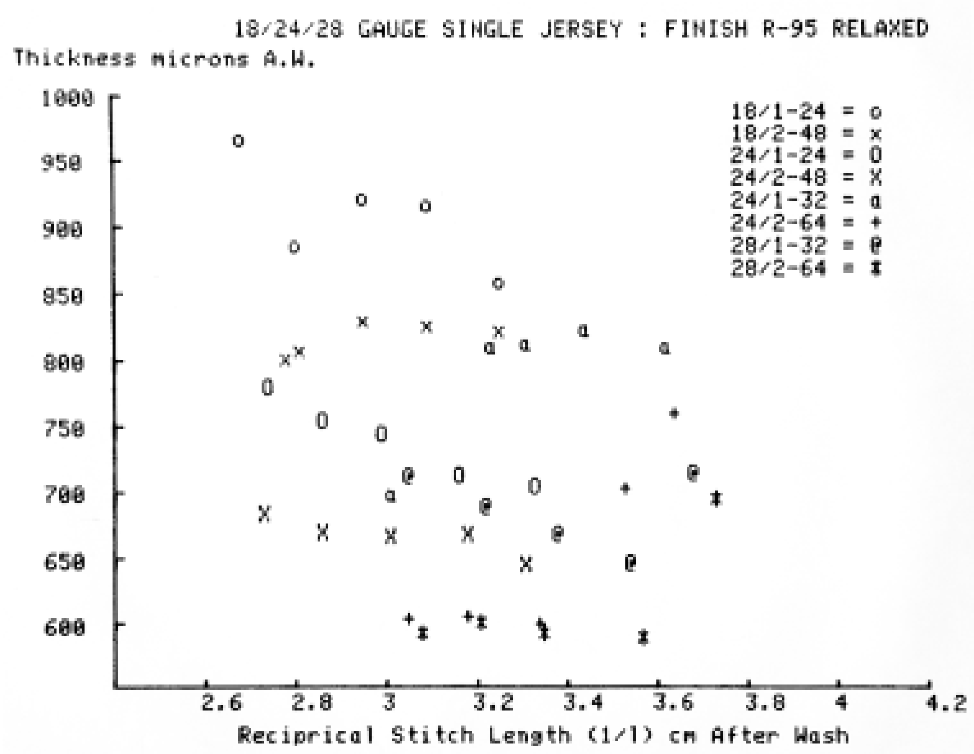

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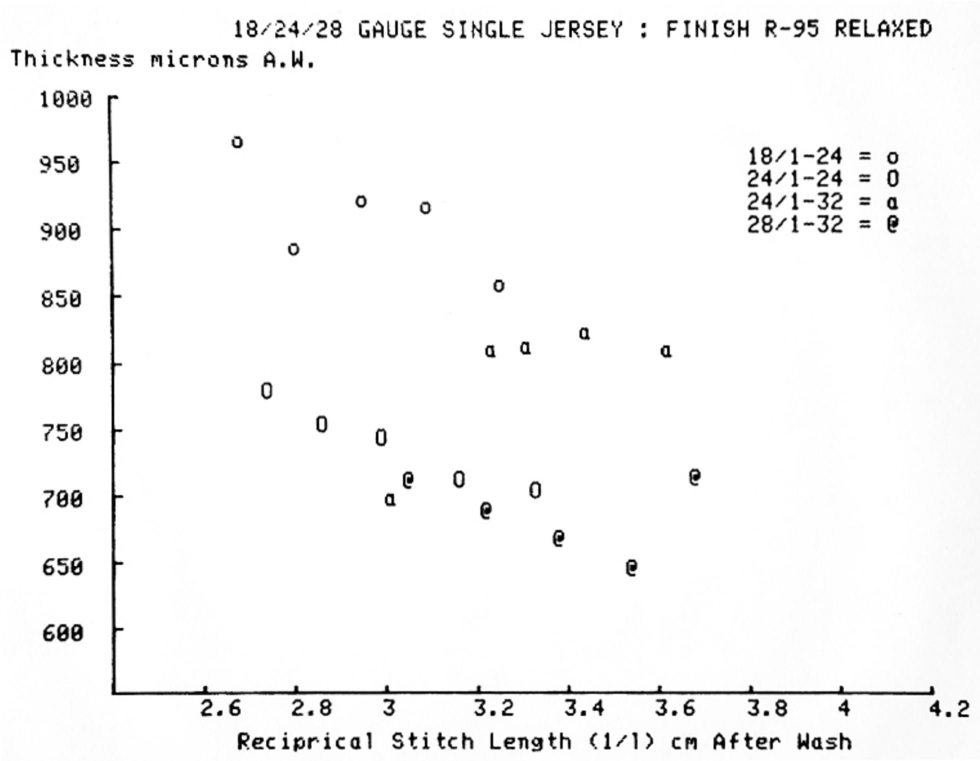

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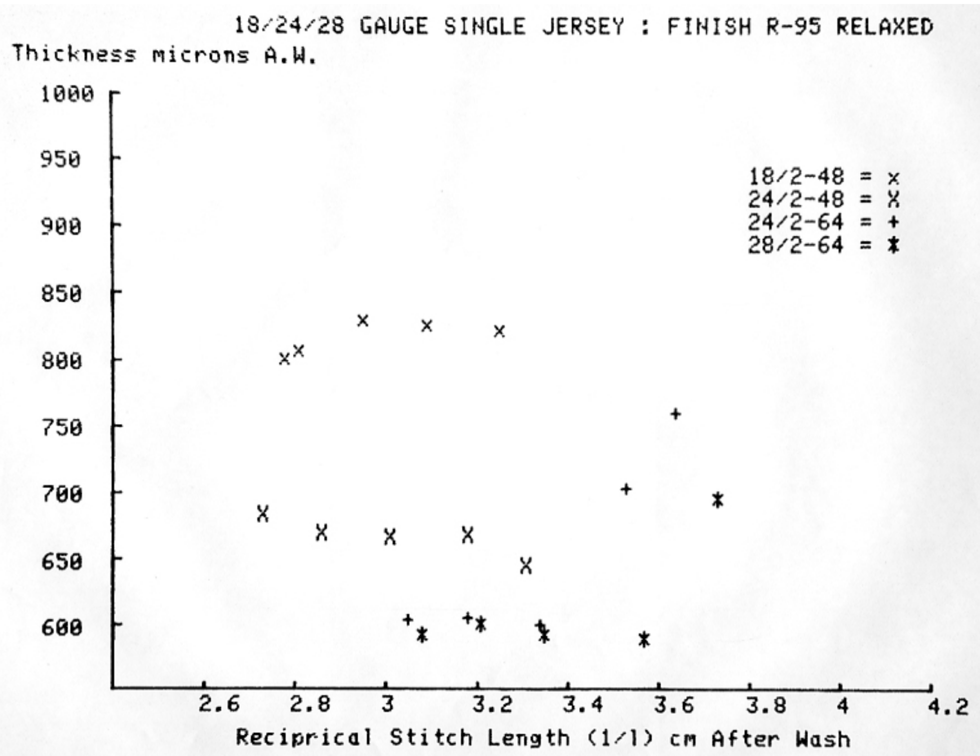

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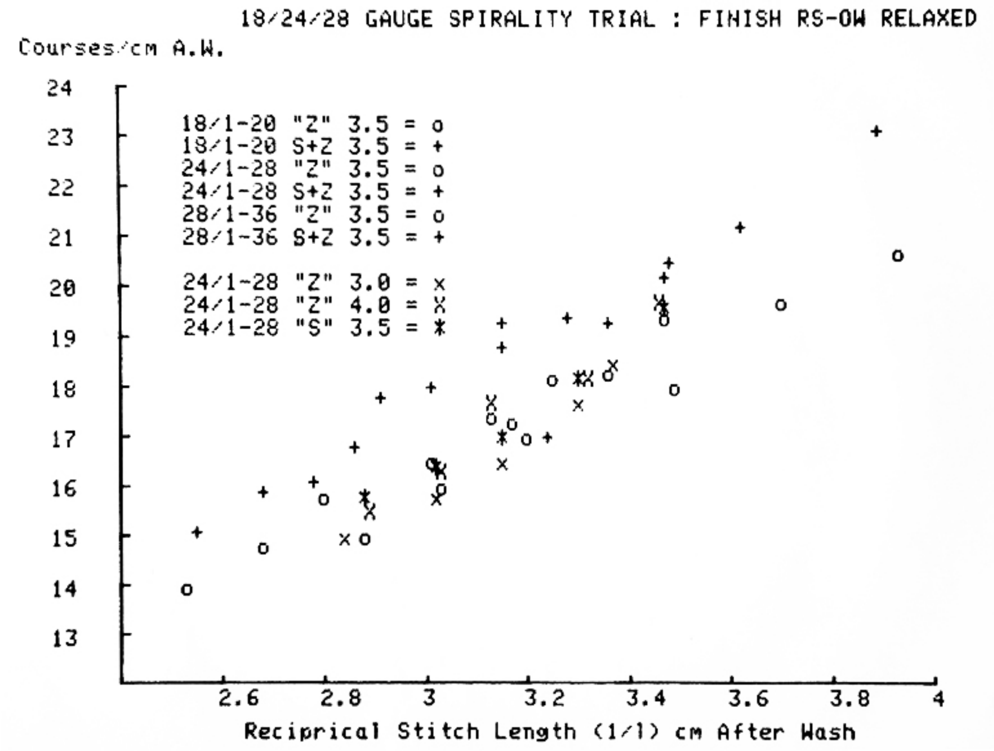

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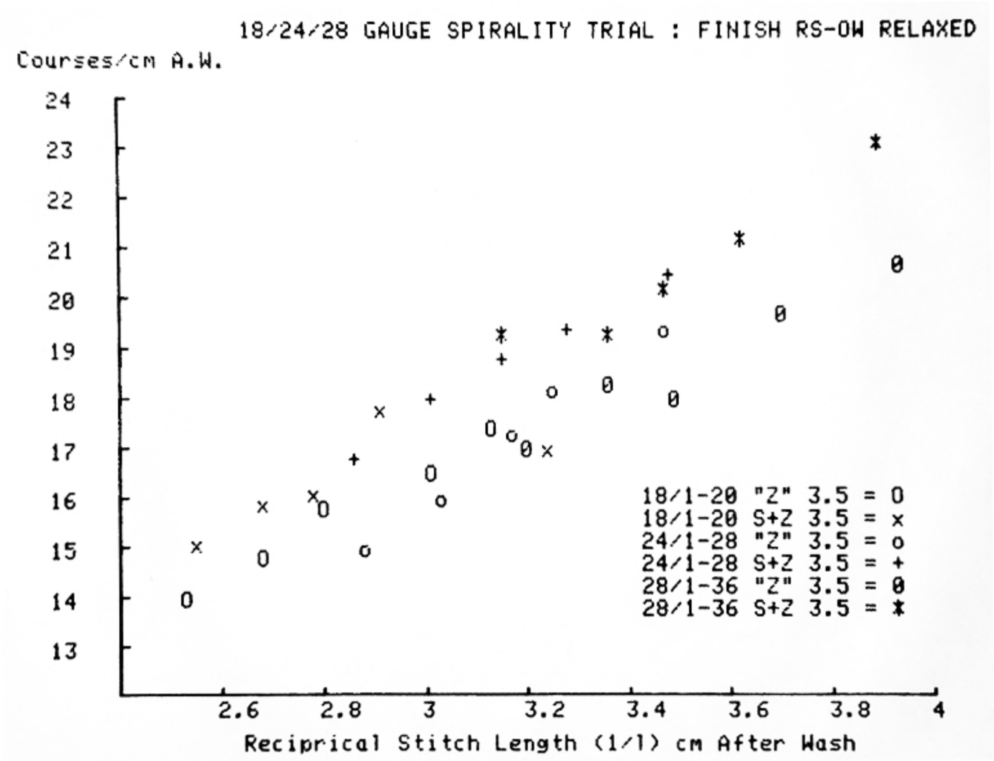

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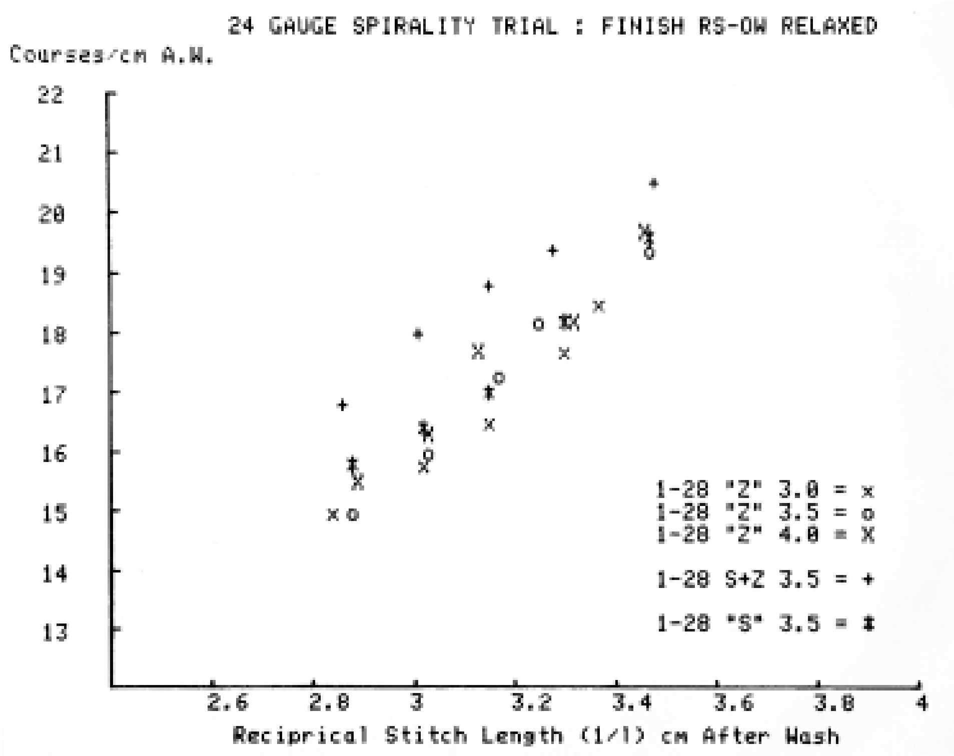

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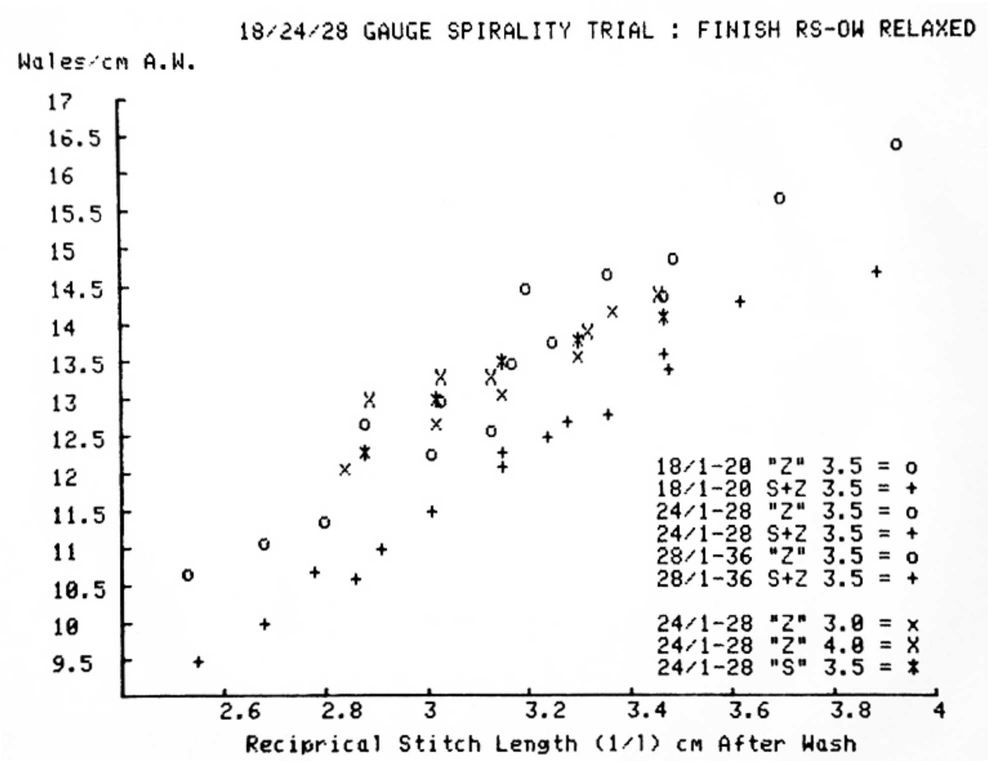

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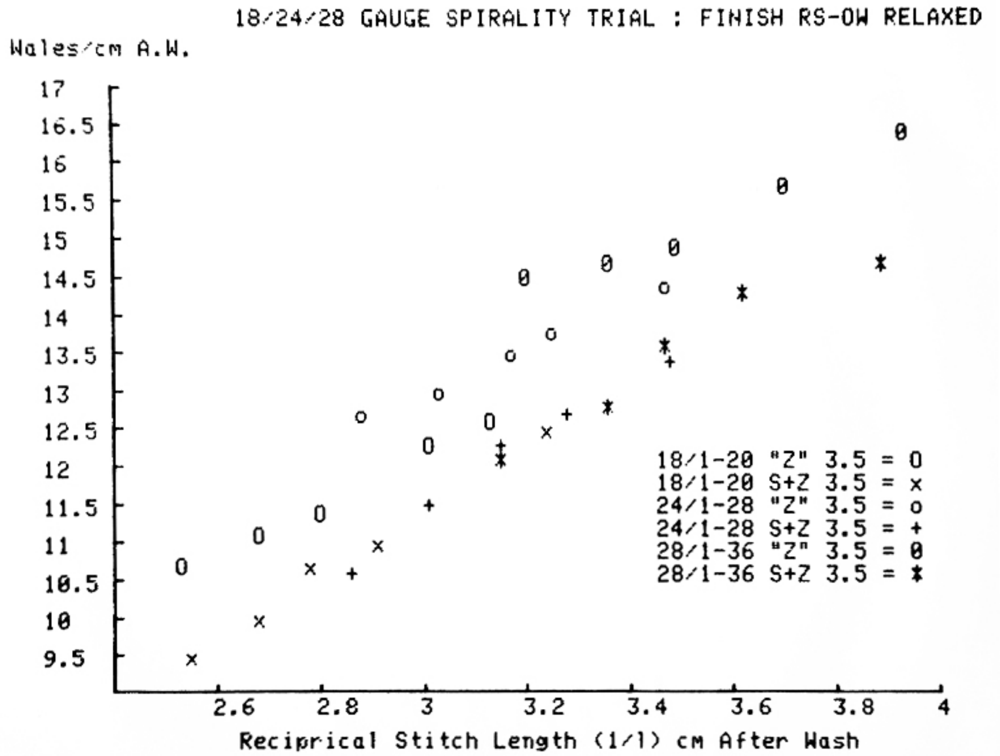

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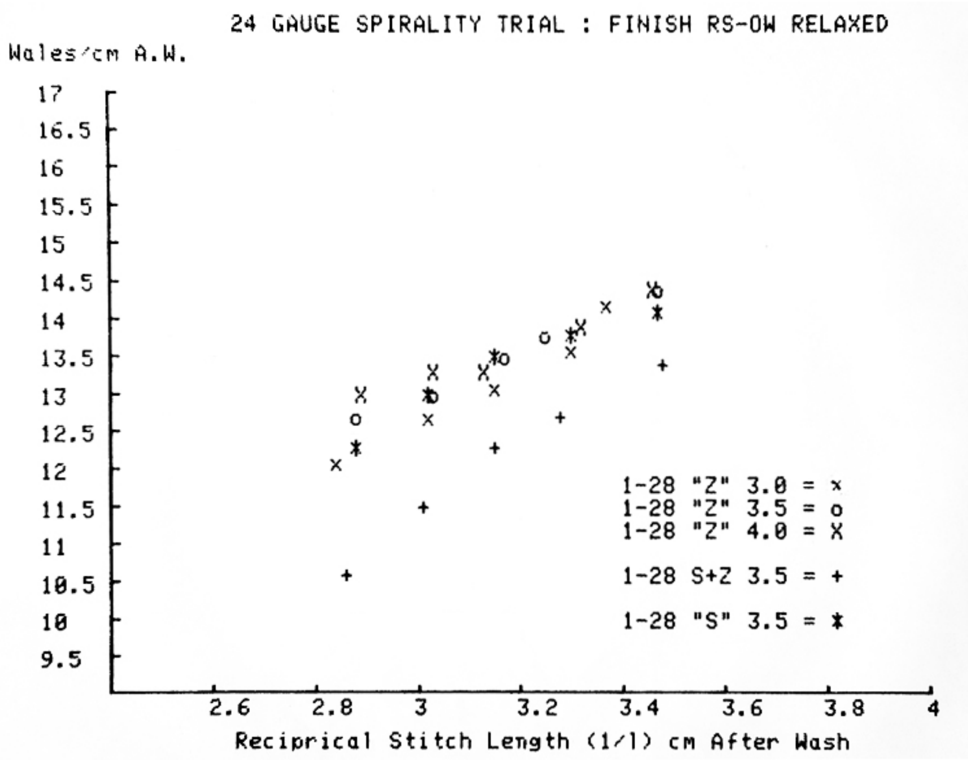

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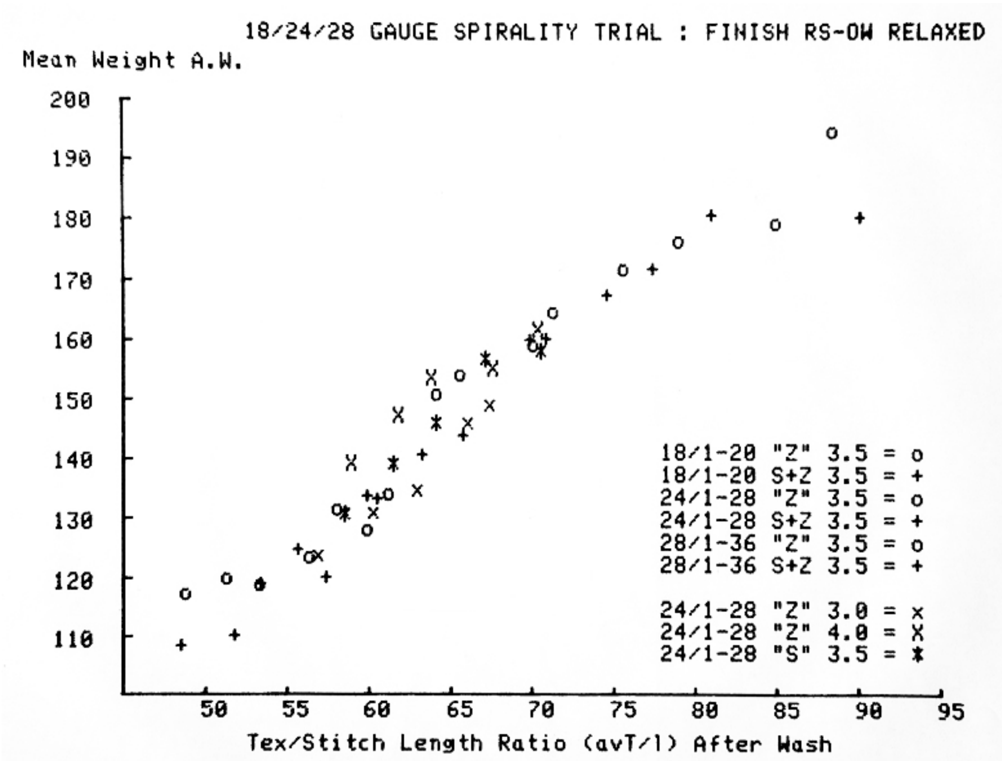

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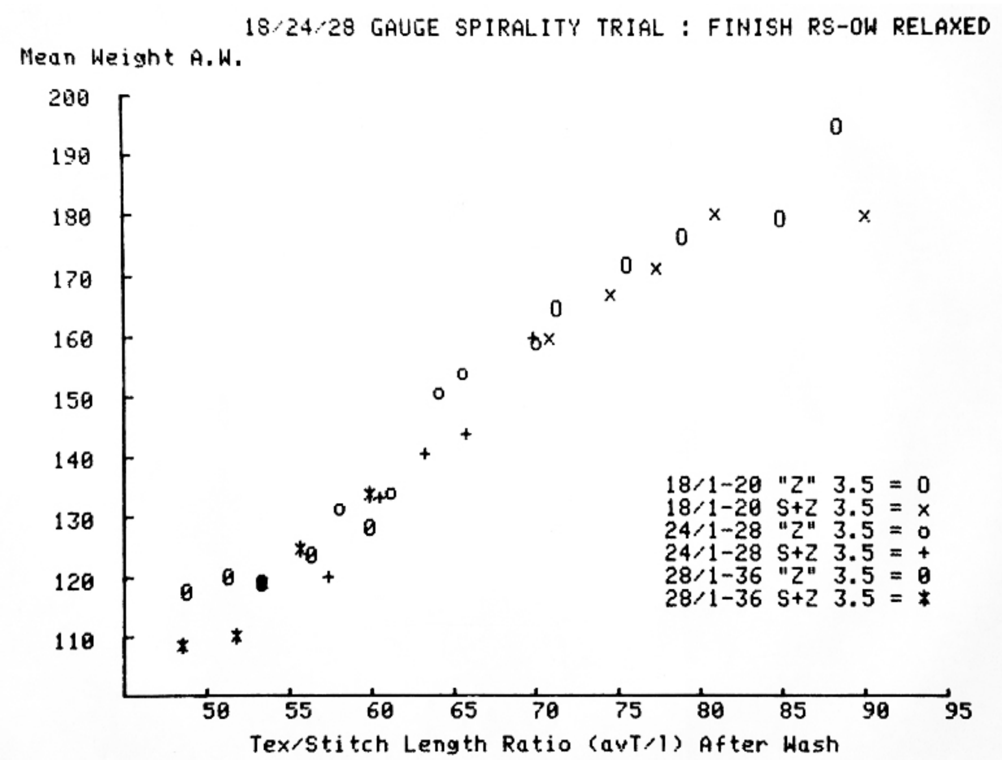

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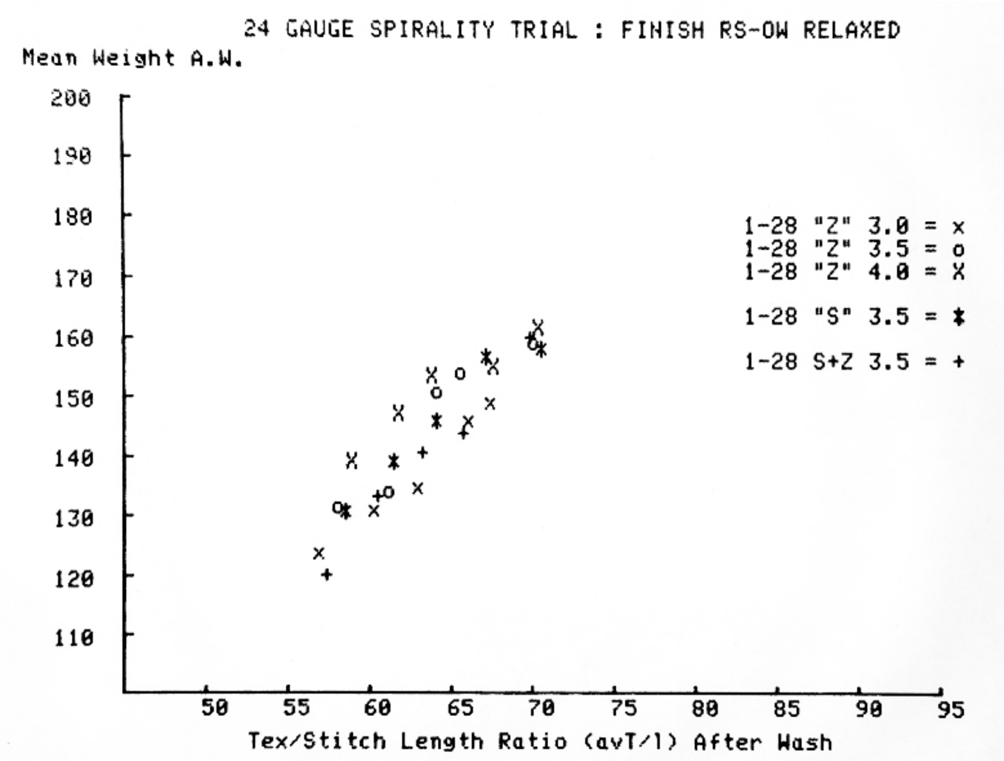

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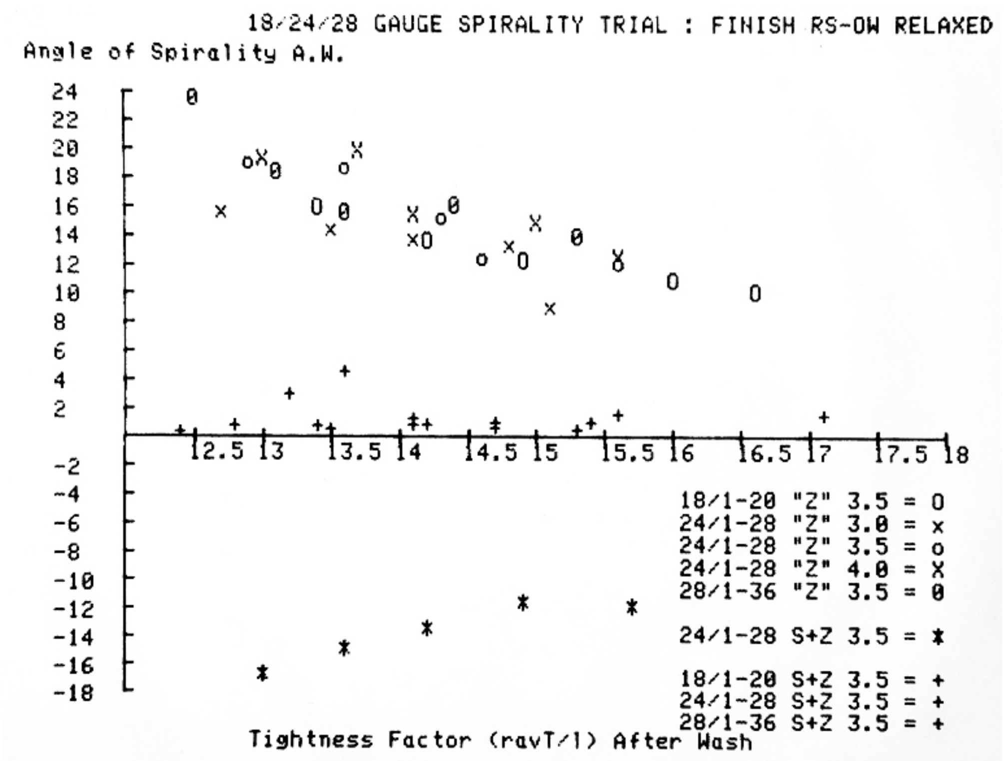

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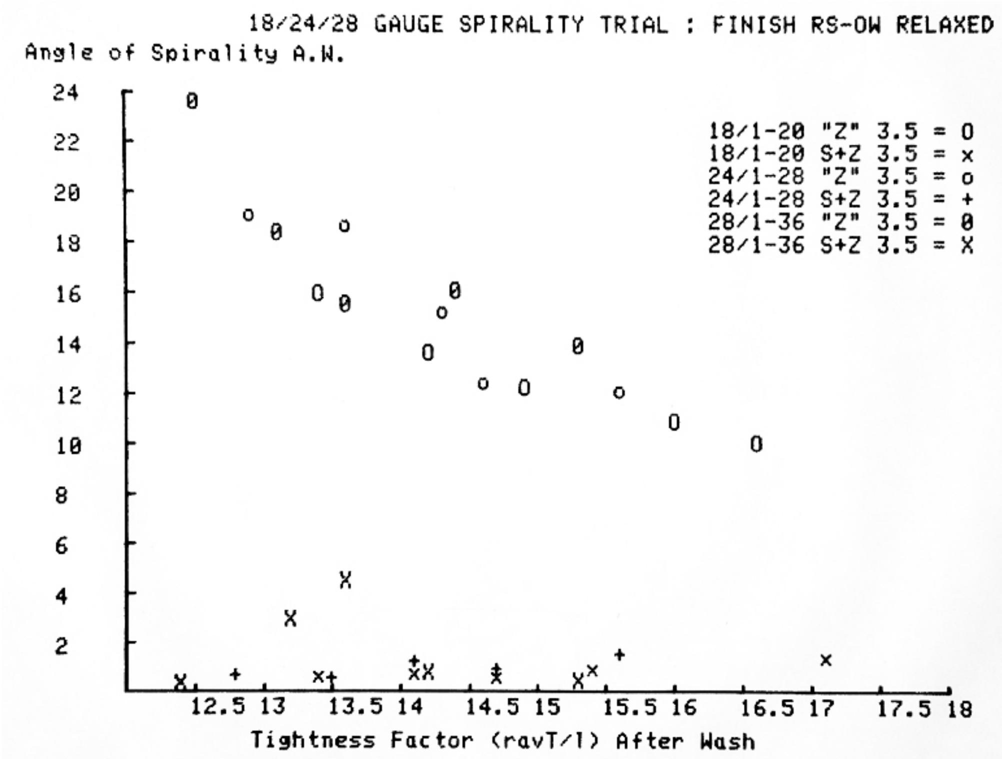

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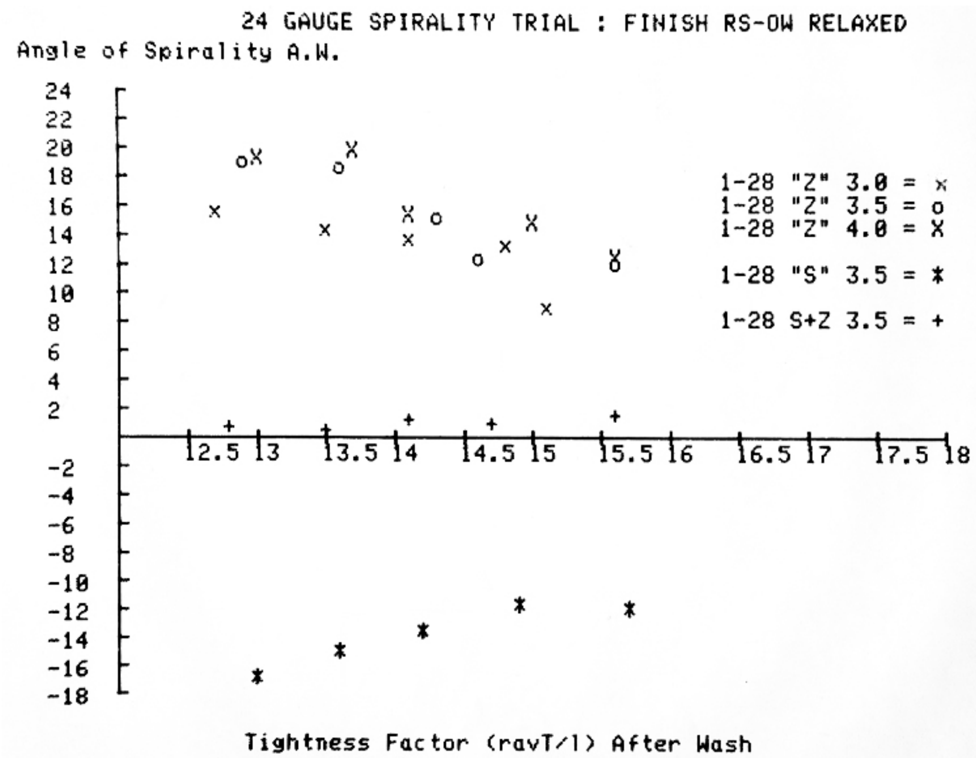

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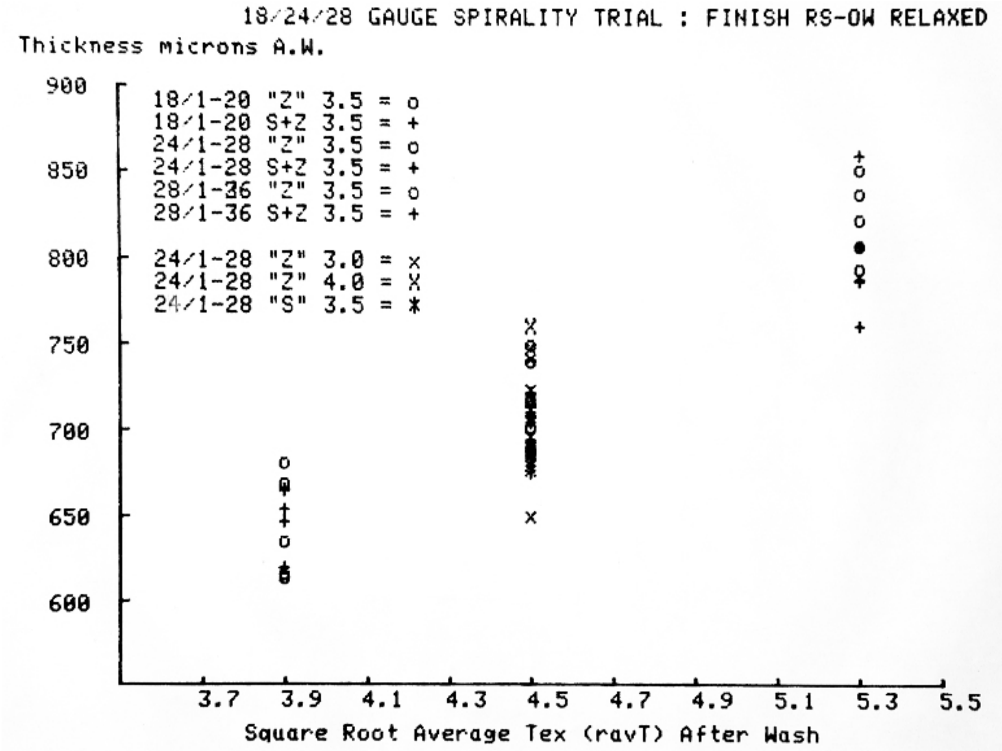

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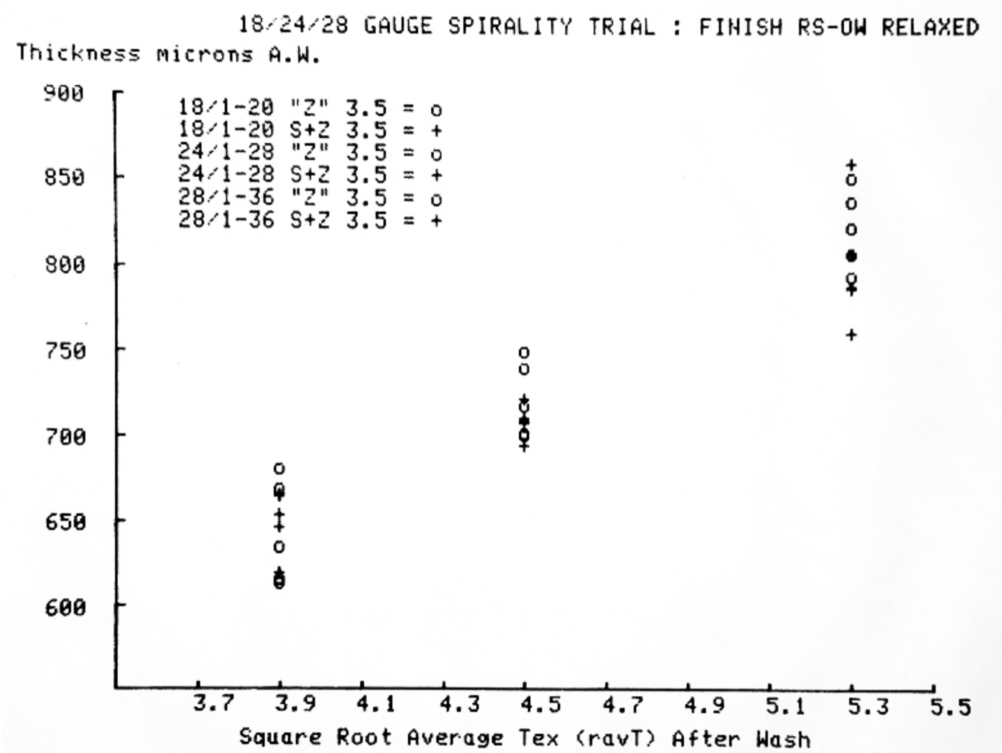

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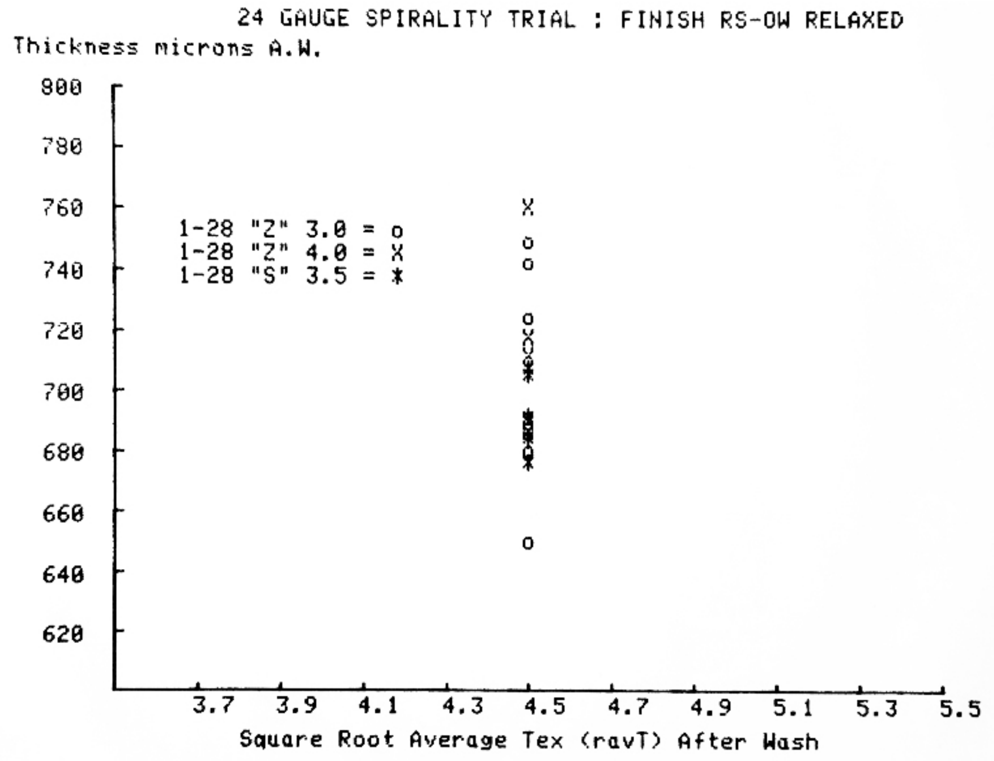

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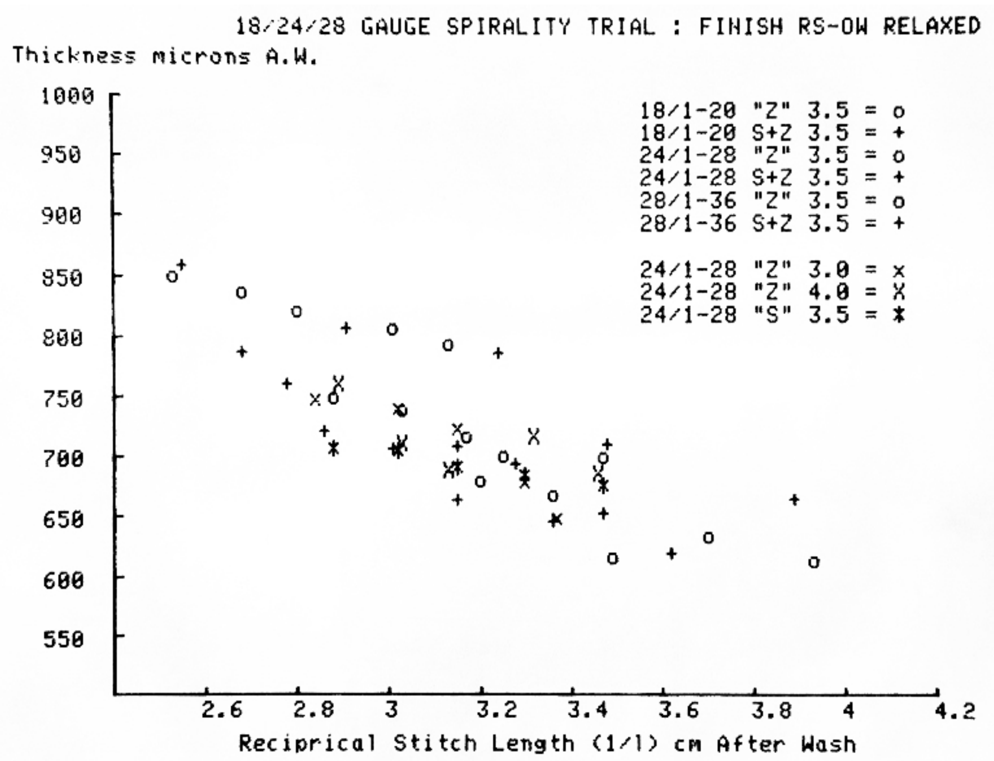

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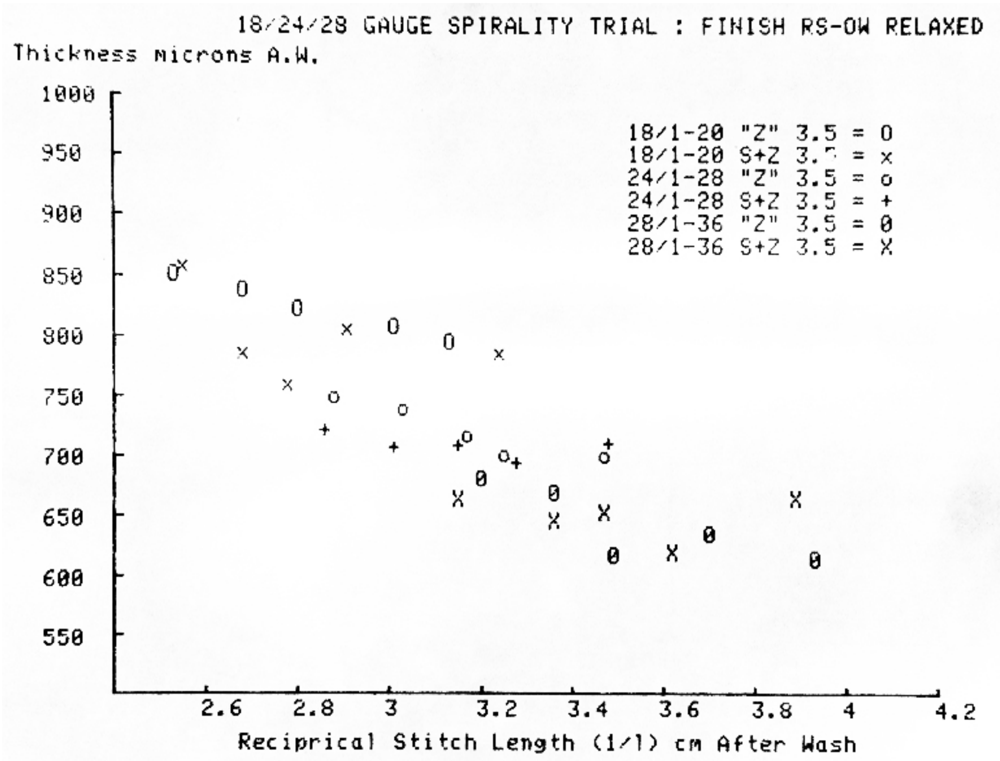

Figure 70