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# 29—VII.—TENSILE TESTS FOR COTTON YARNS
# ii.—THE BALLISTIC TEST FOR WORK OF RUPTURE

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## INTRODUCTION AND SUMMARY

There is no doubt that, other things being equal, an improvement in spinning or in the quality of cotton and in the resulting yarn quality will usually be shown in an increased breaking load of the yarn. In the more general uses of testing, however, the latter is not a direct measure of useful strength, for the test is so far removed from the strains which are liable to injure a yarn in practice. These are rather in the nature of sharp plucks, and the quality needed in the yarn is the ability to stretch without injury as well as to stand a definite load.

Tendering usually diminishes both the breaking load and the extension, but some treatments increase the load while decreasing the extension, in which case it will probably be found that the yarn is, for practical purposes, tendered. As an example, it was found that a dyed yarn broke every few yards in dressing, though the grey was of good strength. The dyed and grey yarns were compared by single-thread and by the ballistic test to be described, one set of results being shown here—

| | Breaking Load, ozs. | Extension % | Ballistic Work |
|---|---|---|---|
| Grey ... ... | $4{\cdot}84\pm_{.07}$ ... | $4{\cdot}17\pm_{.11}$ ... | $111\pm_{3.4}$ |
| Heliotrope ... | $5{\cdot}63\pm_{.09}$ ... | $3{\cdot}21\pm_{.07}$ ... | $98\pm_{1.2}$ |
| Difference ... | $+0{\cdot}79\pm_{.12}$ ... | $-0{\cdot}96\pm_{.13}$ ... | $-13\pm_{3.6}$ |

According to the breaking load, the yarn had been considerably strengthened by dyeing, but the dresser knew, what the ballistic test showed, that it was seriously tendered, owing to the loss of extensibility.

The most complete test for the tensile properties of a yarn is to find the relation or curve connecting the extension and the load at each moment from the beginning of tension to rupture. Examples of such curves, which are given below, show that extensibility alone is a very uncertain guide to quality, for unresistant, inelastic extension is of little value. This is shown by the curves of a yarn when first straightened, the plastic flow of Celanese near rupture or the slow pulling out of yarn spun to too high a count for its staple. Real quality is shown by extensibility combined with a resisting tension. The work or energy absorbed in rupturing a yarn is the sum of each increase of length multiplied by the tension producing it. If the ratio of extension to tension remains the same, this work of rupture is $\frac{1}{2}\times$breaking load$\times$extension. This is very approximately the case for sized yarns; with unsized yarns the extension is less resistant at low tension than near rupture, and the factor is rather less than $\frac{1}{2}$; with artificial silk, the extension is more resistant at low tension and the factor is more than ½. Work of rupture is thus a measure of combined strength and extensibility which takes into account the behaviour over the whole range up to rupture.

Whilst a thread will suffer the same extension to a very close approximation whether broken slowly or rapidly, its resistance and final breaking load increase considerably with the rate of loading (Paper III.). The test should therefore be performed as nearly as possible at the same speed as the strains encountered in practice, which are undoubtedly not slow steady extensions but rapid jerks. Fortunately, the work absorbed in a rapid break is capable of convenient measurement by the ballistic method. This test is being used increasingly on metals and other materials, but in no field are its advantages so decided as in textile testing. The earlier applications of the principle and its possibilities are discussed in a previous communication,[5] the work of Lester[4] being the first and especially noteworthy. Denham[2] has recently used the test on silk thread, and the principle has been applied to testing cotton hairs by Balls[1] and Foster.[3]



**The Ballistic Tester**

The tester described below has been developed with the object of providing a test as convenient as those in vogue for commercial purposes, while giving a result of exact and scientific meaning. It is introduced on the grounds that the quantity measured is the most significant single measure of yarn strength, but its use might equally be justified from the viewpoint of testing routine. The breaking load must be measured laboriously on single threads, or accuracy sacrificed in breaking a skein of which the apparent strength depends on the order in which the individual strands break. The ballistic tester measures the total amount of energy absorbed, which is unaffected by the order of breaking or the number of threads.

Work, mechanical energy, is performed when a point is moved against the resistance of a force, e.g., in the extension of a yarn against its tension or the raising of a body against its weight. In the latter case, the work reappears as energy of movement when the body is dropped. This kinetic energy can be used to extend and break a yarn or lea of yarn. In the ballistic tester (Fig. 1) the falling body is a heavy pendulum (A) which is released from a known height. If no work is done in the swing, the pendulum rises to the same height in its upward swing. If it is made to break a specimen (B) it rises to a lower height and the difference between the two heights gives a measure of the energy absorbed in rupture.

The fixed anchorage (C) is placed so that the specimen becomes taut when the bob is about 1 in. from its lowest point, and it can be adjusted for lengths of yarn from 10 in. to 30 in. The specimen is fixed in two small detachable grips, of which a number are kept at hand, by two serrated plates screwed together. These are hooked over round bars on the anchorage and at the point of percussion of the pendulum. The releasing catch (Fig. 2) engages a square bar on the pendulum automatically when the latter is pushed against it. It can be moved to any height on an arc (D) with no more trouble than the turn of a thumbscrew. The height to which the pendulum rises is recorded by a light aluminium pointer (E) held stationary by the light pressure of a pawl on the top edge of the recording arc (F). Both arcs are graduated in equal intervals of height which in the present instrument are 1/10th and 1/100th of the radius, but could as easily be made to correspond

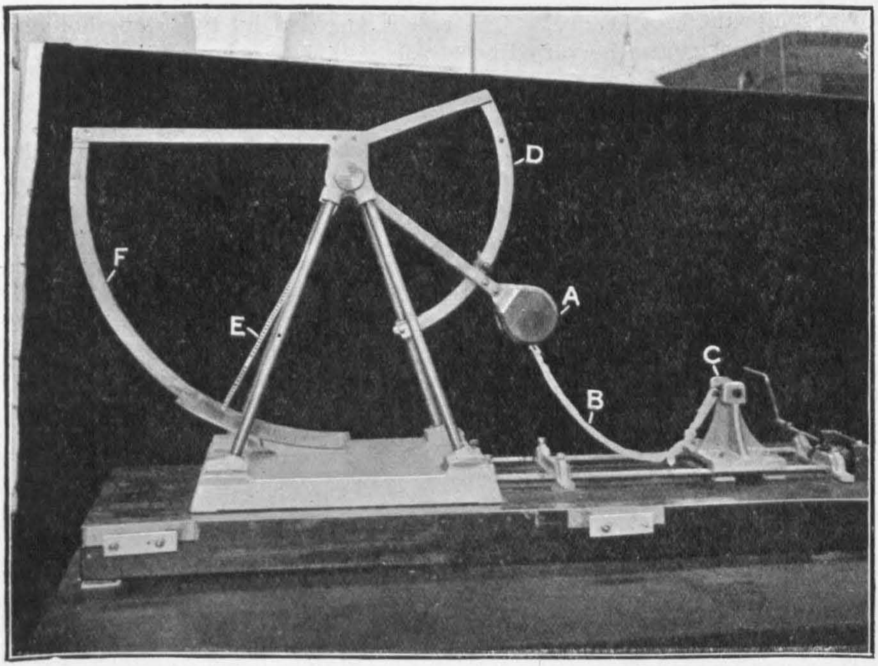


FIG. 1

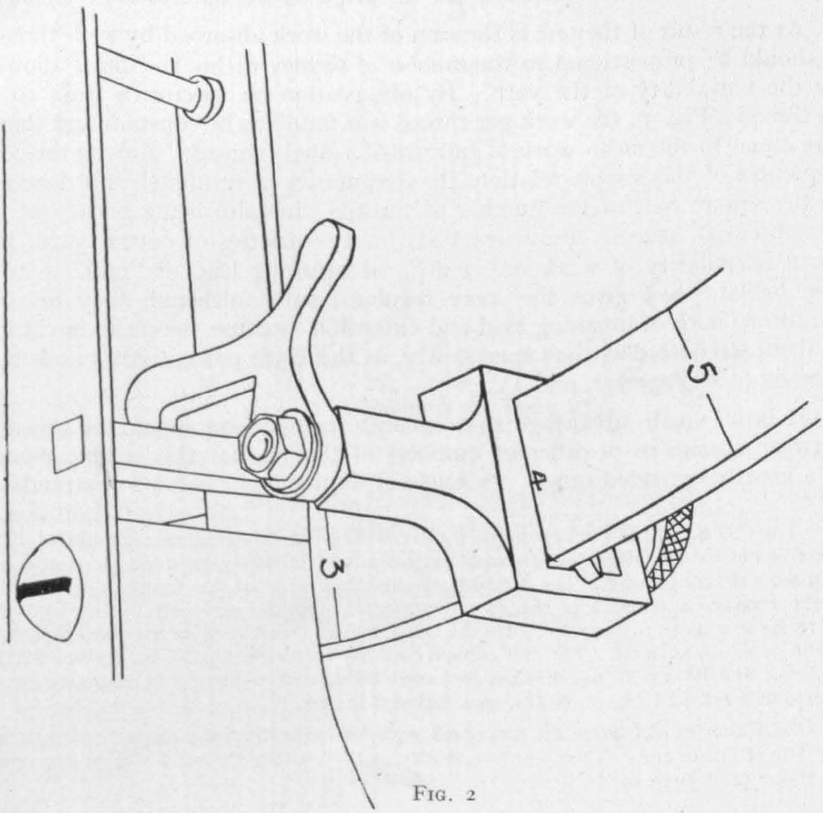


FIG. 2

to absolute units of energy.* The bob is fastened by two stout bolts so that the capacity can be varied by replacing it with a heavier solid bob or a lighter aluminium one.

Apart from questions of convenience, the essential feature of design is that no appreciable energy should be expended except in breaking the specimen. The grips and their anchorages must be rigid, so that they only yield by an amount negligible in comparison with the extension of the specimen. The frame and supports for the pendulum must also be rigid and the axle frictionless (in ball bearings). Furthermore, the pendulum must be designed to resist the impact, to minimise air resistance, and for proper balance, so that the grip can be fixed at the "centre of percussion." As in a cricket bat there is a point where the ball can hit without jarring the hands, so if the impact comes at the correct point on the pendulum, the whole weight acts as if concentrated at the grip and there is no impulsive force on the support or bending moments in the pendulum.

Before a series of tests the releasing catch is fixed so that the swing is sufficient to break comfortably the strongest specimen. A mean reading of 0·3 is sought, as this is in a sensitive part of the scale and ensures approximately the same velocity of the bob, i.e., rate of extension, at break for all tests. For testing leas, the yarn is wound on a wrap reel and the grips fixed at opposite diameters. The routine of a test consists in slipping the grips into position, pulling the releasing trigger, taking the reading, and swinging the bob back to the catch, which occupies in all perhaps five seconds, apart from the time required to fix the grips on the specimen.†

As the result of the test is the sum of the work absorbed by each thread, it should be proportional to the *number of threads* within the limits allowed by the variability of the yarn. By observation on specimens from 10 to 80 threads (Fig. 3), the work per thread was found to be constant and therefore equal to the mean work of rupture of a single thread. Among the consequences of this simple relation, the irregularity of results should decrease as the square root of the number of threads, this also being borne out by the observed figures. From lea tests on 17 varieties of cotton yarn, the mean irregularity of work was 3·46%, of breaking load or "pull" 4·56%. The ballistic test gives the more regular results, although they involve variations both of breaking load and extension, because the mean deviation of skein strength decreases very slowly, as the 1/5th power, with number of threads (*vide* Papers I. and IV.).

It is no small advantage that accurate comparison should be possible between specimens of different numbers of threads, for this is tantamount to a greatly extended range. A single or double tyre cord, a few strands of

* The C.G.S. unit is the erg or the joule ($10^7$ ergs) or the gramme.centimetre. The latter is most convenient for research purposes, and is the work done in raising one gramme one centimetre. The English engineering unit is the foot.pound, but for textile testing one-twelfth of this, the inch.pound, appears very suitable as it gives a figure for leas close to that given by the usual lea test, and because the extensions are of the order of an inch. The full capacity of the instrument is 80 in. lbs., or 92,170 gm. cm., that is, it will just break a specimen which will just bring to rest a weight of 80 lbs. in a fall of 1 in., or 40 lbs. in a fall of 2 inches.

† In a later model, grips are dispensed with for lea testing, the skein being hitched to a bar at either end. The complete routine is then distinctly quicker than the usual lea test. (2nd June 1926.)

sewing cotton, a lea of 50's and a double lea of 100's can be tested and compared, the total work of each being approximately the same and close to the capacity of the one instrument.

The variation of breaking load with *speed of break* is described in Paper III., and this effect may be expected to increase the work of rupture if a weak specimen is broken by the full fall of the pendulum. The results (*loc. cit.*) show a slight tendency to rise, perhaps 2% between readings at 0·2 and

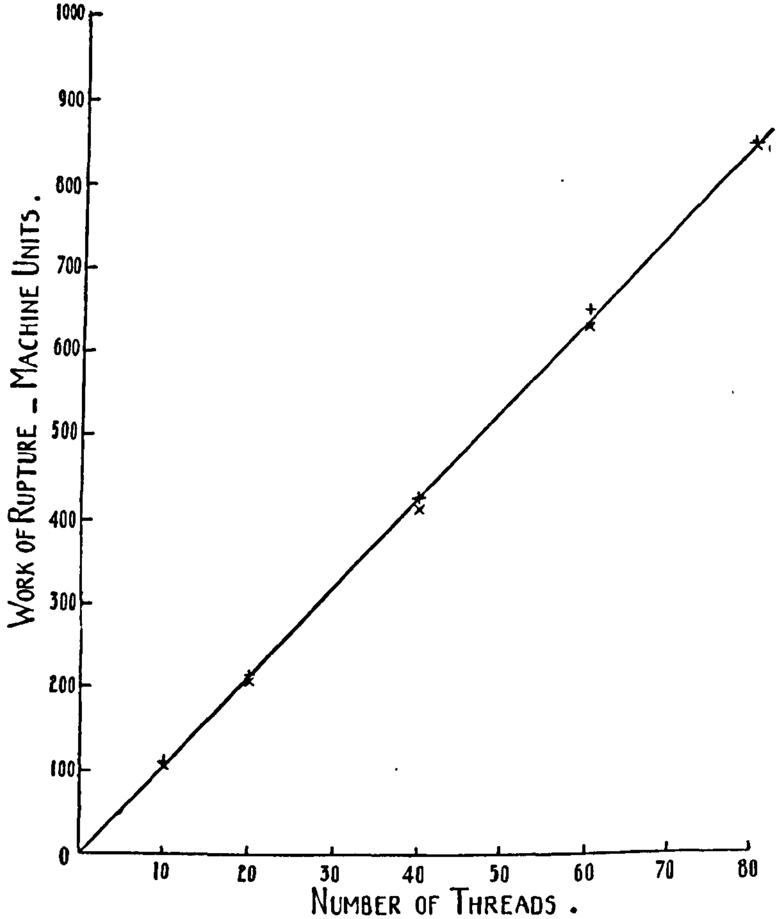


Fig. 3

0·6 on the scale graduated in fractions of the total capacity. In ordinary use the release is set to give readings always in the region of 0·3 to ensure a clean break and a sensitive scale. This also fixes the final rate of extension of the specimen, avoiding the effect of speed on breaking load, and giving the fairest comparison between materials of different strength and elasticity.

Comparison between the ballistic results and single-thread properties measured in other tests is mainly conditioned by the relation between breaking load and speed, and is made clear by a consideration of autographic load-extension curves (see below) and by the experiments described in Paper III.

The work of rupture is not exactly proportional to the *length of specimen*, but becomes so by subtracting a small constant amount. The relation is fully accounted for by the decrease in breaking load with strength owing to irregularity, as found in Paper I., together with a smaller effect due to the more rapid break of short specimens. The energy absorbed at the point of rupture in pulling the hairs apart seems too small to have a measurable effect. For routine testing the length of specimen should be kept constant for the same reason as in single-thread testing, the irregularity along the length.

While designed primarily for testing skeins of yarn as wound on a wrap-reel, the ballistic tester can be used equally well for single tapes of yarn, thus facilitating the use of the "*cut-skein sample*" method. Control tests show a striking degree of identity between sets of halves and such samples are used regularly and confidently for isolating and measuring very small effects in tendering by light or acids, &c.

The rapidity of the test allows the testing of yarns in a state which cannot be maintained for more than a few moments, e.g., bone dry. It is therefore particularly suitable for use in conjunction with the humidified box where a controlled room is not available. The specimen, previously fixed in the detachable grips, can be removed and tested before any change in moisture condition can occur.

Very regular results have been obtained on cords, tapes, strips of duck and wires, the only adaptation being a special form of grip if necessary. In a set of 12 tests on single copper wire the maximum variation was from 84 to 93 units. though the total energy absorption was not one-tenth the range of the instrument. As a routine test for artificial silks, this method avoids the long plastic flow which detracts from the value of measuring breaking load and extension at slow speeds.

The machine comprises a heavy pendulum mounted on ball bearings, with a scale and pointer to record its maximum deflection. It is therefore essentially of the same construction as a standard *lea tester*. A semi-circular pulley is fixed at the axis to strengthen the pendulum and to assist in obtaining the proper balance or position of the centre of percussion. This also serves as a pulley over which a flexible strip with a lea tester hook can be affixed in a second (Fig. 4). A winding apparatus with lower hook is permanently fixed at the end of the stand, and can be operated either by hand or motor. The results are identical with those of an ordinary lea tester.

Expressed in inch-pounds the ballistic work of a lea is usually a fraction greater than the "pull" in pounds, but the fraction is variable, as the latter is subject to the many disturbing factors not affecting the work. Its relation to single-thread breaking load depends not only on the extensibility and on the shape of the load-extension curve, but also on the effect of speed, which may vary according to the yarn. Roughly the results by the different tests are of the following relative order—Single-thread, 6 oz. (60 lbs. per lea); Moscrop, 7·5 oz. (75 lbs. per lea); lea test pull, 44 lbs.; ballistic work, 55 inch.lbs.; but they cannot be calculated one from the other.

The ballistic tester described above has been in regular use in this laboratory since the beginning of 1924, and has proved in practice a thoroughly trustworthy and convenient instrument for routine testing. A model, even more serviceable and simple in construction and operation, is at present under construction.

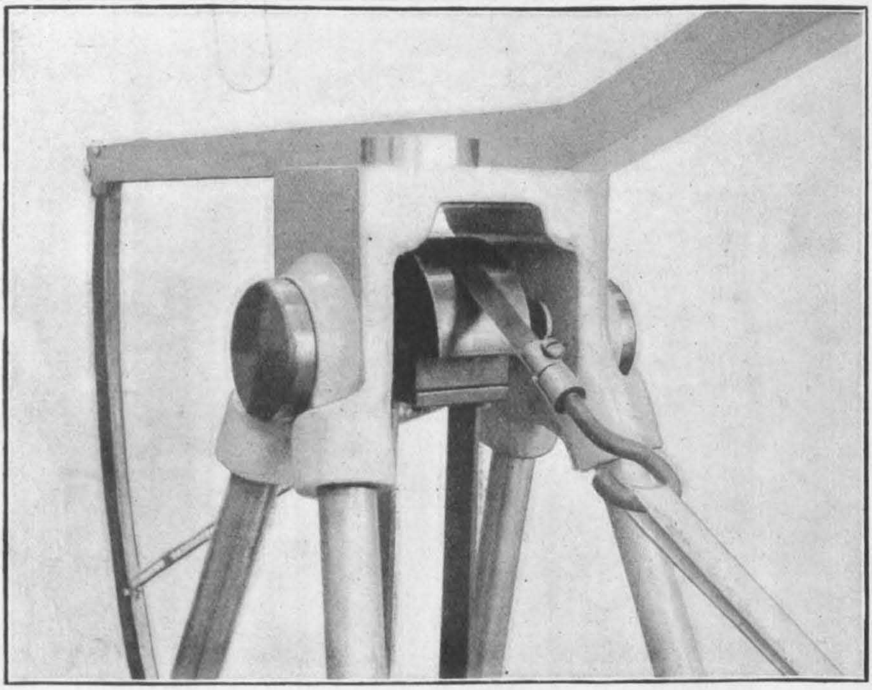

FIG. 4

**Load-Extension Curves**

An understanding of the quantity, work of rupture, which is measured in the ballistic test, and of the relation between this and single-thread tests, may best be obtained by a study of curves of load against extension. They also provide another method of measuring work of rupture and have great use in research, as distinct from routine testing, on unfamiliar kinds of thread, especially in conjunction with the ballistic tester.

Several instruments have been described or manufactured for tracing such curves, most of which are complex and have mechanical magnifying devices which introduce forces too large in comparison with the light load on a yarn. The simplest and soundest for yarn testing appeared to be that described by Shorter and Hall,[6] which has the great advantage of being usable at high speeds. In Fig. 5 a modification of their instrument is illustrated, designed for testing cotton yarns. The lower grip is made adjustable for lengths up to 25 in., and the record is made by a gramophone needle on a smoked glass plate. (The record of a fine pen on a polished card is not much coarser, and is quite satisfactory for most purposes.) The upper grip is fixed to the spring by a very light frame of duralumin. A steady rate of loading is obtained by attaching the carriage to the piston of a single-thread tester, but it may be driven also by hand, motor, or falling weights. Otherwise the principle of the machine and the diagrams are as described in the paper cited.

A few examples will show the use that can be made of these load-extension curves. Fig. 6a shows the trace given by a strand of nickel wire. The horizontal line is that traced when no specimen is mounted and marks

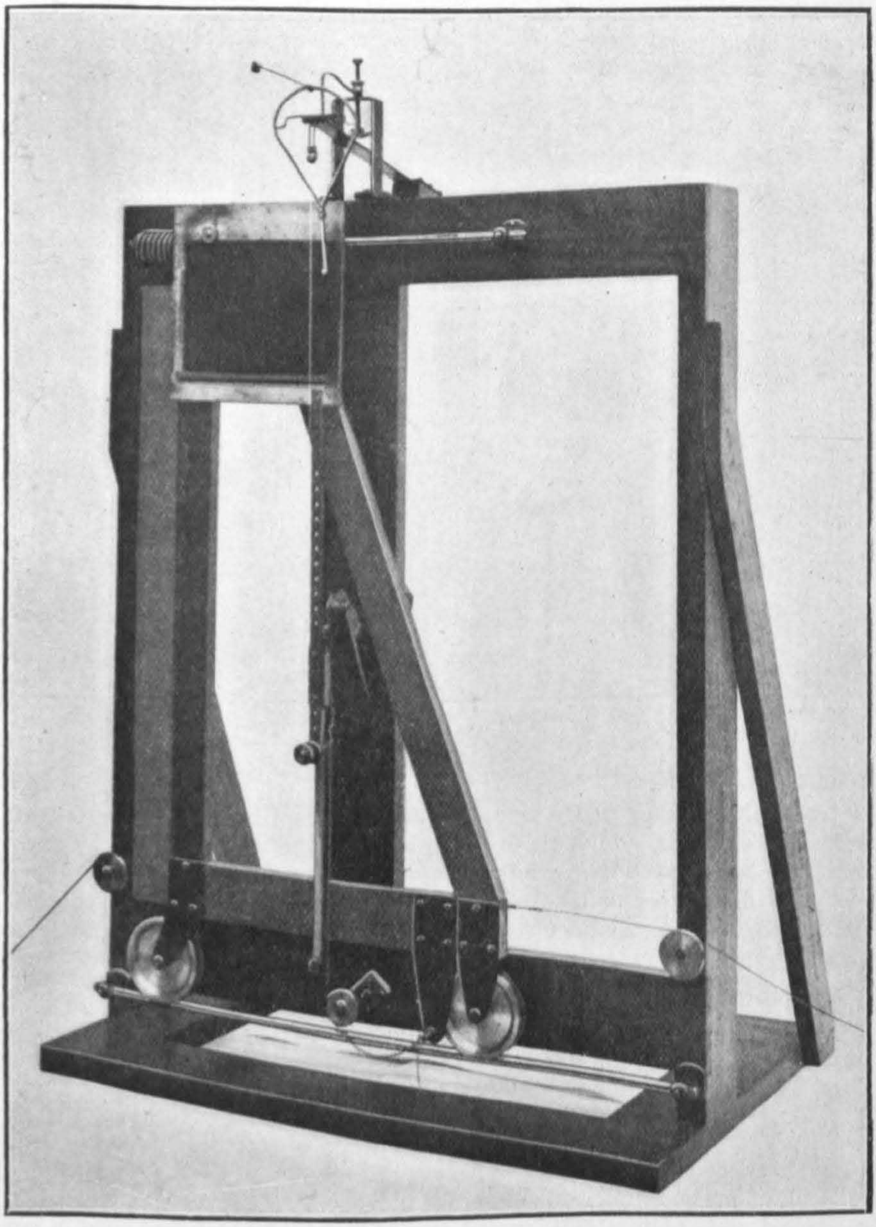

FIG. 5

the zero of tension, the line at 45° to it is traced when the grips are connected by an inextensible specimen, a metal chain, and marks the zero extension. On the trace given by the nickel wire the vertical distance from the first measures the tension, the horizontal distance from the second the extension. In Fig. 6b, the trace is redrawn so that the horizontal distance from the origin is equal to the extension, i.e., in rectangular co-ordinates. This curve is typical of most simple materials. At first the trace is straight and the extension is proportional to the load, independent of time, and perfectly elastic. Then, at the yield point, it increases more rapidly, and in this region the specimen would extend without further load and would retain some extension if unloaded.

Fig. 7, traces given by Celanese and viscose, shows that artificial silk follows a similar course, but the latter "plastic" portion is longer, and the elasticity is not so truly perfect in the straight portion. On Fig. 8 are compared traces of 36's Sakel yarn, sized and unsized. Fig. 9 shows that of a yarn, spun to counts too high for the quality of the cotton, which broke by pure fibre slip instead of snapping like an ordinary yarn. The varying form of these curves shows how differently materials may behave under tension and the very limited information given by measurements at break alone.

The resistance of a cotton yarn to extension is shown more clearly by Fig 10. The simple trace A is that given by a 36's Sakel yarn loaded steadily to rupture, the other of a similar yarn put through a more complicated operation. At low tensions the trace is slightly concave, the resistance increasing as the twisted fibres straighten and press together. Under steady loading it then becomes straight till the thread breaks, but, as the second trace shows, this straight line does not mean truly elastic extension as in metals, but depends on the steady rate of loading. At B the carriage was held still and the thread continued to extend under a decreasing load. On releasing the tension, it was found that a large portion OC of the extension remained, part of which was permanent, whereas part was slowly recovered from, for after a few minutes rest tension began again at D. Increasing the tension steadily again, the yarn passed through its former state at B, and then behaved in the same way as the first yarn loaded steadily. At E the tension was kept constant, but the yarn continued to extend slowly and appeared to come to rest. Further tension was added and again maintained constant at F. The yarn continued to extend for about a minute, when it broke at a load much less than the breaking load of the first, but with an extension not appreciably different.

On Fig. 11 are the traces given by two threads loaded steadily, one very slowly, one quickly, the breaks occupying 100 and $\frac{1}{3}$ sec. respectively. The latter has a lower breaking load, but the final extensions are nearly the same. A change of breaking load with speed is thus a real property of the yarn, while no evidence could be found (Paper III.) of any significant change of final extension.

In Fig. 12 each little figure made by the shading is equal to the product of a portion of the extension, and the tension producing it, whilst the whole shaded area gives the work of rupture. The area increases as the speed is increased, for example, the work of rupture of a 36's Sakel yarn in gram. oms. per cm. was 9·7 at slow single-thread speeds, 12·2 at Moscrop speeds, while the faster ballistic test gave 14·7.

The work of rupture may be expressed as a constant factor multiplied by the product of breaking load and final extension. The factor is 0·5 if the trace is a straight line, and for unsized single yarns it is usually between 0·5 and 0·4. The factor for a batch under test can be obtained from 10 load-extension curves, and the work of rupture then calculated from the mean product of load and extension found on the deadweight tester. The advantage of this is that the test on the Shorter and Hall instrument is

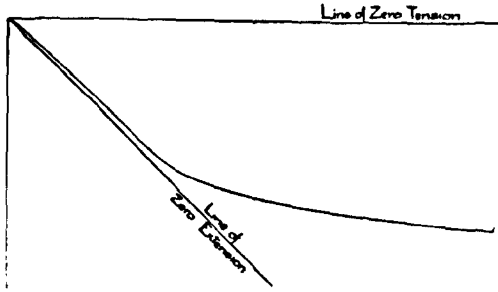


FIG. 6A

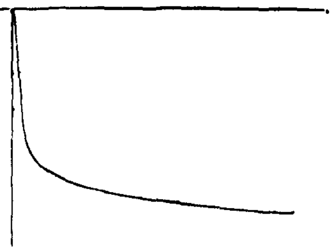

FIG. 6B

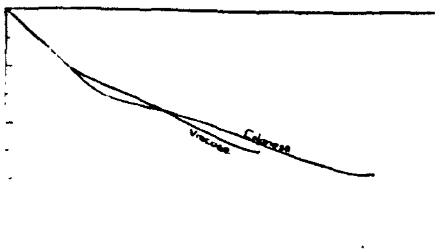


FIG. 7

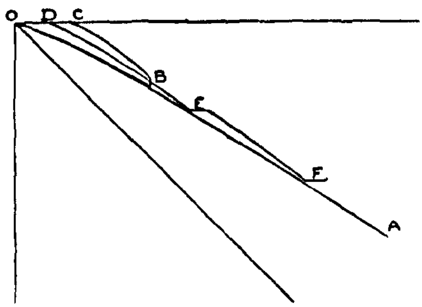


FIG. 10

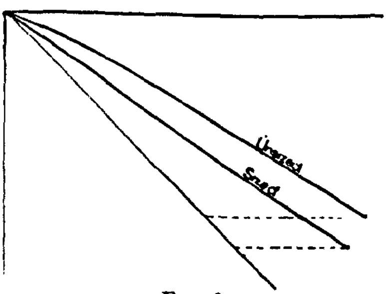


FIG. 8

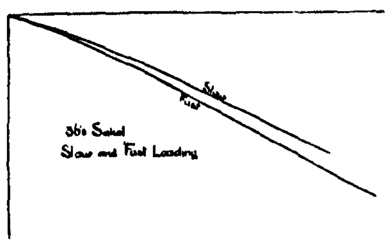


FIG. 11

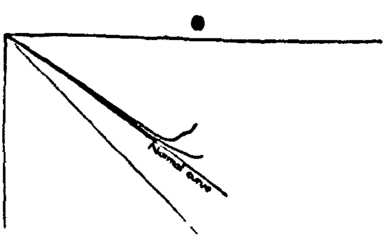


FIG. 9

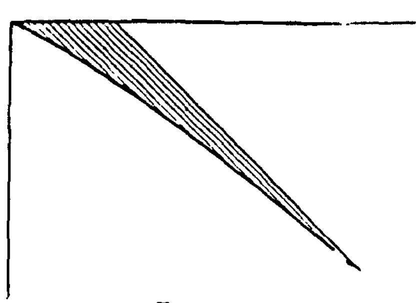

FIG. 12

slow and laborious compared even with the usual single-thread test. Autographic tests at high speeds may also be used to obtain a value for the extension and "work factor" from which to calculate the breaking load at ballistic speeds, and the several tests thus check and complement each other.

## DETAILS OF EXPERIMENTS WITH THE BALLISTIC TESTER

The dynamical principles of the instrument are analysed in Paper IV.

### Number of Threads

The proportionality between work of rupture and number of threads was tested on two sets of specimens of 80, 60, 40, 20 and 10 threads, with the results shown in Table I and Fig 3.

**Table I.**

Work of Rupture of Varying Number of Threads.

36's Sakel yarn, 26·5 inches in length. Reading in 1/1,000th of machine capacity.

| No. of threads ... | 80 | 60 | 40 | 20 | 10 |
|---|---|---|---|---|---|
| Release ... ... | 1,100 | 900 | 700 | 500 | 400 |
| Reading— | | | | | |
| 1st set of 20 ... | 245±5·0 | 264± 3·3 | 283±2·2 | 294± 2·0 | 294± 0·9 |
| 2nd set of 20 ... | 243±3·8 | 245± 3·5 | 273±3·1 | 286± 1·6 | 290± 0·6 |
| Gm. cm. per thread— | | | | | |
| 1st ... ... ... | 985±5·8 | 977± 5·1 | 961±5·1 | 950± 9·2 | 977± 8·3 |
| 2nd ... ... | 987±4·4 | 1006± 5·4 | 984±7·1 | 986± 7·3 | 1014± 5·1 |
| Mean ... ... | 986±5·2 | 992±11·1 | 973±9·9 | 968±14·7 | 996±14·4 |

The work of rupture of the specimens is proportional to the number of threads, for the work per thread shows no consistent variation with number, nor are the differences of statistical significance but due to sampling variations alone.

As the result is a simple sum, its irregularity should decrease as the square root of the number of threads. The irregularity of the product of breaking load and extension was found on the 30-in. specimens of Table II., Paper I., to be for single threads, 12·4%; for the mean of 10 threads, 4·1%; and for the mean of 80 threads, 1·4%. In the above results it is for 10 threads, 4·2% and 2·6%, for 80 threads 3·0%, and 2·3%, which is as near as sets of 20 results could be expected to give.

### Length of Specimen

The work of rupture will not be exactly proportional to the length of specimen for the following reasons—

(1) The breaking load decreases with length owing to irregularity, and the extension decreases in the same proportion.

(2) The time occupied in stretching to rupture increases in proportion to the length.

(3) The work absorbed in pulling the hairs apart and breaking them at the actual point of rupture is a constant addition to the energy absorbed in stretching the whole length.

All three make the work on shorter lengths proportionately greater.

The effect was measured on 11 in. and 30½ in. specimens of the 36's Sakel yarn, one of each being cut from a skein of 30 turns. The results obtained on 25 of such pairs and on 24 specimens of 24 in. length wound alternately are shown below—

| Length | 11 in. | 30½ in. | Difference | 24 in. |
|---|---|---|---|---|
| Gm. cm. per thread | 483±2 | 1126±5 | 643±4 | 917±5 |
| M.D. ... ... ... | 13 | 31 | 26 | 26 |

These three points lie very exactly on a straight line, giving the work as a small constant amount added to an amount proportional to the length. The pairs define this relation for the work in gm. cm. per thread of length L cms., as

$$W=119\cdot6\ (\pm0\cdot3)+L.13\cdot0\ (\pm0\cdot1).$$

For the 24 in. length this gives $912\pm6$, which is statistically the same result as that observed, and 994 for the 26½ in. length, in good agreement with the results on Table I.

The constant amount, 119·6, is equivalent to an extension of 4·6 cm. at the maximum tension, and if the last effect (3) were responsible for the whole amount, it would mean that a resistant extension of this order occurred at the place of rupture. The load-extension curves show that this is not the case, and it is doubtful whether any appreciable energy is absorbed at the ruptured portion, for the first two effects are sufficient to explain the greater strength of shorter lengths. From the two sets of single-thread tests on 10 in. and 30 in. lengths of this Sakel yarn (Table I., Paper I.), the correction to the product of load and extension of 30 in. lengths necessary to make it equal to that of 10 in. lengths would be 0·4% and 19·9% respectively, the theoretical amount calculated from the irregularity being 19%. From the results given in Paper III., the correction for the trebled speed should be about 3·6%. As an addition of 18·9% to the work on the 30½ in. lengths would reduce the constant amount to zero, only a small proportion of it can have the physical significance of work absorbed at the break.

**Ballistic Machine Used as a Lea Tester**

The following tests were performed on alternate windings of the various yarns with a standard lea tester and the ballistic machine used as a lea tester (Fig. 13). For this use the latter is as circumscribed in range as any other deadweight instrument, and 30 turns of the stronger yarns had to be compared with 40 turns on the heavier standard tester. This can be done by multiplying by 4/3, as the difference is not great enough to introduce the complications discussed in the last paper.

Tests on 10 specimens with each Tester. Breaking loads in Pounds.

| | |
|---|---|
| Leas of 60's West Indian yarn:— | Half-leas of 36's Egyptian ring yarn:— |
| Standard $44\cdot2\pm0\cdot8$, M.D. 6·2%. | $49\cdot5\pm0\cdot4$, M.D. 3·2%. |
| Ballistic $44\cdot1\pm0\cdot4$, M.D. 3·0%. | $53\cdot2\pm0\cdot3$, M.D. 2·9%. |
| Half-leas of 36's Sakel yarn:— | Half-leas of 32's Egyptian yarn:— |
| Standard $53\cdot5\pm0\cdot4$, M.D. 2·7%. | $52\cdot2\pm0\cdot4$, M.D. 3·0%. |
| Ballistic $55\cdot9\pm0\cdot4$, M.D. 2·7%. | $51\cdot1\pm0\cdot3$, M.D. 2·0%. |

As is to be expected, there is no significant difference between the results. If anything, the ballistic machine gives rather less variation, which may be a real difference, as the friction is less and the pointer stops dead.

Greater range can be obtained by replacing the bob with a heavier one or by affixing weights to the stem of the pendulum. Calibration is done conveniently by hanging weights and readings converted by a graph from the ballistic scale or taken directly from a deadweight scale on the reverse side of the recording arc.

It must be remembered that the results of such a lea test are of a lower order of accuracy than those of the ballistic method, and do not give a mean value of breaking load. In particular, they cannot be used in combination with the work of rupture to find the breaking load and extensibility separately except in a very rough, comparative way.

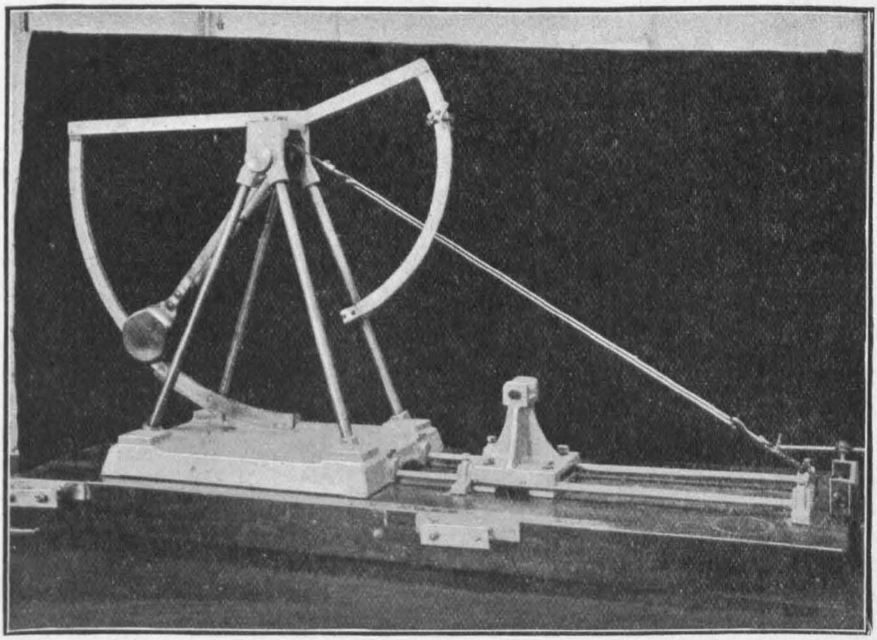

Fig. 13

**Cut-Skein Samples**

In a control test on 25 windings of 30 turns of 36's Sakel yarn, one set of halves gave a mean $313{\cdot}68 \pm 1{\cdot}14$ work units, the other $312{\cdot}44 \pm 1{\cdot}16$. The absolute differences between the corresponding halves were distributed thus—

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Difference ... ... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11...15 |
| Frequency ... ... | 1 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 1 | 1 | 1... 3 |

As 15 of the 25 differences are 6 or under, the probable difference between two halves of one winding is under 2%. With specimens nearer the capacity of the instrument, 1,000 units, and more threads, the probable difference should be correspondingly diminished.

This test was done on a very regular yarn, but was repeated on one of the roughest and most irregular obtainable, a 20's waste yarn. On 50 pairs of "cut-skein samples" (30 turns), the mean of one set was $217{\cdot}62 \pm 1{\cdot}88$, of the other $217{\cdot}74 \pm 1{\cdot}99$, and half the differences were under 6, the distribution being—

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Difference ... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| Frequency ... | 6 | 5 | 2 | 4 | 5 | 3 | 5 | 3 | 3 | 4 | 1 | 3 | 0 | 2 | 2 | 1 | 0 | 1 |

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