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Editorial Notes

The quaint and witty cleric Fuller descanting on books has left on record that "learning has gained most by books on which the printers have lost." In setting sail on our second voyage we wish it to be understood we have no desire to be included in Fuller's superlative series, nor that learning should profit without recognition, so we request our readers to send their own and any other subscriptions they can secure as soon as possible.

The Specialist Demonstrations and Lectures for Sept. are:

"The Prevention of Specky Goods," by Mr T. Boland, Saturday, 20th Sept., 3.15 p.m. (Technical College, Galashiels). Demonstration and discussion.

"Co-Partnership," by Dr T. Oliver, Thursday, 26th Sept., 7.15 p.m. (Technical College, Galashiels). Medals and Certificates for last session will be presented before the lecture.
The S.W. Technical College session will commence as follows:—Elementary lectures on Thursdays (commencing 11th Sept.), will comprise: Preparatory Yarn Processes, 9.20 a.m.; Wool Technology, 11 a.m.; Calculations, 1 p.m.; Weaving Processes, 2 p.m.; Designing, 3 p.m.

Intermediate, do., on Fridays (commencing 12th Sept.): Carding, 9.20 a.m.; Pattern Analysis, 10.50 a.m.; Calculations, 1 p.m.; Dobby Looms, 2 p.m.; Designing, 3 p.m.

Advanced Designing, do., on Mondays (commencing 8th Sept.): Pattern Analysis, 9.20 a.m.; Jacquard Designing, 11 a.m.; Setting and Costing, 1 p.m.; Shaft Designing, 2.45 p.m.

Advanced Manufacturing, do., on Tuesdays (commencing 9th Sept.): Yarn Manufacture, Part I., 9.20 a.m.; do., Part II., 10.45 a.m.; Cloth Finishing, 1 p.m.; Weaving Mechanism, 2.45 p.m.

The experimental departments will be open from 8.30 a.m. to 12 noon and 1 p.m. to 4.30 p.m. daily (except Saturday, 12 noon in the summer term and Wednesdays, 3 p.m. A special course will be arranged on Saturdays for advanced students, and for the full day course there will be a number of lectures supplementary to the above.

The fees are £10 per session of two terms (members), £20 (non-members), £50 foreign students. Special courses scheduled above, 30/- members, £3 non-members. Departmental apprentices’ full day course, £3. Correspondence courses, 42/- members’ nominees; 84/- non-members.

Scotch farmers expect a much higher price for wool than manufacturers are prepared to pay at present, and are disposed to hold up the clips. Due to the severe winter, much Cheviot wool is faulty, broken in staple and impoverished, indeed many sheep were in the process of shedding their fleeces before normal shearing time, due to tender parts in staple. Over a range of years “holding wool” does not pay, because interest on money is lost, and possibly of being caught in a slump is not a remote contingency. Many Welsh farmers carried over 1919 and 1920 clips refusing 32d per lb., and in 1921 were holding three clips worth 5d per lb., and had lost 5 per cent interest in process.

Mr H. Maldwyn Williams (Drapers’ Scholar, 1921) has capped his brilliant Technical College record by passing the Inter. B.Sc. exam. of London University in July. This has entailed work which was all in excess of the normal strenuous course of technical study at the College. He is son of Rev. Howell Williams, Pontypool, and nephew of Mr J. R. Jones, wool manufacturer, Blaenau Festiniog, North Wales.
The splendid results attained in recent years by students of the Scottish Woollen Technical College, Galashiels, in connection with the examinations of the City and Guilds of London Institute, are maintained without diminution this year. As usual, most of the woollen and worsted prizes have come our way. Nine medals have been gained as follows:—

Thomas G. McLaren—Woollen Yarn Manufacture—1st prize, Final, £3 and S.M.

H. Maldwyn Williams—Woollen and Worsted Weaving, Div. I. (Designing)—1st prize, Final, £3 and S.M.; Woollen and Worsted Weaving, Div. I. (Finishing)—1st prize (equal), Final, £1 10s and S.M.

Alexander Goldie—Woollen and Worsted Weaving, Div. I. (Finishing)—1st prize (equal), Final, £1 10s and S.M.

Robert A. H. Croshie—Woollen and Worsted Weaving, Div. I.—1st prize, Grade II., £2 and B.M.

Wm. P. H. Sinclair—Woollen Yarn Manufacture—1st prize, Grade II., £2 and B.M.; Woollen and Worsted Weaving, Div. II.—1st prize, Grade II., £2 and B.M.; Wool Dyeing—1st prize, Grade I., £2 10s and B.M.

Wm. M. Anderson—Wool Dyeing—2nd prize, Grade I., £1 10s and B.M.

S.M.—Silver Medal. B.M.—Bronze Medal.

The three remaining medals for which our wool manufacture students competed were gained as follows:—


Final Weaving Mechanism—Frank Lumb, Technical College, Halifax.

The chief textile teacher in Batley Technical School is Mr J. P. Twohig, Bradford, a former student in the Technical College, Galashiels, and medallist Final Mill Management in 1911.

College Silver Medals are awarded to H. M. Williams and Alex. Goldie, and Bronze Medals to Jas. Moffat and Jas. McClory. During attendance at the College Williams has gained 7, Goldie 4, McClory 3, Moffat 2 City and Guilds medals. They have completed the normal course with distinction, but will take a further year of post-graduate study. H. M. Williams has established a record for wool manufacture students which will be difficult to surpass.

The conditions and form of the College Diploma will be decided by the Governors at next meeting.
Mr D. K. Colledge, head of the dyeing and chemistry department of the Scottish Woollen Technical College, has been awarded the B.Sc. degree of London University with Honours in Chemistry and subsidiary Physics, on the result of the recent examination. He was placed higher than any other Scottish student who took the examination. The success is all the more meritorious when it is considered that his periods of study had to be snatched from a very busy life as lecturer on dyeing and chemistry in day and evening classes, organiser of evening technical classes, and consultant on the very varied problems presented by the Scottish woollen trade.

Recently a manufacturer advertised for a dyer, and amongst the applicants was a young man, Bachelor of Commerce, with Diploma in Dyeing of an English University, as well as City and Guilds final Wool Dyeing Certificate, capable of dyeing samples and of analysing every material used in a dyehouse, yet lacking the practical insight into dyehouse working which every manufacturer demands before entrusting many thousands of pounds sterling in the shape of wool and yarn to his care. The Universities are working much on the principle of a manufacturer making stock, regardless of his products being unsuitable for the market. There comes a time when, like that manufacturer, they must stop making unsaleable goods to be sold at far under cost. The educationists argue that industry is misguided because it fails to absorb their product, instead of studying what industry requires. The wise manufacturer makes samples and ascertains his customers' needs, discarding those disapproved. What would be thought of a manufacturer, after having a certain pattern passed over by every merchant in London, if he should persist in making 1000 pieces to that pattern? The late Professor Perry, in his inimitable fashion, once said that graduates were as like as buttons on a coat, but unlike the buttons they fitted nothing in particular. Technical departments of Universities and Colleges should be more closely allied to the industries which they profess to serve. Every student should spend half of his period of training in the mill. Five years should suffice to give a youth a sound basis in which to "practise" wool manufacture. He could devote a day per week and evenings to study for four winters, with one winter session whole time, while the five summers would be spent entirely in the mill.

The following students are now qualified for the College Diploma—


**Dyeing and Chemistry**—William J. McDonald, James McClory, James Moffat.
Mr Robert A. H. Crosbie, Peebles, has been awarded the Drapers’ Major Scholarship in Wool Manufacture of £100 per annum for 2 or 3 years, tenable at the Scottish Woollen Technical College, on the results of the City and Guilds examinations held in May.

Mr Lawrence Ewart, assistant with Messrs Reid & Taylor, Langholm, and student at the Scottish Woollen Technical College, Galashiels, has been awarded a Drapers’ Minor Scholarship of £20 per annum for 2 years.

Messrs Robert S. Milne, Peebles, and John D. Millar, Innerleithen, have also gained Drapers’ Exhibitions of £10 each.

Messrs Crosbie, Milne, and Millar are apprentices with Messrs D. Ballantyne Bros. & Co., Ltd., and attended the Technical College last session whole time under the firm’s “sandwich” system of training apprentices.

Mr Walter I. Blake, an apprentice with Messrs Wilson & Glenny, Ltd., Hawick, and a student in the Hawick evening classes, has also gained a Drapers’ Exhibition.

Since the apprenticeship scheme of Messrs D. Ballantyne Bros. & Co., Ltd., should be better known we have pleasure in describing its salient features. Immediately after the war, the directors of the firm foresaw the shortage of skilled labour, and proceeded to meet the difficulty by devising an apprenticeship scheme in twelve departments, e.g., an apprentice millman during his four years’ training will spend 6 months in the dye-house, 28 months in the millhouse, 6 months in the finishing room, and 8 months at the Technical College. Usually six of their apprentices attend the College every session. During the last-mentioned period which is taken at as convenient a time as possible, the firm pays full apprenticeship wage and College special fee for departmental training, while the Peebles County Education Authority pays the travelling expenses where the students’ finances require supplement. The firm must feel highly pleased with the way in which the students have responded to the generous treatment received. Hitherto no other firm has adopted a similar scheme, although several have modified schemes in operation. A conservative policy would urge that the training will probably help another firm which has never spent a penny on technical education. But the reformers are sufficiently far-seeing to hail the day when every firm will realise its responsibility to the corporation of which it is a member. The passive resisters will gradually pass into history.
The **Swedish** tariff on wool and wool goods is:—

**Wool**—Free.

**Yarn**—Undyed, under 41m./gram, kr.·20 per kilo or 1·2d per lb.

"  
over 41m./gram, kr.·30 per kilo or 1·8d per lb.

(46's wor.)

Add kr·05 to each for twisted yarns.

Add kr·15 to each for dyed yarns.

**Cloth**—Over 700 gm./sq.m. or 35oz. (58" × 38")

kr.·1·50 per kilo.

Between 700/200 gm./sq.m.

kr.·1·75 " "

Under 200 gm./sq.m. or 100 oz. (58" × 38")

kr.·2·25 " "

Over 300 gm./sq.m. (with under 3% silk)

kr.·2·50 " "

These figures correspond to 9d, 10¾d, 13¼d, 15d per lb. resp.

Men's wear garments, kr. 3 per kilo or 18d per lb.

Men's wear with silk linings, kr. 5·5 per kilo or 33d per lb.

Parcels post—3 lbs., 2/; 7 lbs., 3/; 11 lbs., 4/.

The **Danish** tariff on wool and wool goods is:—

**Wool**—Free.

**Yarn**—kr.·30 per kilo or 1·8d per lb.

**Cloth**—Over 750 gm./sq.m. or 37½ oz. (58" × 38")

kr.·80 per kilo.

Between 750/250 gm./sq.m.

kr.·1·20 " "

Under 250 gm./sq.m. or 12½ oz. (58" × 38")

kr.·1·30 " "

Over 250 gm./sq.m. or 15 oz. (58" × 38")

kr.·3·00 " "

With under 3% silk

N.B.—Artificial silk is reckoned as real silk.

These figures correspond to 4·8d, 7·2d, 7·8d, 18·1d per lb. resp.

Men's wear garments—15% ad valorem.

Parcels post—2 lbs., 1/6; 7 lbs., 2/; 11 lbs., 3/.

The **Norwegian** tariff on wool and wool goods is:—

**Wool**—Free.

**Yarn**—Undyed, kr.·20 per kilo.

Dyed, kr.·30 " "

**Cloth**—Under 220 gm./sq.m. or 11 oz. (58" × 38")

kr.·1·75 per kilo.

Other, with less than 3% silk,

kr.·1·25 " "

Wool clothing

kr.·2·60 " "

The above rates are multiplied by 1·9 at present and the figures correspond to 2·3d, 3·5d, 20d, 14·4d, 30d per lb., while the maximum rates exigible on goods from countries without reciprocal treaties are four times as great as the above rates which are scheduled as minimum.

Parcels post—2 lbs., 1/9; 7 lbs., 2/9; 11 lbs., 3/6.

Cable rate to Norway, Sweden and Denmark, 2½d per word.

A correspondent writes:—"The woollen mill people were worried by the Advertising Convention Americans into selling something and
in half-an-hour sold a good deal. But one of the Americans said that if they had tried more thoroughly and with a little more thinking they could have sold us five times as much. They did not seem to want to sell us anything, apparently from fear of upsetting retailers." My informant wants to see someone organise an all-round entry into the American market with all-wool material. He says, "We are rotten with money (i.e., have too much), we want to buy from you. I cannot buy in the States the good stuff I saw being made in Galashiels district."

[The above strengthens the first impression made on us, that the above American invasion comprised many actors who secured a cheap holiday, and wanted a cheap suit thrown in to the bargain. There is no excuse for a prosperous American failing to secure a Galashiels suiting through the regular channels, if he cares to spend the money. One loom's output would have clothed the whole Convention, so our manufacturers did right in denying the back-door trade.—EDITOR.]

Apropos of the advocacy of better advertising of Scotch tweeds, it seems strange that only one firm in Galashiels thinks fit to display a sign. Every mill in Lancashire has its name tersely stated on the chimney stalk. Thousands of visitors pass through "the Scott country," yet Galashiels presents a bill-board two miles long not utilised by the best woollen makers in the world. Let each firm have a name for its product. "Plusphor," "Nethergala," etc., can adorn the chimney stalks, and passers will speedily enquire the significance of the legends. The world generally does not know the names of Galashiels tweed manufacturers, and are thus easily deceived by impostors.

An Australian mill director writes:—"I cannot express in a letter how much I appreciate 'Scotch Tweed,' but it will give you some idea of how much I enjoy it when I tell you that I am like the young people who are anxiously awaiting for another chapter of an exciting story. It is both interesting and instructive, and I trust you are receiving sufficient support to keep it up to its present high standard."

Our friend, Mr Wm. Cronin, President, Irish Wool Manufacturers' Association, attributes trade depression to increasing demand for ready-made clothing, and urges need for protection. He might as well recommend sweeping back the Atlantic with a broom! Irish makers should cultivate the ready-made acquaintanceship more. Since Irish woollen wages are 25% lower than British, he has no case for protection, and should recommend better organisation in the mills.
London Shrinking.

With the more exacting demands of woollen merchants, the subject of correct moisture condition in woollen goods has of late become very important. In this connection we may refer to the enterprise of Messrs John Gladstone & Co., Cloth Shrinkers, Galashiels. This business is of long standing, but in the post-war years has been greatly extended, recently taking in a large cloth warehouse adjoining the old premises in which the London shrinking process was commenced. Thus the floor space available has now been more than doubled.

Formerly Gladstone's business was confined practically to shrinking and pressing, but since the war the difficult commercial relations existing between manufacturer and merchant has led to 90% of the goods shrunk being also measured and examined, so securing the stamp of a reliable referee.

Cloth is sent from far distant mills, e.g., whipcords from the South-West of England, worsteds from Yorkshire, and tweeds from all over Scotland. A striking feature is that many English firms send their pattern ranges to receive the impress of this firm's excellent workmanship. There is no doubt but that the handle and appearance of these low quality cloths are improved by the process, so that they can scarcely be recognised as the same goods which were sent to the shrinker. A hard file surface is changed so as to have a mellow handle. Some time ago we expressed astonishment to a manufacturer of lower grade woollens at the fact that his goods could bear the expense of London shrinking. He answered that his cloths needed improved finishing more than Scottish woollen cloths did, and that he could secure a much better price for shrunk cloths than for the same cloths sent from his mill. But Gladstone's main business is shrinking Scottish woollens and worsteds, and the success of the operation is evinced in the enormous increase in work which has come to Beechbank Works.

 Manufacturers send goods in every stage of finishing, sometimes from the tentering machine, while others steam and blow the cloth first, and so get rid of the creases arising in scouring, etc. Mr Finlay, the principal of the firm, states that the latter procedure is better, as it gives a better foundation on which the shrinker's art can be practised. The proper classification of cloths for distinctive finish is very important, e.g., Cheviots, Saxoines, worsteds, velours, vicunas, check-back overcoatings, piece-dye blacks and blues call for special attention. Many manufacturers use a blowing machine, and might as well omit the process through inattention to detail. All goods should be pressed before blowing. If a raw Cheviot cloth be blown with-
out pressing the handle will not be much improved, but if the cloth be steamed, pressed, and then blown, the last-mentioned process will tend to fix the pressing on the piece. Of course, that procedure calls for extra labour, and in these days of high costs the firm is apt to demur at incurring extra expense, but the result will repay the means taken to secure. The machinery is thoroughly up-to-date; the hydraulic press equipment has recently been doubled so as to cope with 120 more pieces per day. Several narrow-width presses are still retained for Huddersfield worsted trouserings, North of Scotland homespuns and cheviots, as well as for samples and ranges. We were astonished to hear that so many 29 in. width pieces are still in demand; we had thought that such had practically ceased to be made except by crofters, etc. The pressing department is equipped with the latest labour-saving devices, changing the pressman’s job from a back-racking occupation to one which is as easy as any other in the mill. Every mill should be equipped in the same way, and we recommend manufacturers to write Messrs Aimers, McLean & Co., Ltd., Engineers, Galashiels, for complete specification. A description of a similar plant will be found in a lecture on “Tweed Finishing” by Mr Donald Brydon, Hawick, published in the “Scotch Tweed Specialist Year Book, 1923.”

A very large export trade is done with America, Japan, and Scandinavia. About 24 Swedish firms appear in the book, and several in Denmark, but Norway seems to have dropped below Scottish standard altogether. Practically every country in Europe claims attention; even Esthonia, Czecho-Slovakia, Serbia, and Rumania, figure in the list. But in glancing over the pre-war list the gloomy consideration arises that the demand from many famous German firms has been reduced to skeleton dimensions.

A correspondent writes:—We have been carrying out another series of research experiments with various raw oils on wools. You will be interested to see the enclosed sample of top which has been impregnated with the fatty acids of whale oil, a commodity which is on the market commercially, and which has been largely used in the textile industry. The sample in question was hung in the window of our laboratory for 15 days. It has been extracted with boiling ether for an hour, and you will see the yellow stain. This proves the necessity of the oil used for woollen manufacturing being perfectly free from whale fish oils and their derivatives.

Messrs Platt Bros., Ltd., Oldham, have agreed to supply the Sanderson-Boland spinning invention at moderate cost.
Carding Calculations.

Belt Drives.—Calculating the length of a belt gives a better result than by measuring with a tape, or string, as we cannot draw a tape as tight over the pulleys as the running belt is. After tape measurement a belt sometimes needs a good piece cut out. Subtract 2" for balata, and 1" for leather, from every 10 feet of dead length to allow for stretching of new belt. Length of open belt = twice distance between centres of shafts + average diameter of pulleys \times 3.14.

What length of belt is required for a main drive, distance between centres = 20 feet. Average diameter of pulleys = 30" or 2 1/2". Then $2 \frac{1}{2} \times 3.14 + 20 \times 2 = 47.85$ (dead length), $47.85 \times 4.8$ (or $4.6$) = 477 1/2" length of leather belt to order.

In calculating for cross belt, we must first find the hypotenuse of the right-angled triangle formed by the distance between centres and the mean of the pulley diameters. This does not take into account the slight curvature of the belt as it passes from the centre of the pulley face to the point where it leaves contact, but for practical purposes it is near enough. To install a cross belt on the foregoing pulleys.

Hypotenuse = $\sqrt{20 \times 20 + 2.5 \times 2.5} = 20.15$'

Then $48.15 - 2.4$" (1/2 deduction to make up for slight curvature) = 48" length to order.

Wheel Trains.—Velocity Ratio = Number of turns of driving wheels ÷ Number of turns of driven wheels. The pitch circle of two wheels passes approximately through centres of the teeth elevations, and in measuring the pitch when ordering new wheels, we must measure from the centre of one tooth to the centre of the next or (as I prefer) from the edge of one tooth to the edge of the next, which gives the same result. Let $N =$ rev. of big wheel ($D$, diameter) of $T$ teeth, $n =$ revolutions of small wheel ($d$, diam.) of $t$ teeth. The length of circumference passing point in one minute = $\pi DN$. Then $\pi DN = \pi dh$ and $TN = tn$ or $n = NT/t$.

The condenser train of wheels is a clock train and follows this law.

Rubber Calculations.—Doffer Wheel, 268 teeth, driven pinion 24 teeth, Driver on same bush = 32 teeth. Rubber shaft change wheels 26 and 25 size of rubber rollers, $2 \frac{7}{8}$ rubber $\frac{7}{8}$ thick, play when running as $\frac{1}{2}$", doffer 36" add $\frac{7}{8}$" to diameter for card. From these particulars calculate effective speed of material taking thickness of 18 cut slubbing as $\frac{1}{4}$" and assume that it is $\frac{3}{8}$" buried in doffer teeth and stands out from stripper the same amount as the thread when rubbed. Size of stripper with card, point to point, $2 \frac{1}{16}$" stripper wheel 26 teeth.

Doffer = $36 \frac{7}{8} \times 3.14 = 115.9$, 0-0%
Striper = \( \frac{268}{24} \times \frac{32}{26} \times 2 \frac{1}{16} \times 3.14 = 110.7" \), \(-4.5\%\)

1st Rubbers = \( \frac{268}{24} \times \frac{32}{26} \times \frac{85}{32} \times 3.14 = 114.7\), \(-1.0\%\)

2nd Rubbers = \( \frac{268}{24} \times \frac{32}{25} \times \frac{85}{32} \times 3.14 = 119.3\), \(+2.9\%\)

With other particulars we get:— Doffer = 115-9, 0-0%; Stripper = 115-0, -0.8%; 1st Pair = 119-0, +2.6%; 2nd Pair = 123-8, +6.7%.

Thus the stripper is losing -85% on the doffer, but as this roller travels heel first we must look upon it as a bare roller. Thus it is not out of reason to suggest that the material (naturally curly, full of life and electricity, being combed straight when placed into doffer teeth, contracts this amount when released from doffer teeth to this smooth roller, which has little or no grip on it and simply acts as a stripper and carrier. This may also explain the reason why a slow stripper gives a yarn which stretches more when spun (see Carding Notes, T. Boland, November, 1923, Scotch Tweed). If the stripper is run faster than this it keeps a tension on the material which is already straight and we must also put on tension at the first pair of rubbers to pull the material down between the divider points. Thus we have two distinct tensions on the slubbing where it can stand little, but if we contracted a little on the stripper, the slight tension on the first pair of rubbers is not so severe and calculation shows +2.63% on doffer (of course, it is more than that on the stripper), sufficient to keep the material down in the divider and avoid double ends. If the stripper was nearer the speed of the doffer possibly 25 or 24 teeth wheel needed on the rubber shaft and the gain on the doffer would be over 6% in the case of 25 and correspondingly more with 24 wheel. Thus it can be readily seen how this affects the thread at this point. Wool varies in loftiness on the doffer thus we cannot make any definite allowance with certainty.

**Speed Calculations.**—Line shaft = 96 revs. carding engine pulley = 32". What pulleys would be required to drive carding engine at 90 for Saxony, 75 fine Cheviot, 60 Harris, not allowing for slippage of belts. The speeds are inversely as the diameter of pulleys.

- \( \frac{32 \times 90}{96} = 30" \) pulley for Saxony;
- \( \frac{32 \times 75}{96} = 25" \) Cheviot;
- \( \frac{32 \times 60}{96} = 20" \) pulley for Harris.

**Surface Speed.**—What is the surface speed of a fancy in feet per min., when cylinder 90 revs., 36" body pulley, 8" fancy pulley, diameter of fancy from point to point 14". Then \( 14/12 \times 36/8 \times 90 \times 3.14 = 1485' \) per min.

**Belt and Cog Wheel Drives Combined.**—The doffer offers a good illustration. What is the speed of a doffer in revs. per min. when cylinder, 90 revs., 6" pulley on cylinder shaft, 18" doffer wheel, 24 teeth pinion, large cog on doffer shaft wheel 232 teeth?

\( 90 \times 6/18 \times 24/232 = 3.1 \) Revs. per min. doffer speed.

To know what effect the varying speed of doffers has on wool being carded, and what to do when more blending power required, are very
desirable ends to achieve. The following calculation shows how many doublings a doffer makes with a cylinder. The wheels being the same as in previous calculation, doffer 40" and cylinder 54" for modern set and cylinder 50" and doffer 30" for older set, 1 inch for card in both cases.

90 x 55/12 x 3.14 = 1296' per min. of cylinder.
3.1 x 41/12 x 3.14 = 33.3' per min. of doffer.
1296/33.3 = 39 doublings on modern set.
90 x 51/12 x 3.14 = 1202' per min. of cylinder.
3.1 x 31/12 x 3.14 = 25.2' per min. of doffer.
1202/25.2 = 48 doublings on old set.

From comparison the smaller doffer would appear to do more blending when running the same rev. per min., but we must consider the larger "arc of contact" between the larger cylinder and doffer. Owing to the wool being put on the doffer teeth sooner and not leaving contact of cylinder teeth for a longer time (of course there is one point of nearest contact, but the wool is combed by cylinder teeth even 1 or 13/4" from this, and the longer the wool this combing takes place over the longer space). By comparing the arcs of contact we may see there is about the same amount of blending, and the faster surface speed gives a better clearance of the cylinder. This is the recognised method of comparing carding power but no man can say what takes place actually on these fast revolving swifts and at what point the different qualities of wool begin to be carded, but one can get some idea on average batches by estimation, and for comparison we take definite figures and give each roller the same treatment. It is no good saying, "I think this or that," if thought is not supported by evidence. The fact remains that these larger cylinders have great advantage and the inventors of this idea say that less waste (amounting only to dirt) is made between the cylinders, more carding power and more efficiency over a wider range of qualities. They have made 64" swifts and 50" doffers, 12" workers. Too much bulk seems to be the only objection as the large workers strain the pedestals and the large doffers prevent the use of 4 workers. I will base my calculation on this, and show the advantages of a modern set over the old-fashioned kind, from a production standpoint re the modern tape condenser, which has double the number of ends to feed as the old 60 end single doffer has. Tape condensers are put behind these old machines without any addition to the carding power and results are expected equal to those previously turned off by the single doffer. Needless to say they cannot be got. Either the diameter of the rollers must be increased or another cylinder added. The large doffers compare favourably with the smaller ones as regards blending and carding power because the ratio of comparison is as the square root of the diameters of the rollers.
(a) swifts: \( \sqrt{(55/51)} = 1.04 \); (b) doffers: \( \sqrt{(41/31)} = 1.15 \).

Taking 38.9 doublings on 40 inch doffer, the increase of diameter increases its blending and carding power. \( 1.04 \times 1.15 \times 38.9 = 46.5 \). Thus we have the advantage of speed and practically the same carding and blending power. To follow this reasoning a little further comparing their power and surface speed ratios, assuming both make the same number of revs. on all the parts. Then \( \sqrt{(55/51)} = \text{swift ratio}, \sqrt{(41/31)} = \text{doffer ratio}, \sqrt{(10/8)} = \text{worker ratio} \). The product of these = 149.9/111.9.

As there are the same rollers on each swift, the power ratios = 1.34 for big machines to 1.00 of small machines. Now the doffer is the actual deliverer of material to the next swift, therefore multiplying this by the surface speed ratio which = 40/31 or 1.32 and 1.3 \times 1.32 = 1.76, or about 76% more efficiency. (The workers have greater surface speed but as they do not actually deliver anything to the next swift they are left out). This stands good throughout the machine when the revs. and the number of swifts are the same. The material is fed double with 120 end tapes but we cannot run the bobbin drums the same. Generally a machine running 20 revs. with 60 ends would not run more than 15 with a tape, owing to fear of over-crowding on the back cylinder. So to make the old machine come near to the modern one, an extra part would have to be added or a new machine with larger swifts, doffers, etc., provided.

E. STEPHENSON (Peterhead).

[Our contributor has raised an excellent subject for further investigation. That the "amplitude of carding contact" is proportional to the square root of the diameter of the rollers follows from the geometrical proposition that "the square on the tangent drawn to a circle from an external point is equal in area to the rectangle on the whole and on the external part of any secant through the point to the circle." (Euclid III., 36.)

![Diagram](image)

\[ D \text{ is the diameter of roller, } D^1 \text{ will not differ appreciably from } D \text{ on a 40" roller, when } x = 1" \text{ or } 1\frac{1}{2}" \text{ (the amplitude of contact), } a = \text{extreme distance at which a wool hair can be affected by receding tooth. The proposition establishes } x^2 = aD^1 \text{ i.e. } = aD. \therefore x = \sqrt{(aD)}. \text{ Since } a \text{ is constant for any quality of wool, } x \text{ is proportional to square root of roller diameter.}

But as our friend states there is a limit to increased size imposed by excessive weight and strain on supports, increased cost for materials of machine construction, increased power to drive. Moreover,
"difference in curvature" due to difference in size causes the card teeth to have varying working power on the wool. Again by the above analysis to get the same "arc of contact" would entail a larger cylinder for Saxony as for Cheviot wools, but of course such generalisations may be vitiated by other unforeseen considerations. As the author has well said we are largely ignorant of what occurs between fast rotating rollers. We would recommend that Mr A. W. Stevenson, B.Sc., of the Research Association, Leeds, should apply to the "carding contact" his stroboscopic method of motion analysis which has been so successful on the worsted spinning frames. In this the thread, as it passes downwards over the spindle appears to stand still and thus its form can be studied. [EDITOR.]

Condenser Merits.

Compare relative merits of tape and ring doffer condensers.
The advantages of the tape are:—100 per cent. more production, a better made and better skinned, rounder yarn, softer to handle, better individual gristing, requires a little more twist, does not rub two threads together, no tickling or pulling from one another. On certain blends the ring doffer produces a stronger yarn than the tape condenser; the increase in breaking load often reaches a maximum of 6 per cent. However, this is not always found, as in certain other materials the tests show that the tape condenser produced the stronger thread, but this is the exception rather than the rule. To prove anything really definite a series of tests must be taken from each (preferably single thread tests) as a solitary hank test gives no final proof of any properties of the two yarns. In the two examples given the results of the test are too near to be taken as the breaking loads of the two yarns. The disadvantages of the ring doffer are:—The low production, not so good individual gristing of yarn, although a little stronger on some blends, and it is an open question if it will weave better than the tape thread which is a little weaker. On other blends I have known them to be as near as 2 per cent. to each other on the same batch, tested by yarn tester (with 30 threads on 54 in. reel). Here is an example proved this week, all the same wools and the same batch, 29 cut Saxony black. From the tape at 20 lbs. per hr. spinning direct, 120 lbs. of batch, the test pull was 24½ lbs. The remainder was put through a ring doffer set at 10 lbs. per hr., spinning direct. The test pull was 26 lbs. To quote another example, this week also, on the same sets and wools 29 cut Saxony brown: From the tape at 20 lbs. per hr. the pull was 22 lbs. From the ring doffer at 10 lbs. per hr. the pull was 18 lbs. The wool had no elasticity. J. Don.
Setting of Cloths.

Setting of Celts.—Reference has already been made to Walter Law's investigations on the overlapping or "tippling" of threads in the larger float weaves. Twills were then under consideration. He found that Ashenhurst's sett required greater augmentation in mats or hopsacs (Scotch, "celtic") than in twills. Since two or more threads and picks work together they are more easily displaced than in twills. Indeed a celtic may be treated as the plain weave with thicker yarn. According to Ashenhurst the plain setting in worsteds \( e = 10\frac{1}{2}\sqrt{c} \), then for 2/2 celtic, the count could be reckoned as \( c/2 \) and sett \( = 10\frac{1}{2}\sqrt{(c/2)} = 7.4\sqrt{c} \) but each thread in calculation is really two threads so that sett \( = 14.8\sqrt{c} \). Again for 3/3 celtic, sett \( = 3 \times 10\frac{1}{2}\sqrt{(c/3)} = 18.1\sqrt{c} \); for 4/4 celtic, sett \( = 4 \times 10\frac{1}{2}\sqrt{(c/4)} = 21\sqrt{c} \).

Law stated that \( 4\frac{1}{2}\% \) should be added to the 2/2 twill sett for that of 2/2 celtic, while \( 9\frac{1}{2}\% \) should be added for every end above 2 in the float for larger celtics. The intersection theory with flat structure gives the following co-efficients of \( \sqrt{c} \) shown in line No. 1 of table, Law's results in line No. 2 and the plain setting consideration in No. 3.

<table>
<thead>
<tr>
<th>Float</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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<td>Flat</td>
<td>10.5</td>
<td>14.4</td>
<td>15.7</td>
<td>16.8</td>
<td>17.5</td>
<td>18.2</td>
<td>18.4</td>
<td>18.7</td>
<td>18.9</td>
</tr>
<tr>
<td>Law</td>
<td>10.5</td>
<td>14.6</td>
<td>17.2</td>
<td>20.4</td>
<td>22.5</td>
<td>24.8</td>
<td>27.1</td>
<td>29.3</td>
<td>31.5</td>
</tr>
<tr>
<td>Plain</td>
<td>10.5</td>
<td>14.8</td>
<td>18.1</td>
<td>21.5</td>
<td>25.7</td>
<td>27.6</td>
<td>29.7</td>
<td>31.5</td>
<td>31.5</td>
</tr>
</tbody>
</table>

Law's statement may be formulated as

\[ e = a (1 + 0.95f(-2))/f(f+1) \]

where \( a = 21\sqrt{c} \)

The plain structure analysis would give \( e_1 = \frac{3}{2}a\sqrt{f} \), \( e_1 \) will equal \( e \)

when \( 1\sqrt{f} = (81 + 0.95f)/f(f+1) \)

or when \( 1\sqrt{f} = 1.62f - 1 = 0 \).

By trial we find that when \( f = 9 \) this is true. It would appear that until the 9/9 celtic is reached the threads do not roll together perfectly and behave like a single thread of nine times the size in plain interlacing, although always approaching towards that end. From geometrical consideration we would have expected that condition to have been reached with 7/7 celtic. So that further investigation is necessary.

Setting of Satins.—Satins form the third class of weaves with equal floats in warp and weft. The late Edward Armitage of Huddersfield gave the sett for 5-end satin as \( 7.5\sqrt{(6c)} \), and for 8-end satin as \( 9\sqrt{(6c)} \). For comparison 2/2 twill sett would be \( 6\sqrt{(6c)} \). Walter Law states that the "flat structure" sett should be augmented by \( 5\frac{1}{2}\% \) for every end in the mean float.

5-end satin, mean float \( 2\frac{1}{2} \), augmentation \( 2\frac{1}{2} \times 6\frac{1}{2} = 13\frac{3}{4}\% \)

\[ \text{Sett} = \frac{v}{2} \times 1.1375 = 0.81a. \] (Armitage, "82a).
8-ond satin, mean float 4, augmentation $4 \times 5\frac{1}{2} = 22\%$

Sett = $\frac{8a \times 1.22}{2} = 98a$

(Satir, mean 4, augmentation 4 x 5 = 22%)

Satin derivatives with equal floats in warp and weft may be treated similarly, e.g., celtic twill or twilled hopsack 3.2.1.2 step 3 would have mean float of 2, allowance for overlapping would be 11% or factor 1.11. Sett = $\frac{8a \times 1.11}{2} = 74a$. Sett for 2/2 twill = 67a, so that the celtic twill should have about 10% higher sett than 2/2 twill requires.

---

**Current Prices.**

**Wool Prices.** (Fleece washed), Blackfaced 13d (unwashed), Cheviot 27/29d, Half-bred 23/23½d, Southdown 34d, Dorset 31d, Shrop 31d, Suffolk 29½d. Oxford 28d, Welsh 16/20d. **Skin Wools:** 64’s (super) yield 70%, 51d; 60’s (strong) yield 73%, 48d; 58’s (come-back) yield 75/80%, 53/46d; 59’s (super x) yield 80/85%, 36/38d; 50’s (first x) yield 85%, 31/32d; 46/48 (second x) yield 88%, 26d.

**Top. Quality No.** 70 64 60 58 56 50 48 46

**Price.**

<table>
<thead>
<tr>
<th>Weight</th>
<th>77</th>
<th>74</th>
<th>67</th>
<th>59</th>
<th>49</th>
<th>37</th>
<th>30</th>
<th>28</th>
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</thead>
<tbody>
<tr>
<td>Wht. 2/24</td>
<td>84</td>
<td>80</td>
<td>72</td>
<td>66</td>
<td>58</td>
<td>47</td>
<td>40</td>
<td>37</td>
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<tr>
<td>Wht. 2/36</td>
<td>87</td>
<td>83</td>
<td>75</td>
<td>69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wht. 2/48</td>
<td>90</td>
<td>86</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

18d extra for mixtures. 21d extra for marks in Botanies.

**Worsted Yarn.**

<table>
<thead>
<tr>
<th>Weight</th>
<th>84</th>
<th>80</th>
<th>72</th>
<th>66</th>
<th>58</th>
<th>47</th>
<th>40</th>
<th>37</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wht. 2/24</td>
<td>87</td>
<td>83</td>
<td>75</td>
<td>69</td>
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<td>90</td>
<td>86</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Subtract 3d from Merino and 1½d from Crossbred for wool to dye, and then add 6d (black) to 9d for solid shades, 9d to 12d extra for mixtures. Mixtures involve more care and reduce output through the carding machines having often to stand while batches are corrected to standard shades.

**Cloth.** Botany worsted 64’s (Indigo piece dye). *“Pinhead.”*

<table>
<thead>
<tr>
<th>Weight</th>
<th>16</th>
<th>18</th>
<th>20</th>
<th>22</th>
<th>16*</th>
<th>14†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count 2/32</td>
<td>2/26</td>
<td>2/22</td>
<td>2/18</td>
<td>2/32</td>
<td>40 cut</td>
<td></td>
</tr>
<tr>
<td>Price 11/6</td>
<td>12/4</td>
<td>13/2</td>
<td>14/</td>
<td>12/9</td>
<td>12/6</td>
<td></td>
</tr>
</tbody>
</table>

† in woollens, standardization is impossible, but a good 14 oz. Scotch Saxony has been selected and for monthly comparison costing worked on a fair basis. If silk introduced 2½d should be added for every unit per cent. of silk by weight.

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WOOL MERCHANTS
Silk Throwing and Spinning.

Recently we had the privilege of inspecting the processes of silk spinning in the mills of Messrs Reade & Co., Ltd., Congleton, Cheshire, (founded 1784), and also in two of the Macclesfield mills. The former dealing with spun silk and the latter with thrown silk. Of the two branches, spinning and throwing, the former, applied to so-called waste-silk, is more important in this country. The latter has been a declining trade for the last 40 years. So in the gloomy picture which the silk trade usually presents it is pleasant to record one branch which is holding its own. At one time silk was considered a luxury, but owing to the use found for waste silk it has become the universal article of ornament in textile fabrics. Of course for cheaper goods the newer artificial silk is having still greater vogue as costing 7s against spun silk at 20s and thrown silk at 60s per lb. For every 100 lbs. of raw silk produced there are about 120 lbs. of silk which cannot be reeled, and so silk spinning dealing with the latter has great possibilities. Before the French treaty in 1860, there were 40 throwing mills in Congleton now there is not one, and only two spun silk makers; but these are virile and employ several hundred workers. One of the Macclesfield mills visited had 1000 workers and to our astonishment 70 handlooms working on silk tie cloths. But Macclesfield has taken a new lease of life through introducing knitting circulars and warp looms using artificial silk in vast quantity and the old hand frames formerly used in Hawick have been taken up for special work.

China, Japan, Italy and South France are the chief producers of silk. Silk is the product of the larvae of certain moths. These envelope themselves in a cocoon. As the fluid thread is produced it is coated with a gum (sericin) which becomes hard after the cocoon has been completed. The gum will dissolve in water but the thread or fibroin is insoluble, although the chemical composition of each is not greatly different.

Reeling the silk from the cocoon is a simple but tedious process. Cocoons are placed in a basin containing hot water to soften the gum and the outer coating is stripped and put aside as waste, four or five of the silk filaments are taken over guide wheels and run on to a reel. The outer coating first spun is too coarse and the last part on the inside is too fine, and so only the middle portion of a cocoon is reeled. The best China silk is "filature." Japanese silk is good, clean, strong and fine, but the colour is not so white as China silk although the reeling is much better done. Ordinary China silk reeled by very ignorant people often varies from 4 to 8 filaments in the single thread. French and Italian silks are usually better than the Asiatic, but very little of these come to England. America is a large buyer of French
and Italian raw silks which are admitted duty free while the thrown silk is admitted under substantial tariff and so the American silk with its centre in Paterson N.J. has been well protected and has developed to great dimensions.

Silk throwing is the process of converting raw or reeled silk into suitable state for warp or weft, as the reeled silk imported from abroad is too fine and not strong enough to stand the weaving process. After sorting, washing and drying the silk is mounted on swifts and the ends passed through eyelets on to a bobbin which is revolved. Considerable variation in winding quality was observable but on the whole the winding stoppages were few, considering the very fine nature of the threads and the way in which they had been put together in the foreign country. Tram silk is made up with about 3 turns per inch inserted on 2 or 5 single threads for weaving, and 5 to 11 for hosiery. Organzine is made up of 2 or 3 threads which have been previously twisted in the single state and then reversed twine is imposed in the second operation. As organzine is used for warp 20 or more turns per inch are frequently imposed in the second operation.

The bobbins are then taken to a reeling frame and the threads are put up in hank form. The Grant reel is now generally used, since the traverse is wider, quicker, and with less liability to entanglement than on the old reel. The hanks are 5000 or 10000 yards long according to size of thread. Testing the silk is an important matter since there is considerable variation. Silk is numbered by the deniers (0.05 gram) weight of a 450 metre hank. The hanks and the deniers vary somewhat, but their number relation for practical purposes is practically "grams per 9000 metres." In England the denier system is used as well as "drams per thousand yards" and in the worsted trade "yards per oz." but the last mentioned system is not recognised in the silk centres. The denier count is 17.4 times higher than the equivalent dram count, i.e., 52 denier = 3 dram silk. If in testing the average count is found to be 24.9 deniers, the silk will be described as 24/26 denier. Silk is also tested for moisture condition and 11% regain from absolute dry weight is defined as standard condition.

Silk waste, unlike wastes of other textile materials is of as good quality frequently as the main product, because it consists chiefly of pure silk which is in an unreelable condition. After opening the bales the silk is freed from its natural gum by boiling or discharging the loss being from 25 to 30%. There are preparatory opening processes not unlike the woolen cocks spur teasing and carding. Further operations of dressing, spreading, doubling and drawing after the worsted idea follow. In spinning, cap frames are used for the finer silks, while for the longer and coarser types flyer frames are in use. The cap frame can be run at a higher speed and since in the flyer frame it is difficult to regulate the drag as the process proceeds the former is
being more widely used. After spinning, the yarn is wound and doubled preparatory for the actual twisting process on the twisting frame. Subsequent to this the surface of the thread is cleaned from fluff and projecting hairs by passing quickly over a small gas flame. For the silk trade the thread is quilled for weft to suit small loom pirns or warped on bobbin. Spun silk is frequently reeled into skeins and made up into five or ten pound bundles. The count is defined in the same way as cotton by the number of 840 yard hanks per pound but the specified count is the folded, not the single number, e.g., 60/2 silk would be usually composed of two singles of 120's, while in the cotton trade this would be written 2/120. The yarn is then washed very carefully, and sent to the dyer. After dyeing or bleaching the silk is wound on cheeses, different sizes being used to distinguish counts as well as different coloured tubes. Finer counts are put up on smaller cheeses so as not to impose too much drag which would give an unfair tension on small yarns during warping.

Recent investigations show that "artificial" silk although of equal fineness is not so strong as real silk and is much weaker when damp. In bursting, rubbing, wearing, silk is much stronger than other fibres but to ripping or splitting stresses such as "catching on a nail" silk is inferior to ramie and linen. It appears that ultra-violet rays deteriorate silk very rapidly. Seaside and strong sunlight render silk weak, but since silk is only used in the woollen trade as ornament and thus in small percentage, these considerations are not of great consequence. Most silk firms have been forced to devote much attention to artificial silk which is bought from the specialist producers.

The Scottish agents for Messrs Reade & Co., Ltd., are Messrs J. H. Bathgate & Co., Galashiels, to whom all commercial enquiries on this subject should be addressed. Editor.

Burr in Cheviot Wool.

You may be interested to see a sample of home Cheviot (sent herewith) containing burrs which are exactly the same as those to be found in Colonial wools. I have never previously observed these during my life-long experience as a wool sorter. I have always understood that Colonial burr, if it happens to grow in this country never comes to maturity. As soon as the winter sets in, the burr is killed. It will be interesting to hear if any similar incident has been observed elsewhere. I have heard that in South England the burr sometimes matures as the climate is warmer there than here, but Cheviot wool is not raised further south than the northern part of England so far as I am aware.

S. Robertson.

[Perhaps some reader may be able to offer a satisfactory explanation of this unique phenomenon. Editor.]
Another useful type of design made from the 2/2 twill is the diamond or "basket" check. It is made in sizes ranging from 8 x 8 to 48 x 48, and the size of pattern is also influenced by the counts and setting. One of the largest of these patterns was made in the 48 x 48 design with 8 cut 2-ply yarn. The smaller effects are much used in cloths for sportswear and overcoatings, while the larger designs are applied to costume and mantle cloths.

Example R 16 x 16, = Fig. X. Oliver's Weaving Problems. It is usual when making these designs in various sizes to determine the number of twills in each direction by dividing the ends in the complete design by 4 (ends in base twill). Thus in R there are 4 twills to the right and 4 to the left. A design on 28 x 28 would be made with 7 twills each way and so on. It may be difficult for the student to follow the left twill section from the illustration given, which is for one repeat only, but by extending the design to 32 x 32 he will have a better idea of the result and effect in the cloth. The designs generally are constructed on the basis of the two and two ends in the warp as for 2/2 twill motive designs, so that any of these designs will draft on shafts = (threads in design + 2) + 2; e.g. R will reduce to 10 shafts; a 32 x 32 design to 18 shafts and so on.

The "basket" check effect is well developed in light warp and dark weft or in 1 light 1 dark colouring. The latter, however, due to the floats of three in the weft, gives a distinct wave stripe. The arrangements of the floats of three in the design is such that they are on the odd picks on one side of the diamond and on the even picks at the other side. This may be avoided if desired by making the design with the 2/2 ends in the weft. If the design R is given a quarter turn so that weft becomes warp the 2/2 ends will then be in the weft, and the objectionable floats of 3 are thrown to the back of the cloth. Further, the design will draft on 2 shafts less as illustrated at R₁.

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<thead>
<tr>
<th>Draft R₁</th>
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<tr>
<td>10</td>
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<td>15</td>
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The reduction in shafts is only possible with those designs constructed on even 8's as 8 x 8, 16 x 16, etc. Designs S₁, S₂.
are two small "basket" checks. $S_1$ is made with the 2/2 ends in the warp, and the minimum draft will be on six shafts thus: 

-1, 5, 2, 6, 3, 5, 4, 6. $S_2$ with the 2/2 ends in the warp will draft on 4 shafts: 

-1, 2, 3, 4, 2, 1, 3, 4.

As with motive designs 2/2 Celtic may be introduced for some part of the basket check. In large designs the centre portion of the diamond may be made up of 2/2 Celtic, or the whole of the left twill section may be replaced by this weave. In the light dark colouring, sections may be developed with threads interlacing 3/1, so that the dark or the light colour may be given greater prominence.

The 6 shaft twill may also be used for motive and basket check designs, but in these only one-third of the threads in the complete design will reduce to two shafts by drafting. These are the threads on which the twills right and left are completed and are 3/3 and opposite.

D. R. CHRISTIE.

A correspondent writes:—I have just received a few interesting samples of Yorkshire cloths. One of these is a remarkably good imitation of the Scotch overcoating Witney finish. It is made to the following particulars: Warp, all 2/20s black cotton, 23 ends per inch, 76" wide in loom. Weft 2/8 skein lovat mixture, 22 picks per inch. The cloth weighs 23/29 ozs. per yard (58" x 58\(\)). The weave is the 4 shaft satinet or broken weft crow, and this with the close wefting, milling in the width, and subsequent raising covers up the cotton warp completely. The ratio of weights of warp to weft are as 1:5. Another cloth which is very popular is made as an imitation of the "pinhead" worsted. It is made with light grey worsted and black cotton, one and one warp and weft. The worsted yarn is more bulky than the cotton and imparts to the cloth a fairly good handle. Other cloths of the whipcord variety are made with worsted warp and cotton or shoddy weft. In the trousering group wadding weft of low quality is introduced into fine worsted warp backed cloths for the purpose of adding weight.
The Speeds of Power Looms.

In considering the speed of a power loom one thing on which everyone who has experience of the practical side of power loom weaving is agreed is the regularity of speed. Any variation of speed acts immediately in an exaggerated way on the picking motion. A loom which is running satisfactorily at 90 picks per minute if suddenly changed to a speed of 95 picks per minute would not pick in the same speed ratio as the increased speed of the loom would lead one to expect, but very much quicker, and the picking motion would have to be adjusted to weaken the pick to suit the new speed should the loom continue to run at the increased speed. On the other hand, should the loom run slower the picking would weaken so much that the loom would bang-off owing to the shuttle not reaching the box before the warp-protector takes action. This feature of the picking motion makes it imperative that the speed on the line shaft should be steady. Although this is admitted to be right, it is not always found possible to put in practice where the motive power is from the steam engine, as a varying load on the engine acts on the speed.

In a mill where carding and spinning is combined with weaving and all the plant is driven by one engine, the speed of the engine will be affected more than where the power looms are driven independently of the spinning plant. The load which the engine has to take in the morning, and especially after the weekend's rest, is much greater than what it is when the machines have been warmed up and are running easy, and the slow speed of the line shaft is very marked in the loom department. Again, should the carding machinery be switched off for any reason the increased speed at once shows itself by the looms running much quicker. Owing to these and other causes of the varying speed of the steam engine, it is now recognised that electric motive power, with the looms controlled in sections, gives the best results. Besides being more economical the drive is invariably steady, and the liability to damage the loom and the cloth is minimised.

In deciding on the actual speed at which a loom has to run various items have to be taken into consideration. Taking looms in general the speed varies from 60 picks per min. to 200 picks per min. The carpet loom is necessarily run slow, while the plain cotton loom is run at the highest speed. The type of loom in general use for the Scotch Tweed trade usually has a speed varying from 85 to 100 picks per min., except where the centre shedding motion is in use. With these the speed is usually from 60/80 picks per min. The older type of fast loom is expected
to run at about 90 picks per min. This is the recognised standard speed, and the piece-work rate of the weaving department is built on this basis. The newer types, although set out by the makers to run at 110, are usually run at 100, and in some places they are reduced to a speed of 95.

High speed is where the difference of opinion among many managers and tuners usually occurs. The higher speed loom gives at first thought the idea of increased production. Where the work is plain and the quality good the result is satisfactory, but where the work is difficult with numerous shafts in use and varied colours of weft are running, the nominal speed of the loom has not the same effect on production. In the mixed fancy trade it is found that the weaver has more confidence in handling the loom where numerous shuttles are working when a loom is run at about 90 instead of 100 picks per min.

There are two other points which are often overlooked—i.e. the efficiency of the work produced and the wear and tear on the loom. In the first should the quality of work be plain and good then the difference in efficiency will not be much affected, but when the work is difficult and the yarn tender or fine count the efficiency is liable to suffer from the effect of the quicker running loom. In the second the wear and tear is more marked when the loom is running at high speed. In the case of the picking motion this can be readily understood; as the lay travels faster the speed of the shuttle must be increased. This puts extra strain on the picking strap or picking stick, also sharper contact with the picker. These are bound to wear out sooner. Again, as the shuttle is caught by the picker when it enters the box the increased speed will give a sharper blow and the picker will be cut very much quicker.

If the swells be tightened to hold the shuttle firmer the side of the shuttle will be worn away sooner. The effect on the other parts of the loom, though not so marked, will show through time in increased breakages, because the different motions of the loom running at high speed have a greater tendency to breakages when the loom gets out of gear. On this subject the experience of tuners will vary greatly, but it is a point where careful analysis is required in deciding on the speed of the loom so that the efficiency of the work produced is not impaired, while the maximum speed of the loom may be obtained relative to the kind of work on which the loom is being used.

Geo. Mabon.
Stains on Sulphured Goods.

In goods bleached with sulphur dioxide, trouble frequently arises through the appearance of brownish coloured stains which on analysis show the presence of iron. Investigation shows that these stains may arise in almost any stage of manufacture. For example, it has been found that:—(1). In carding operations, portions of the card wire adhere to the wool and become embedded in the cloth resulting in a deep brown iron stain when the goods are placed in the sulphur chamber. (2). In weaving, drops of water containing iron fall from leaking steam pipes causing brownish stains. (3). In scouring and milling, water containing iron either from leaking steam pipes or from water condensing on the pipes and dripping back on the goods or from water lying in the pipes give rise to brownish stains. (4). Water collecting in certain pipes of hydro extractor and occasionally splashing over on the goods when these are being hydro-extracted cause big brown stains. (5). Water condenses on the roof of the sulphur chamber and drips back on the goods. Although in most sulphur stoves iron nails are carefully excluded, yet the roof is frequently packed with sand containing a large percentage of iron, and after some years working this gives rise to stains.

In the last case investigations were made in the first instance to find the cause of the stains by work done in the laboratory. The test showed that the wood in the roof of the building contained considerable quantities of iron. Assurance was given that the stains were not observed before the goods went to the sulphur chamber and hence it was certain that the stains were not due to causes (2), (3), or (4), because iron stains show up in the goods when the latter are in an alkaline condition, as they are after scouring. It appeared that the cause of the stains must be looked for in the sulphur stove and the presence of iron in the wood tended to confirm this. If stains are caused by drops of water condensing on the roof and dripping back on the goods it is easy to test the point, by suspending along inside of the roof a blanket which will cover the goods and prevent the drips.

After experimenting on these lines, however, the stains occurred as frequently as before. It then became necessary to visit the factory for although all information that was thought necessary was freely given, every investigator knows that very important facts are frequently overlooked. On examining the stains in several cloths in the factory it was found in nearly every case that when the centre of each stain became broken up a small piece of dirt was found in the thread. Even faint stains showed the presence of this dirt when the thread was unpicked, although the cloth on a general examination showed no evidence of it. These black specks are found on analysis to contain iron, indicating that the cause of the stain was present in the yarn b-
fore sulphuring. It may be important to note at this stage that a piece of material, such as cardwire could be present in the yarn without showing the stain before sulphuring, and yet if the fault was due to water containing iron dripping on the goods in scouring this would show before being sulphured. This is due to the fact that the acid formed during sulphuring dissolved a small quantity of the iron from the cardwire; this spread over the goods.

The goods, however, are always alkaline after scouring and this neutralises the acid containing the brown stain. It is only when the goods are alkaline that the iron shows the "iron stain" and it is not sufficiently realised that the interior of the yarn or cloth is still alkaline after coming out of the sulphur stove, although on the surface the material may be acidic, this is the cause of the stains in many cases appearing more in the centre of the cloth than on the surface. A trace of ammonia on the surface of such a stain will soon show the presence of iron there. As the black specks present in the yarn were not caused by cardwire and were present in most cases in the very centre of the threads, the cause must be looked for in the raw wool. Examination showed that the sand present in the unscoured wool contained a large percentage of iron and this sand was not being wholly removed before carding, etc., we must thus add another cause of stains in sulphured goods as the presence of sand containing iron, and this is a cause which is frequently difficult to remove. If it were practicable to run the goods in a 1—2% solution of lukewarm acid (sulphuric or hydrochloric) for 30 to 45 minutes after scouring and before sulphuring the brown stain would not appear when the goods were placed in the sulphur chamber.

D. K. Colledge.

"The combined steaming and air cooling machine" made by Messrs Chas. Bailey & Sons, Dewsbury, is one of the most important modern additions to a finishing room, and has indeed become a necessity to any cloth manufacturer who aspires to reach the front rank in his particular branch. The process imparts a permanent finish which is impervious to rain-spotting. The machine, which is illustrated in our advertisement pages, is the most successful one on the market, and indeed so far as we have seen is the only one adopted by Scotch Tweed makers. The firm has sold 1200 machines at home and abroad, with many repeat orders, and as many as 16 machines have been sold to one large firm.

Glasgow merchant wants to know manufacturers of dress Tartans (10 oz. / yd. sample sent). Shetlands and Homespuns.
—D. L. C., c/o Technical College.

Edinburgh merchant wants makers of serges, gabs, etc.
**Queries and Answers.**

Q. 62.—We have had difficulty with wool chrome black. In the finished piece, white warp, black weft, we got a plum appearance or reddish shade on the black, but distinct from Logwood black. The dyeing was done in an unpolished copper pot, 250 lbs. of wool, 10% Chrome Fast Black CAT (Clayton) started up with 2 quarts of acetic, 25 lbs. glauber, raised to boil (the pots are not steam heated but with the fire beneath and hence the heat varies considerably), boiled half-hour, added 2 quarts formic, boiled quarter-hour, added 2 quarts formic, boiled half-hour, added 2% chrome, boiled half to three-quarter-hour. (2) Using Diadem Black T (L. B. Holiday), the strength went down in carding, dirt floating about in dyehouse (dust and insoluble part in dyestuff). (3) Solo Chrome Black WD. (British Dyes) gave the best result, exhausted with sulphuric acid. (4) Erio Chrome Black T (Geigy), used 12%, but could not get level. We did not wash colours after dyeing.

[Samples of material and further information should be sent before definite explanation can be given. The quantity of dyestuff appears excessive, and dyes like Erio Chrome Black do not dye so well in metal vessels or in hard water. It is obvious that under the conditions of working adopted the B.D.C. dye will give the best results.—D. K. C.]

Q. 63.—We are having some difficulty at the present time with certain batches of Saxony yarns coming up specky. On looking at the wool one cannot see much the matter with it, and the carder says he has the machines close set, sharpened all through, etc. Notwithstanding all this, the goods came up specky, and we would like to submit the matter to you for your opinion.

[With reference to the sample submitted containing white ticks, it is not advisable that the machine set should be sharpened throughout. It is much better to leave the cylinder blunt, and to sharpen the workers only, because if the cylinder is sharp it brings the ticks right through to the doffer without the workers getting a chance of fulfilling their function, while leaving the cylinder blunt allows the workers to beat the cylinder, as the latter will bring the ticks round and round until they ultimately disappear. The doffers should be sharp and close set, say, 32 gauge for the yarn in question. A roller clothed with card or emery (preferably the former) should be kept constantly working on the doffer. A breast and four cylinders should be quite sufficient to give satisfactory results with this batch. Instances have been adduced of Yorkshire scribblers with six cylinders, and the product from the second...
cylinder was as good as from the sixth cylinder. The number of the cylinders is not so important as the relation which holds between the various parts. (From information supplied by Mr T. Boland) —Editor.

Q. 64.—We are not satisfied with the lubrication of our wool, viz., 12 lbs. oil to 100 lbs. wool and no water added. Will you advise?

[With reference to lubrication of the wool, we think that the use of oil alone is less satisfactory than mixing with water, either as an emulsion or applied separately. 16 lbs. oil and 8 lbs. water per 100 lbs. wool would give good results, but instances are well known where less oil has been used and more water, even 10 lbs. oil and 15 to 20 lbs. water. Water tends to disperse electrification, and there is no fear of card wire rusting as is commonly asserted.—Editor.]

Q. 65.—Will you state the standard speed for 9 in. condenser drums on 30 cut and 22 cut Saxonies, all new wool, single doffer condenser?

[With single doffers at a grist of 30 cut Saxony 22 rev. per min. would be a good speed for drums, while some reduction would be necessary for 22 cut (say) 20 rev. per min., as it is necessary to avoid over-crowding the cylinders. But much will depend on the texture of the batch.—Editor.]

Q. 66.—We have often two to four hours’ loss of time in carding due to shading batches. Do you think this excessive?

[“Shading batches on machine” is a great trouble in all Scotch Tweed firms, and two to four hours’ loss of time may be taken as less than the average. It would be much better to follow the Yorkshire practice of seeking to arrive at the correct shade in the teazer house, putting an armful through the trial carder and correcting accordingly. The armful, of course, would require to be representative of the bulk.—Editor.]

Q. 67.—What do you consider the best method of burrdyeing?

[See Jan., 1924, issue, page 140, for full account of different methods. But we consider that the logwood method gives the best results in Scotch Tweeds, where so much silk is used.—D. K. C.]

Q. 68.—We have had considerable trouble with fancies in Saxony checkbacks showing through on the face. The cloth is constructed 1 face 1 back, with extra warp stitching, 2/2 twill back and face. Is there any particular method of stitching that would help matters? It is already set as close as possible. On examination in the grease and after scouring it appears perfect, but after milling the fault appears, and the molder finish only makes it worse. Why should checks be so much less
liable to show through with Cheviot face and Saxony back than with Cheviot face and back?

The best design for 1 face 1 back checkback with middle warp stitch is on 10 shafts straight, 1 face 1 back 1 stitching for 5. If the closer setting does not remedy defect, the fancies should be hardened with more twist. The use of a slightly thicker count for the face or a finer count for the back frequently gives good results. This is quite admissible in 1 face 1 back fabrics within certain limits; a 20 cut face and 24 cut back would be quite satisfactory. The period of milling should be reduced to the minimum consistent with the effect required. The fancies in the all-Cheviot checkback are more liable to show through than one with Saxony lining, because the long, strong Cheviot fibres force their way through the face. Two-fold Saxony fancies are used with good results in the all-Cheviot fabric. Two-fold fancies in the all-Saxony fabrics should give good results.—D. R. C.

Q. 69.—We have had trouble with "browns" and "tans" in the spinning. These colours always seem to spin badly. They say here that anything with red in it spins badly. Can you give the reason for this?

The statement, "Anything with red, etc.," is perhaps legendary in this particular mill; it has no meaning, because the carder and spinner in many cases do not know when there is red in a shade. The following factors influence the spinning quality of wool:—(1) Length of time wool is boiled in dyeing; (2) Number of dye additions made, with consequent cooling and heating of wool in the boiler; (3) Whether or not acid is present during dyeing; (4) Whether or not chrome is used, and the amount used; (5) Amount and kind of dyestuff used. This last factor is not usually considered, but there is much prima facie evidence to make it a subject of enquiry.—D. K. C.

At present great pressure is being put on the yarn twisting departments. All kinds of marls are wanted. Ordinary 2-ply yarns for thornproof, bannockburns, etc., abound; while the homespun types have slack twists and knop effects more common than the traditional lumpy singles. The Scotch tweed plants have always been planned to take much more single than ply yarn, so that under the present conditions of trade few firms can keep their looms going even by running their throades 50 per cent. overtime.
CLOTH COSTING.

In order to compare the various systems of cloth costing in the Borders and elsewhere, why not give particulars of perhaps two cloths, and ask your readers who are interested to cost them by their own methods? No names of firms nor even of individuals need be mentioned, but you could publish the results and I venture to say the comparison would prove very interesting indeed. The following particulars would be sufficient.—Grist and price of yarn, reed, shots in loom, ends finished, yards finished for any given number of ells. I would suggest shooting about 50 or 60, and perhaps 20, as I understand in some mills, shooting below a certain fixed number is not taken into consideration.

D.G.M.

[We agree with our correspondent that the problem is full of interest and thus invite our friends to send specifications of three cloths, fine, medium and coarse, (say) 50, 36 and 20 shots approximately. Where the correspondents have first-hand experience of yarn making, the costing of yarns should be included. Again where possible fine double cloth worsteds and centre stitched woollen overcoatings should receive attention. No correspondent’s name will be divulged. “Nom-de-plume” or initial will be the distinguishing mark of contribution. We shall be pleased to analyse the systems and to publish what is likely to be of public service. We have much data and the subject matter of an open lecture prepared, but have delayed publication owing to the difficulty of finding a suitable audience to which it can be profitably presented. EDITOR.]

Messrs Geo. Hattersley & Sons, Ltd., Keighley, have sent on loan to the Technical College a single cone pirn winding machine with 10 spindles, one side arranged to wind from cop, bobbin or cheese to wood loom pirn, and the other side to wind from hanks in addition. The machine is fitted with ball-bearings and patent weighted roller tension fittings and bobbin boxes above and below. Shortly after the autumn term will have commenced a Saturday afternoon will be devoted to the demonstration of its advantages over other types of winding machine.

American enterprise ousted many of the older types of English winders from the Scottish market, but Messrs Hattersley wish to demonstrate that their machine is superior to the American with lower cost of upkeep, which is a very serious problem. Relative to the above question few firms seem to realise the importance of restricting the number of spindles per winder to the number she can tend properly. To see a winder trying to keep 15 spindles running with about 7 of them actually running is a common occurrence. Of course, with fine grists she may keep 15 running, while with medium 10 spindles, and with thick grists 8 spindles may be all she can properly tend. Again, winding from hank may frequently entail reduction to 6 spindles per winder.
College Class List, 1924.

Abbreviations used—City and Guilds Exams.—Final Grade = f; Grade II. = II.; Grade I. = I.; First Class = 1st; Second Class = 2nd; Woollen Yarn Manufacture = Y; Design = D; Analysis = A; Calculations = C; Mechanism = M; Finishing = F; Weaving and Designing Div. I. = W_1; Do. Div. II. = W_2; Wool Dyeing Grade I. = Dyeing.

**College Work**—Post Graduate = PG; Advanced = A; Intermediate = I.; Elementary = E; followed by the percentage mark based on general considerations of exam. results, experimental work and aptitude.


Claude Weinbach (Paris) 170 W.I. 2nd.
Geo. Malcolm McDonald (Melrose) 170 YII. 1st, W.I. 1st.
John C. Hutcheson (Melrose) 170 YII. 1st, W.I. 1st, Wor. Yarn I. 1st.
Jas. Huck Ferguson (Portobello) 168 YII. 1st, W.II. 2nd.
Geo. G. Anderson (Galashiels) 167 YII. 2nd, W.II. 2nd.
R. Arthur Nelson (Glasgow) 167 YII. 1st, W.I. 1st.
John Watson Hay (Portobello) 164 YII. 1st.
Robert Gray (Selkirk) 160. YII. 2nd.
Thos. O. Lamb (Galashiels) 159 YII. 1st.
Wm. A. Laidlaw (Duns) 158 YII. 1st.
George Tait (Selkirk) 155. David McPherson (Peebles) 152.
Wm. Graham (Galashiels) I. YII. 1st.
Denis H. Mellor (Huddersfield) I. YI. 1st, Dyeing 2nd.
Gordon B. Kynoch (Keith) E72 Worsted yarn mfr 1st.
Campbell Barrons (Innerleithen) E70.
James Thomson (Cockenzie) E69. YI. 2nd, W.I. 1st.
Roy Cairns (Innerleithen) E63. W.I. 1st
John Grierson (Galashiels) E60.
William Reid (Jedburgh) E60.
James W. Rae (Galashiels) E60. John Collier (Selkirk) E60.
George Sanderson (Galashiels) E56.
George Simpson (Edinburgh) E56.
Wm. Allan Taggart (Peebles) E54.
Wm. P. Donaldson (Edinburgh) E54.
Robert S. M. Stordy (Peebles) E53.
Donald A. Hossack (Cromarty) E50. Charles Sykes (Galashiels) E.
Geo. Dryden (Selkirk) E. Edward Traynor (Kilkenny) E.
Alexander Miller (Selkirk) E. William Kyle (Peebles) E.
John Inglis (Peebles) E.
William J. McDonald (Walkerburn) PG, Silk Dyeing, final, 2nd.
James Moffat (Peebles) A80, Wool Dyeing, final, 1st.
James McClory (Galashiels) A75, Silk Dyeing, f 1st, Cotton do., f 1st.
William L. Forsyth (Peebles) A72, Wool Dyeing, final, 2nd.
Donald A. Dixon (Galashiels) A50.
Wm. McC. Anderson (Peebles) E75. Wool Dyeing I., 1st.
Andrew Ruckbie (Peebles) E60, Wool Dyeing I., 2nd.
Robert Graham, (Galashiels) E (Chemistry only). f
David Lumgair (Selkirk) E. f = Part session.

Besides the above 11 ex-army men did not take the ordinary course and several students on special work. Those without percentage mark attended part session or were absent from examinations or failed to reach standard, except in P.G. (no % award).

The following students attending only evening classes passed
City and Guilds examinations and their work has been approved as part of diploma course—Galashiels—Stuart B. Illis, Yf1st; George B. Duthie, YfI.1st, Wor. yarn manuf. I.1st; Jas. S. Anderson, Af2nd, Cf2nd; Adam H. Poisons, W1.2nd; John A. Lindsay, W2.2nd.


Students should preserve this list as the official record of the session's work as the only College Certificate issued will be the Diploma at the end of the course.

COLOUR PATTERN ARRANGEMENT.

In your last issue there is a short article on Colour Arrangement by Anglo-Scot. Now, while the English system may have its advantages in certain types of patterns, surely the one quoted is not one of them. To begin with, it is not given in its simplest Scotch form,

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The "bracketing" is surely simple enough to be understood by the veriest novice and the pattern in this instance entails at least no more labour than the English method. In the writer's opinion, one advantage the Scotch method has over the English, and which has not been mentioned in any of your articles, is that it is much more easily visualised. However, I am open to admit that this may be a matter of custom. In reference to the writing out of a pattern in full, being no more labour than "bracketing," this is absurd; the following sample taken at random from an overcoating pattern shows this.

```
A 1 3 24
B 1 3 6
C 1 3 6
D 1 3 6
E 1 3 24
B 1 3 12
```

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Editorial Notes

The Specialist Lectures for December are:—

"Recruiting for the Woollen Industry and the School Leaving Age," by Dr T. Oliver, 9th December, at 8 p.m. (S.W. Tech. Coll.).

"The Dyeing of Wool, with Special Reference to Fastness to Light," by Mr E. P. Rendall (British Dyestuffs Corporation), 16th December at 8 p.m. (S.W. Tech. Coll.).

A Colonial writes:—I find "S.T." as full of interest and useful information as ever.

An Anglo-Scot writes that he thoroughly enjoys reading "S.T." He considers it the cheapest and best textile literature he gets.

The London Wool Sales show 5% drop on cheap wools, but little change on Scottish requirements. Scottish wool merchants report that less wool has been sold in the last two months than in any period since the War.
German textile machine-makers are strenuously endeavouring to get their machinery placed in this country. But we were astonished to receive recently a letter written in German. We have heard so much about the linguistic accomplishments of our foreign rivals that we understood that they always presented their advertisements in the language of the country to which they wanted ingress. But some at least do not seem to be any better equipped than many of our own people are in this respect. Our German expert has kindly translated the letter as follows:—"We are sending you to-day another example of our Cloth News prospectus, entitled 'Machines for Bleaching, Mercerising, Dyeing, &c.' The numerous demands for the prospectus we have received in the past year show that the book is well adapted for teaching purposes. We shall gladly supply you with these prospectuses, and enclose two order notes so that you can let us know the number of copies required." As we do not think it would be fair to our own machine-makers to distribute these amongst our students, we did not accept the obliging offer of the German firm.

An Anglo-Scot writes:—We are busy showing our winter ranges and are quite satisfied with the reception. Undoubtedly the finer qualities are in demand, and prospects are much better than for the last two years. We are still working full-time, but "fancies" seem to trouble people who have been in a "plain" rut for so many years. With the great decline in the plain trade, competition will be much more pronounced in fancies. Many of our fine worsteds are pirated in America. Patterns are sold to manufacturers in U.S.A. from this side, and also by agents in America, which is a mean business.

An Irish correspondent wishes an assistant designer from Scotland in what he describes as an "up-to-date mill" and that an applicant need have no fear of what he reads in the papers, as the Irish are now "quite a peaceful and loving people and making general progress to the advantage of all concerned." We are inclined to doubt the pleasing prospect presented and, moreover, no ambitious young Scotsman would care to be marooned in Ireland, unless his prospects are very poor in this country, because in the past it has been found almost impossible to get a satisfactory job out of Ireland.

Messrs Asa Lees & Co., Ltd., have presented the S.W. Tech. Coll. with a Spindle Reversing motion and patent Tin Roller end for exhibition. We express the thanks of the College authorities to the donors.

The British Dyestuffs Corporation, Ltd., have issued a brochure showing the dyeing of many fashionable acid colours with 10% Glauber's salt, and 2% sulphuric acid.
An idea dominating minds in the Scottish Woollen trade is that if a lecturer represents a firm with something to sell to them he must necessarily not be worth listening to. This is a great fallacy, and indicates lack of true analytical outlook which enables a listener to take the "precious" from the "vile." As a rule, our best lecturers have been representative of firms selling products to the woollen industry. This attitude contrasts strongly with that in Germany and in America, where new ideas are constantly being picked up from under our noses and put to practical use. Henry Ford, essentially a motor car manufacturer, sent a young man to learn all about the flax industry except the traditions, because in every trade there are reputed so many things that cannot be done that one is tempted to sit down with folded arms and conclude that whatever is must be right, and that everything is presently so well done that it cannot be improved.

The paucity of attendance at Mr O'Callaghan's lecture on 11th Nov. may be explained by the fact that Galashiels water has only 5° of hardness, due to the water being collected from the Silurian grey wackes, but only a mile below the town boundary the shore of the Old Red Sandstone lake is reached, and the water drawn from such strata is hard, containing iron as well as lime salts in solution. Hawick has much harder water than the other Border textile towns, because part of the head waters are drawn from the Carboniferous Limestone strata, and a few softening plants have been installed in Hawick. But the lecturer demonstrated that where much water is used in scouring it may pay to eliminate even 10° of hardness.

In Sept. we had the pleasure of inspecting the Silk Research Association premises within the precincts of Leeds University. The accommodation is very small compared with what the other Textile Research Associations afford. But it is wonderful what extensive investigations have been made by Dr Denham and his assistants in spite of cramped premises of the "army hut" nature. The investigations are confined to physics and chemistry at present. We do not approve of the squandering of money in vast buildings for such purposes, yet we think that if the Silk Industry is content to allow its researchers to work in a college backyard it indicates a type of mind foreign to the aims of research and to all industrial progress.

Lowe, Sons & Co., London (formerly Galashiels), have bought the whole stock of Russell & Macfarlane, Glasgow, now in liquidation. This is another misfortune of the times. Such cloth is offered to tailors at prices far below legitimate standards and tends to hinder business.
Huddersfield Fine Cloth Manufacturers have protested against unfair French competition in the N.Z. market due to depreciation of the franc.

Portuguese Import Duties on Textiles have been raised.

Although Austria is in bad commercial odour, there nevertheless does exist considerable opportunity for trade in specialties. Many unsatisfactory experiences were due to laxity in preliminary investigations of the financial standing of the clients. British firms are advised to become members of the British Chamber of Commerce, Vienna, so as to gain the local knowledge essential.

British imports to Peru and Irish Free State have decreased, while those from Germany and U.S.A. have increased during 1926, but Irish exports to Britain have risen.

The check-back overcoating is gradually passing from favour. Firmer cloths are wanted, as many check-backs were notoriously loose in structure and were defective in wearing capacity. Moreover, the raised surface so much favoured for kindly feel has gone entirely. The pile wore off and left the garment presenting a very shabby appearance, which no excellence in quality could ever counterbalance. Cheviots are coming into better demand, but still mainly in the finer grades. In marl yarn overcoatings the feeling is for contrast in hue rather than contrast in tone or depth of shade. Soft blues and browns are the best hues, and the tone to suit the class of business. Men's wear, of course, would be darker than ladies' coatings.

Sir Wm. Raynor, one of the most prominent wool dealers, is to be made a burgess of Huddersfield.

A foreman finisher should have had experience in both wet and dry departments of finishing, as it is impossible to get a satisfactory finish in the latter process if the cloth has not been satisfactorily finished in the preliminary wet process. If the soap is not properly adapted to the scouring and milling requirements and where the cloth is only partially cleaned, it will usually be cleaner along the sides than in the middle of the piece. We heard of a case where the sides of a piece were over-cut and thready even to damaging the selvedge, while in the centre the pieces were dull. The finisher had endeavoured to correct this by grinding and adjusting the cropping blade, and then had sought to alter the raising gig, but all without avail. It was ultimately found that the soap used in milling was too weak to carry the grease in the cloth, and instead of being saponified so that it would wash out in the washer, it could be scraped off the surface of the cloth. When a satisfactory soap was secured so that the goods lathered up to ensure cleanliness, there was no trouble in subsequent processes.
Selection of Raw Material.

Summary of Halifax Lecture by Mr S. B. Hollings (Wool Record).

Opposition to high prices tends towards spinners attempting to make from coarser tops yarns which should be made from finer tops, and much of this has taken place in later years. The busiest Yorkshire firms are those producing the cheapest lines. Wholesale merchants want to buy what is "safe." They must meet the requirements of the million rather than the select. Few firms purchase raw material and control it to the finished article. Some say that specialisation is the cause of Yorkshire's success, but the most successful are those self-contained. Top makers buy wool from different states and blend; 64's West behaves different from 64's N.S.W., and there are four districts even in West Australia with peculiar characteristics. Latterly there has been 10% depreciation of quality standard in Bradford. Some try to make warp 64's replace average 70's, and super 60's for average 64's, and so on. Maintaining good standard may mean small margin, but it paves the way for future prosperity. There is more scope in crossbred than in botany. Medium and fine cross blend better than comeback and pure botany. For hosiery a spinner wants a bobby, full-handling wool with a good lift, while for a coating yarn the fibres must be more compact. N.Z. cross is more solid and compact than South American, particularly from Patagonia, Chile, and Falkland Islands. Great change in Argentine wools has happened in the 20th century; they are not now so harsh in handle. Indeed, there has been marked improvements in all South American wools. The well-known Punta produces ideal hosiery.

Artificial silk in conjunction with wool has revolutionised the ladies' dress trade, hence manufacturers must exploit these possibilities to bring increased business. A successful Bradford manufacturer could not buy a favourite yarn at his price, and he substituted another he thought as good. When a spinner raises the price 4cll he places his clients in an awkward position, because entailing a higher cost of cloth than the price that the wholesaler will pay, so that the manufacturer has to look around for cheaper yarn. A little dissection of the above yarns showed the mistake. (The surface of the yarn largely determines the handle in the piece.)

Seasonal change affects manufacturing property of wool, e.g., owing to very dry season in South Africa this year's clip is vastly superior in quality. There is little 64's, the bulk being 70's. Last year's clips yielding 64's are summer 70's this year. Thus a spinner buying Cape tops will find his standard upset, and the reverse will happen in another year. The Australian
clip is also very good, largely through dry season giving finer quality. Spinners must carefully select materials. Finer quality wool produces finer yarns and finer pieces.

**REED IMPROVEMENT.**

I shall value your advice on an idea to make reeds with every eighth wire a different colour from the others, say (1) brass, (2) coloured or, perhaps, better still, left unpolished. The drawer, as he fills in the reed eight splits at a time (the most common way) would have the different coloured wire between the finish of one eight and the beginning of the next. He has thus a guide from beginning to end. Recently, I have been marking reeds for a young drawer, who could not be trusted with fine reeds, with the desired result, which, needless to say, has saved time for the drawer, tuner and weaver. I do not think reeds made with this guide would cost much, if any more, to produce than reeds as made at present. The idea is very simple and seems insignificant, but on the other hand if it will obviate mistakes in sleying wherever cloth is made, a great deal would be accomplished.

**JOHN CHRISTISON (Innerleithen).**

The idea is quite good. Brass wire would not stand the friction and coloured steel wire would rust, and unpolished would become polished. There is also great variation in drawer's practice, which would be about equally divided between 6 and 8 splitfuls, and some drawers would prefer to sley with more than that, so that a reed which would suit one man would not be suitable for another.

G. M.

In answer to the above, Mr Christison writes:—I have noted that unpolished wires retain the unpolished appearance even with all the friction they undergo. If the edges of the guide wire were left unpolished, it would be all that would be required. The ends of the guide wires might be brass coloured, \( \frac{1}{4} \) in. from end of reed, or having a small notch in the wire. If every eighth wire be taken as the guide, the drawer handling eight splitfuls at a time would commence and finish every handful at the guide wire. If six or twelve splitfuls handled, obviously, the guide would be at the fourth and second handful respectively. Recently we have put guides on some fine reeds by running heddle twine, 3 and 1, through the wires and pushing it to the end of the reed, thus giving a guide at every fourth wire. When this is done with old reeds, care should be taken to put the guide on the best end of the reed, as the edge, on which the guide is, goes into the reed bed, and it is that part of the reed which comes in contact with the cloth. Although primarily designed for young drawers, even experienced drawers are pleased to have a guide on fine reeds, and perhaps none would appreciate the practice more than the tuners.
Distribution Costs.

Recently the Golden Square correspondent of the "Wool Record" said:—"What we have to do is to set to work to see if we can discover some means of lowering conversion costs at the mills." This is the usual dictum of the trade theorist, but there seems a much greater need for a reduction of the costs of distribution. About half the cost of a cloth to a manufacturer is the price of materials, over which he has no control. If we take a fancy woollen cloth selling at 11s per yard the wool, dyes, soap, etc., will cost 5s 6d at least. In passing through the wholesale merchant's warehouse, the price will rise to 14s/16s, according to the grade. Then in passing through the retailer's hands, another 50% increment is made; i.e., when the wearer receives the cloth it will be costing from 21s to 24s. So that it would seem to cost much more for the tailor to keep the cloth lying on the shelves, take down, cut off a length and pass to his cutter than it does to sort, dye, card, spin, warp, wind, weave and finish the cloth. The cloth manufacturer has a margin of 5s 6d a yard on which to effect economy, while the distributors have from 10s to 13s, so that it is perfectly obvious that the great field for getting down cost of clothing is not in the conversion costs at the mill, but in the distribution of the cloth. If a manufacturer can reduce his costs 20%, that will only reduce the costume or suit length 3s 9d, but 20% reduction on the cost of distribution would mean 7s to 9s 6d per suit length, while 20% reduction on the garment making bill would effect a further saving of 15s to 20s.

Quite likely neither merchant nor tailor is making much profit, but we find fault with the system, and not with the profits of individuals. Distribution expenses are enormous, but there is no valid reason why they should be, and we are gradually drifting into larger, e.g., the reconstruction of Regent Street, etc., has cost a fabulous sum. It is gradually dawning on provincial minds that London is becoming too expensive to maintain. The producer is being squeezed between the upper and nether millstones to admit of the distributor living riotously. The distributor is constantly crying for the manufacturer to economise, but he does not set a good example. Our national extravagance leads to the false prosperity of large distribution firms. Compare the balance sheets of public producing companies and large distributing firms. At the end of the depression when all the weak producing firms will have gone bankrupt, the large distributing houses will have no longer bankrupt stocks to buy, with which to catch the public eye by advertising on the front pages of London daily newspapers.
The small provincial shop will then beat the London emporium for quality and price every time.

The warehouseman is being squeezed into lower prices by tailors who maintain their old prices for the garments. It is useless to argue about a doomed system which is becoming obsolete. If a Galashiels tailor, charging his customer 60s/65s for "cut, make and trim" of a suit, ceases making, and sends the cloth to a Leeds garment-making factory, he will get as good a job for 20s/27s 6d, "cut, make and trim to measure." But the tailor will not give his customer much benefit. He will probably still charge 55s. Need we wonder that the multiple shops are scooping up most of the business? The manufacturer fixes his profits on production units and not on percentage of value, while the distribute almost invariably fixes his profits on the latter basis. The percentage margin basis makes expensive goods too dear to sell.

To recommend reducing conversion costs by increasing output is all very well, but from 1914 to 1920 we made enormous accession to our producing power (probably 50% higher than in 1914), while there is a smaller wool supply than the pre-war average, so that we cannot possibly get an all-round increase of output. The only way to effect economy is by reducing waste and the non-productive activities of many mills. Much of the older machinery may need to be put out of commission. One-third part of the yarn-making plant in Galashiels is already in that state. Such need not be scrapped, but should be kept as a standby against sudden bursts of trade. To facilitate this, old plants and buildings should be relieved from the taxation load while out of commission. In the depression of 1907/09, half the yarn-making plant of Hawick was scrapped because the standing expenses were too heavy, and from 1914-1920 that machinery would have been invaluable. With better organisation, fewer people would suffice for the work. Hardship must necessarily be felt when workers change over to another industry, but the problem of finding work for 200,000 miners, eliminated after the present stoppage, will be incomparably greater than finding work for the eliminated wool industry operatives.

Pre-war in America, blue was the favourite colour for women's wear, and the blue serge suit was not less prominent among men. But since the war, a great revolution has taken place introducing great variations in colours, so that the demand for blue has become insignificant. This is reflected in the rag trade, blue serge shoddy or mungo has always been much sought after because giving a useful colour without dyeing. The scarcity has forced the price up abnormally. Moreover, the high tariff excludes rags from Europe.
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Coming to practical applications, wool-steeping in the form usually advocated has disadvantages, and has never been a real success, but the steeping method is ideal in principle. Suint liquor possesses a real scouring capacity, due, not to carbonate of potash, as popularly supposed, which is present in negligible amount from the scouring standpoint, but to natural soaps, which are salts of potash with certain organic acids (potash oleate is a small constituent) with other complex colloids possessing emulsifying properties. The suint constituents probably emulsify and facilitate the distribution of the wool grease on the growing fibre, and the temperature for this would be blood heat (98°F.). Thus cold steeping, though removing much sand and dirt, removes the suint constituents without allowing them to emulsify and remove the grease. Moreover, carried out in separate tanks it occupies time and space unnecessarily.

The steeping should take place in the first bowl of the set, and at over 98°F., but a serious difficulty was encountered. After traversing the first bowl with water only, at the ordinary scouring temperature of 130°F., the wool refused the rollers. With a cold first bowl there was no sticking, though a poor scour and incomplete wetting out, but on progressively raising the temperature, before ordinary scouring temperature was reached, the trouble became acute. The method was persevered with, and the batches showed an improved scour compared with the ordinary soda scour, but the inconvenience, loss of time, and danger of smashing gear made it impracticable. After several months further experiment (3.3.1926) at a Scottish mill cleared up the problem. The solution lay not in lowering but raising the temperature to at least 140°F., a scarcely obvious move, in view of established axioms re temperatures permissible for wool scouring. The removal of grease is also more efficient. Thus in comparative experiments a greasy Cape containing 70% grease recked clean wool, and reduced by a cold steep to 17.5%, was reduced at 140°F. to 12% and at 160°F. to 10% of clean wool.

The key of the method is a first bowl initially charged with water only at not lower than 140°F. and run off to waste systematically at intervals and in quantities depending on the rate of accumulations of impurities and made up with fresh water. With cleaner wools letting-off may be scarcely necessary during a day's run. The process goes more smoothly as the suint accumulates in the liquor, and at the commencement of a run the machine should be stopped for a few minutes as soon as the bowl is fully charged with wool to mellow the liquor and get this portion of wool properly soaked. Submerging plates on
the front forks are an advantage. Any tendency to stick at the rollers (more likely at commencement) is obviated by slight easing of roller pressure. Also the level of liquid should be maintained so that the wool reaches the roller still sodden with liquor. Three-bowl sets have worked satisfactorily, the second with soap and soda, and the third a little soap. Four bowls are better as the quantity of alkali can be greatly reduced. With five bowls the first two can be made hot steeping bowls, the suint carried through with the wool being sufficient to provide a further scour in the second bowl, made up with fresh water as it discharges its liquor to the first. Scouring is completed in the remaining three bowls with soap only. In this process the dirt comes away first and settles out without clogging the bowls, and the grease layer is gradually thinned down. Be types of wool suitable, greasy merinos are easiest to work. With normally greasy crossbreds the first bowl takes longer to mature. Mills where one set has to handle different qualities are at an advantage in this respect when it can be arranged to pass crossbreds through bowls previously matured with merino.

Limed wools respond well to the method. A preliminary shaking is desirable as much of the lime shakes out. Whereas the ordinary scour with its high emulsification prevents settling out of the lime and causes formation of sticky insoluble lime soaps on the fibre, the hot steep readily removes it, partly in suspension with the dirt and partly in solution as bi-carbonate. The lime should be removed before it comes into contact with either soda or soap, and the soap should never be used in the first bowl where limed wools are concerned. Mazamet wools should not come directly in contact with soap solution. Owing to having been slightly bleached with sulphur fumes, they are acid in reaction, causing decomposition of the soap and contamination of both liquor and wool. As this wool has been deprived of suint, matured liquors from greasy merino scours, with a little ammonia added to neutralise the acid, give the best results. The cost in material is obviously greatly lessened, 50/100% of previous costs. The output, according to definite statements of firms who have adopted the method, can be maintained at the normal rate of the old scouring method. The efficiency of scouring is not easily proved by figures, but several firms are convinced of all-round improvement as to leave no question of their reverting to the old method.

Details substantially those of this method have been independently circulated under the designation "Natural Emulsion" scouring. Research Association's priority in working the process has, however, been definitely established. Also during the investigation the Duhamel system was published, in which special plant has been devised to apply the same principles, and
a brief outline of the procedure will indicate the points of similarity and difference. The raw wool is fed down a vertical chute of square section about 10 feet high, along with recovered suint liquor. A light squeeze throws the liquor to a sump, and the wool is taken off by a special swift, the boards of which carry tongues of unequal length, to open out the wool. A brattice feeds it to the press, which returns more liquor to the sump, and delivers the wool over another brattice to the first bowl. The wool then proceeds through the other three bowls of the set. The liquor running to the sump is pumped into a special centrifuge described as an essential feature of the method. The sediment and the grease-laden liquor are discharged at separate outlets by automatic devices so that the separator runs continuously. The grease-laden liquor is pumped to a system of grease separators like milk separators. The grease is finally discharged as high-grade lanoline into the lanoline tank, and the degreased suint liquor goes to the suint reservoir which feeds the chute and first bowl. The bowls are of novel construction, 300 gallons against 1500 for the average English bowl. The base of the bowl resembles four inverted pyramids in row, designed to settle out the dirt, each with a let-off at the extremity, being geared together to discharge at regular intervals half a gallon or so of sludge to the sump. There are no side-pans. Four forks working in unison are mounted on one side of the middle shafting, while along the other side is a companion set also working in unison but in opposite phase. The wool is lifted out by a rotating cross frame carrying sets of prongs to a brattice which feeds the rollers. The squeezed-out liquor runs to the sump, and the wool passes to the second bowl in the usual way. This is charged with water only. The liquor from it is mainly run to waste, and is replaced either from the third (soap) bowl or the fourth (rinsing) bowl. The wool enters the third bowl practically free from dirt, but still slightly contaminated with grease, which is removed by a soap liquor in this bowl, after which it receives a rinse in the last bowl containing water only.

Naturally one object of the special plant would be to emphasise the contrast between this and the old method. At the same time the simple letting-off device, elimination of side-pans, the reduction in bowl capacity to allow much more rapid change of liquor, and the systematic methods of recovery of lanoline and of degreasing and re-circulating suint liquor to give a more concentrated detergent, though undoubted advances on the older practice, are not essential to the carrying out of the hot steeping process. The special chute and conveyor are, however, quite novel, and the fact that no mention is made of the vital question of temperature gives the impression that the sticking
of the wool at the first bowl rollers could only be got over by this means. Thus my procedure may be regarded as an advance on the Duhamel treatment, as no special apparatus or alterations to existing sets is necessary. I have not discussed many points of detail, somewhat out of place in this broad treatment of the subject, but the Association will welcome any enquiry from its readers on the method and use its best endeavours to assist them in successful practice.

The Theory and Practice of Setting.

(Summary of Lecture at Dewsbury by Mr Joe Brook.)

The great importance of this subject is not fully appreciated. Text books do not treat settings comprehensively, and afford the student little knowledge of adjustments of the carding machine under actual working conditions. In practice, setting problems are apt to form a "vicious carding circle." Incorrect settings will give rise to conditions which will render effective settings impossible. Successful adjustments can only be made face to face with actual working conditions; they cannot be predetermined by any formula. Every experienced man knows the troubles from unsatisfactory adjustments re fancy motion, but before he can solve any given setting problem he must be aware of all its factors. To deal effectively with varied materials, the student must possess intimate knowledge of the possibilities of machine and materials, and this cannot be gained by haphazard study. Great care must always be exercised in setting the various motions to separate the fibres thoroughly. In former days, when conditions were not as now, quality of product was considered of far greater importance than quantity. Setting by gauge was not then established, the use of senses, with knowledge of principles, being relied on. Settings cannot be made by sight alone owing to the fact that light must strike the machine at various angles, and the irregular alternations of light and shade make it impossible to judge accurately by the eye alone the distances between the rollers. Those pioneers did not rely on sight alone, but on hearing and touch as well. A highly cultivated sense of touch is a valuable asset to the man of practical experience, as it will convey more definite information than the gauge or sight can. When setting, an experienced carder instinctively tests the points of the card wires on the workers by touch or "feel" for degree of sharpness. If, after long running, it is considered advisable to set a particular section to 30 gauge, it may be found possible to pass readily, say, the 26 gauge between one worker and the swift, while between the swift and the succeeding worker
the distance answers to 30 gauge. An inexperienced overlooker relying entirely on the gauge, would very likely adjust the roller with the widest space to 30 gauge, whereas an experienced man would pause to investigate, the difference arousing his suspicion. Examination would likely reveal either that the cardwires displayed excessive sharpness or none at all. In the former case they might have become keen and forward through continuous running under bad setting; in the latter, "point" may have been lost owing to the roller being out of truth. If such a roller be closely set, much risk would be incurred. Setting methods long ago differed widely from modern practice, as the machines were set while in motion; while modern setting by gauge demands that the machines shall be at rest. The former idea may appear impracticable, but is advisable, particularly with old worn-out machines, as it is safer. However, gauge setting has good points which cannot be ignored, and it is advisable to combine the best in both methods. Steel setting gauges are 8-10" long and 1-2" wide, but measurements are taken by the thickness of the gauge. A set of six gauges is necessary, each varying in thickness. An important point to realise fully is that the distance to be gauged is not between rollers of hard, unyielding surface, but covered with cardwires of varying flexibility. The correct method is to hold the gauge somewhat loosely by the edges, between thumb and first finger, inserting it between the rollers and drawing it through the space to be measured by a slow and steady backward and forward movement. A short pause should be made at the point nearest to contact between the rollers, until, after proper adjustment, a slight, even pressure is felt on the steel blade. Holding tightly, or by the flat sides, or by all the fingers, or pulling through the space quickly or jerkily, will induce confused perception. Bear in mind that gauge-setting is only one of the elements in adjustment, while adjustments, collectively, are only one factor in carding. Mechanically accurate adjustments are not necessarily effective. The full value of setting can only be secured by fore-knowledge of what its effect will be when combined with all other carding factors which compose the carding problem. The assertion that carders cannot possibly work machines at maximum efficiency unless by aid of setting gauge may be open to discussion, but it is well known that indiscriminate gauge setting even mechanically accurate often leads to carding inefficiency. What matters is the skill of the man behind the gauge. This is why trained sense is vital, and in wool carding or wherever delicate mechanical adjustments are required high sense discrimination has cumulative mental results. All sense perceptions are register-
ed in memory and by the law of association of ideas, conditions analogous to those which caused the first perception will recall it. In time these associated ideas if properly dealt with, when acquired, pass into the sub-conscious mind, to be recalled automatically when required. Judgment will become instantaneous and intuitive and the border of expert knowledge is reached. The continued insistence on the importance of scientific methods has led to the modern tendency to rely on the gauge alone, but there is art as well as science in machine setting. The operation remains as indefinite as it was fifty years ago; no authority can yet define positively what a setting by a given gauge number is, nor predict what its effect will be on card clothing or materials. There is not even unanimity among those who use the gauge as to interpretations of setting distances connoted by gauge numbers, e.g., 28 setting of one could be the 32 setting of another, or even the 26 setting of a third. Gauges are designed for determining very fine measurements, and yet in actual use we hear of "tight," "medium," or "easy" according to estimate. But if the gauge is used to determine a setting it should be strictly made, and not in a rule of thumb way in loose terms. Their mere admission suggests loose, careless or ignorant setting. A trained and discriminating sense of touch should tell when the adjustment conforms to the gauge. This "feel" cannot be explained in mere words. The indefiniteness of the terms is bound to be reflected in the settings. If setting by a 30 gauge, and a closer adjustment is desired, setting "tight" to the same gauge may injure the card clothing; it is preferable to use a finer gauge, and to rely on it absolutely, otherwise there would be no sense in providing sets of four and six. The system is far too prevalent, and it should be discontinued in practice. Accurate settings are only possible when the rollers are truly circular and the card clothing good. Good card clothing means that the contour of the wires and their degree of "point" must be such that their carding efficiency remains unimpaired. However, angles or sharpness are not uniform throughout the machine, as no two sections are exactly alike in these respects, position and function both having influence. It may sound paradoxical, but good card condition can only be assured by skilful setting and accurate adjustment made by good condition. Such reciprocity produces well carded product.

(To be continued.)

(Article on "Scotch Feed" by Mr E. Stephenson held over.)

A mill expert writes: "I consider 'S.T.' a most valuable help in keeping the Scotch Tweed trade in the front, and it is improving with age."
In making 2/1 twill baskets a similar method is used to that described for 2/2 twill. Fig. D is 2/1 twill basket on 18 × 18. As in 2/2 basket, the design is divided into 4 squares and starting points marks, 'x' for twill right and ' ■ ' for twill left. But in running out twills, counting two marks as one, the twills are run out in this case not for 9, but 8 ¼, thus each twill starts and finishes at right angles to each other. Every third end and every third pick are the same, so one-third of design will draft on one leaf, but it is usual to use 2 leaves.

Fig. E is reduced draft and plan, to work "back-up" in loom. In making plan E the front two leaves are filled in 1 up 2 down, then the back 12 leaves are filled in 1 up 2 down. Then the back 12 leaves are divided into 4 as shown in E. The starting points are again marked and are run out in a regular manner as shown. Note that there are four starting points marked " □ " After these have been run out, all that remains is to fill in between 1 down 1 up. Fig. F is as fig. E but for face up. The front two leaves are filled in 2/1. The starting points in this case are blanks, and are filled in between 1 up 1 down, every third pick is, of course, 2 down 12 up, reverse from E. This method holds good for any size, 24 × 24, 30 × 30 and so on. The above is a little difficult to explain in writing, but an actual demonstration makes it quite plain.
Wool Prices. Unwashed Blackfaced, 10½d; Cheviot, 14½/15½d; Half-bred, 13d; Fleece washed Southdown, 21d; Dorset, 20½d; Shrop, 19d; Suffolk, 18d; Oxford, 17¾d; Welsh, 10/13d. Skin Wools: 64's (super) yield 70%, 36d; 60's (strong) yield 73%, 32d; 58's (come-back) yield 75/80%, 29/31d; 56's (super x) yield 80/85%, 25/27d; 50's (first x) yield 85%, 19½/20½d; 46/48 (second x) yield 88%, 17½d.

Top. Quality No. 70 64 60 58 56 50 48 46 Price. 51 47 42 39 32 25 22 21

Worsted Yarn. Wht. 2/24 61 57 52 49 42 35 32 31 Wht. 2/36 65 61 56 53 Wht. 2/48 69 65 18d extra for mixtures. 21d extra for marks in Botanies.

Woollen Yarns, white (with one-sixth sinkage)—Super Saxony 56 cut, 68d, 42 cut, 62d; Strong Saxony 30 cut, 52d; Super Cheviot 36 cut, 44½; Medium Cheviot 20 cut, 32d; Strong Cheviot 15 cut, 27½d; Blanket, 10 cut, 21½d.

Subtract 3d from Merino and 1½d from Crossbred for wool to dye, and then add 6d (black) to 9d for solid shades, 9d to 12d extra for mixtures. Mixtures involve more care and reduce output through the carding machines having often to stand while batches are corrected to standard shades.

Cloth. Botany worsted 64's (Indigo piece dye). *"Pinhead."

Weight 16 18 20 22 16* 14† Count 2/32 2/26 2/22 2/18 2/32 40 cut Price 8/10 9/6 10/2 10/10 10/10 11/3

† In woollens, standardization is impossible, but a good 14 oz. Scotch Saxony has been selected and for monthly comparison costing worked on a fair basis. If silk introduced 2½d should be added for every unit per cent. of silk by weight.

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SPEN VALE WORKS.
HECKMONDWIKE, England.
Instruction of Young Weavers.

(Lecture at Innerleithen by Mr J. T. Wright. 25-11/26.)

Probably no other large industry so much depends upon the skill of the ordinary worker as woollen manufacture does. Iron and steel-making, shipbuilding, constructional work, and transport employ many workers who bring to their work only a sound mind and a sound body, as the work indeed demands nothing more. They lift and lay and move about the tools and materials of the skilled, but are themselves unskilled. It scarcely matters whether they work in a housebuilder's or shipbuilder's yard. Very different are the conditions in the woollen industry. From the fibre to the finished piece every operation demands considerable skill. Many of these operations demand long practice before they can be quickly and accurately performed. And at many stages individual workers become solely responsible for much valuable material. Through carelessness or ignorance on the part of one worker the value of yarn or cloth may be seriously diminished, even destroyed. A peculiarity of our trade is that the work passes not so much from department to department as from worker to worker, i.e. not so much from spinning to weaving and then to finishing as from spinner to weaver then to the finisher. When the blame for bad work can be laid, not at the door of a department (which has not even a body to be kicked), but at the door of a worker (who has), then that worker will naturally exercise more care, not only because of the value of the materials in his charge, but also because his reputation as a worker is at stake. Herein we see the fallacy in the often-expressed thought, that the time and labour spent outside working hours at home or at evening class, fitting oneself to be an efficient worker, results in benefit to the manufacturer alone. If the worker's effort was lost in the mass of his department's production there might be some excuse for this attitude, but there can be none where the quality and value of the finished article bears the indelible evidence of each worker's skill or lack of it. To neglect any aid to increased efficiency is to do oneself as much (perhaps more) harm as our employer. Just as the manufacturer's worst advertisement is to sell bad goods, the worker's worst advertisement is to sell bad work. The latter is as distinctly traceable to the worker as the former is to the manufacturer; the market for both is of the same limited dimensions, and the same ultimate fate awaits the vendors.

There is the other idea, equally false, that as a result of attending an evening class the worker's wage is inevitably increased. While it is true that many have used the evening classes as stepping stones to higher posts, it must be admitted that the average student's pay is not benefited to any great ex-
tents. Indeed, it is quite conceivable that wages may be adversely affected by the sudden accession of unmastered knowledge. In our particular case of weaving, if a weaver accustomed to using thumb knots learns of their unsuitability for textile, adopts the weavers' knot, it is possible her production and consequently her pay would suffer a reduction. That is but one instance of how the wage of a conscientious weaver would be affected. Time would, of course, remedy this, production and pay would revert to normal, but during this time the inefficient weaver would also be increasing her production of bad work, and there would be a constant disparity between the wages of good and bad weavers, to the disadvantage of the former.

Of what advantage then to the weaver is technical instruction in her craft if the advantage is not reflected in her pay? Chiefly by her increased skill she reaps benefits which are quite independent of the wage she earns. In the first place, a good weaver is given the preference when a good loom is empty, and it is as easy for a good weaver to work a five-shuttle 24-leaf piece in a good loom as it is for a less efficient weaver to work a three-shuttled 8-leaf piece in a bad loom. The efficient weaver would also get the more difficult and more interesting work, involving many leaves and shuttles. In this respect her wage would be favourably affected, but the "canker would always remain," that one weaver through her very carelessness and inefficiency was earning on simple work almost as much as a better weaver was earning on much more responsible work. That is the usual lament in busy seasons, that learners get all the good straightforward work, while older weavers are working hard on worse jobs. But when a slackness prevails we soon see the advantages that skill confers on a weaver. In good seasons a manufacturer is glad to get even bad weavers, but when times are bad he is equally glad to get rid of them. Bad weavers mean busy darners, and much darning implies a heavy increase in cost of cloth. Efficient weaving means darning expenses lowered below the average, hence a good weaver, while valued in busy times, is thrice valued in slack seasons. Skill then on the part of the worker is equally desirable (1) to the employer, because it means cheaper production, (2) to the employee, because skill is the capital on which she transacts her business, and an increase of skill means a more stable business, i.e. steadier employment, more interesting work, and possibly increased earning power. The problem before us is how best to instruct a weaver for her own and her employer's advantage.

(To be continued.)

Scottish Woollen Wages.

While much attention has been directed to the inadequacy of remuneration in mining and engineering trades, few people realise that the reason of the scarcity of skilled labour in the Scottish woollen industry is probably due to the uncertainty of the aggregate rather than the inadequacy of the rate of remuneration to piece-workers, who comprise over 50% of the employees. The trade is afflicted by great seasonal fluctuations. On the annual average, the whole wage bill of the Scottish woollen trade will not vary more than 5% either way from £1,500,000. But in individual mills the variation may be 50% either way, and piece-workers' wages will be affected much more than the average, e.g. if a wage bill falls from £40,000 to £20,000 per annum, we may be certain that the piece-workers' wages will have been reduced to two-fifths or less of the previous total.

To many it may come as a surprise to know that Galashiels wages (comprising mills, clothing factories, dyeworks, skin-works, and engineering) fell from £400,000 in 1922-23 to £310,000 in 1925-26, or from £81 to £24 per head of population. Selkirk has fared better, only dropping £20,000 in the same period, and as the initial conditions, viz., £36 ½ per head of population, were better, the effect of a £3 drop per head on the town's shopping power has been less felt. Hawick's woollen wage bill has only fallen £10,000. But as the spinning and weaving business is nowadays completely overshadowed by the knitting trade, the former is no longer the controlling factor in Hawick's prosperity. But we understand that knitting has suffered much depression also. The only oasis in the barren waste seems to be Peeblesshire, which has maintained the status quo. The inhabitants of Innerleithen-Walkerburn should feel comfortable relative to their less fortunate neighbours with a constant sum of £40 per head of population. The reflex action on the shops of the various towns will not be exactly in these proportions, because at least 300 Galashiels workers are employed in Selkirk, Peebles, &c., and the inhabitants of the smaller towns visit Galashiels to buy goods.

There are even greater fluctuations in towns not wholly dependent on the woollen trade, e.g. in the above period, Dumfries has lost 50% of its woollen manufacture wages. Although that shortage cannot but be felt, its direct effect on a town of the size of Dumfries is not so great, as there are only two mills. From the above considerations it may be concluded that the average wage in the Scotch Tweed trade does not exceed £100 per annum, and the average piece-workers' wage will be less. It should be borne in mind that the year of reckoning ended
early in the miners' strike period, so that the present year may show even worse results. But our trade prophets predict a good time ahead if we can only solve the coal problem. Certainly never before has there been greater wealth of good taste displayed as in the get-up of the styles for winter 1927-28.

**Worsted Spinning Research.**

It has been an axiom in worsted spinning that the material must never be drafted twice in the same direction. Mr Howard Priestman, in his text-book on the subject published in 1906, (pp. 96-97), mentioned the axiom when discussing possible theories of fibre movement, but emphasised the fact that cotton is frequently drafted twice in the same direction, and proposed that, with suitable carriers, this might be done for wool.

It is perhaps a comment on the attitude of the trade towards a new idea not backed by persuasive salesmanship, that no progress was made along the lines indicated until a year or two ago, when Mr Priestman and the writer had the opportunity of doing so for the Woollen and Worsted Industries Research Association. The first experiment showed that the axiom had little foundation, but difficulties soon appeared in the control of the fibres in the second draft. They would wrap themselves round any convenient roller, in fact go anywhere they ought not to have gone. The difficulties would seem to be overcome for a day or two, but a change in the atmosphere, condition of the rovings or something quite intangible would bring a recurrence of the trouble. After many failures and following many false scents success seems at last to have been attained. The experimental frame runs day after day with no more attention than it would receive under mill conditions. The yarn and cloth made have been passed by many well qualified judges as quite up to (if anything above) the average commercial standard.

The net result of the application of the improved drafting to spinning frames would be to halve the space required for the preceding drawing, or to reduce by one-third the space required for the complete drawing and spinning plant, with corresponding decreases in attendance, capital charges, power and repairs.

As is usual in research work, more of the nature of the problem has been learned from failures than from successes, and the investigators hope by following up these failures to make further additions to the theory and practice of drafting. 

A. W. Stevenson.

This development bids fair to change worsted spinning practice and certainly calls for revision of the theory. The
investigators responsible should be well known to many readers, Mr Priestman as author of standard works on wool spinning, and Mr Stevenson as old College student. As an apprentice with Aimers, McLean & Co., he attended the science classes in the Burns Hall and Back Road, and in the new buildings took over the teaching of mechanical and electrical engineering. Gaining a Whittworth Exhibition he proceeded to Edinburgh University, graduating B.Sc. in engineering with distinction, taking also the medals in physics, engineering design and electrical engineering. He took up post-graduate research in combined bending and torsion at Prof. Beare's request, but relinquished the work to widen his practical knowledge, gaining a very varied experience of design, testing, research and commercial work with some of the largest electrical and aeronautical concerns. That he should have returned to textiles is not surprising. His forbears were weavers of the once famous "Earlston ginghams," his grandfather was for many years foreman at the mill now owned by Simpson & Fairbairn, Ltd., while his maternal grandfather, Alexander Wight, an Elliston apprentice blacksmith, subsequently travelled in the Near East as erector of silk mills, and finally settled at Clydebank as manager of a cotton factory he had erected.—Editor.

The Self-Acting Woollen Spinning Mule.

Summary of Lecture by Mr A. E. Inglis (Asa Lees & Co., Ltd.)

As Asa Lees & Co., Ltd., are not so well-known in this district as in other parts of the world, I should say a few words in introduction. Samuel Lees, the father of Asa Lees, founded a small works on part of the present site, towards the end of the 18th century. There he made drawing rollers, the only part of the machine at that time constructed of iron. An advertisement of his (before the existence of the Exchange) announced that he attended the "White Bear" in Manchester, at certain times for the receipt of orders, etc. The firm has developed with the textile trades, and at present employs thousands of men and has a world-wide reputation.

The woollen mule is not really a "mule" at all; being a direct descendant of Hargreave's spinning jenny, the first machine to attenuate the threads by carriage draft. Crompton of Bolton combined the Hargreaves jenny with the drafting rollers invented by Arkwright, the result being called in joke a mule or crossbred, and the name has stuck.

In judging the merits of any machine, four cardinal points should be noted:—(1) Workmanship; (2) Breakages; (3) Faulty
Motions; (4) Heavy running. The "name plate" is a fifth point which too often twists our judgment, but the less the better. In these strenuous days we cannot afford to allow our judgment to be warped in any way by prejudice. There are not so many makers that it is impossible to give all a fair examination.

To put Asa Lees' mule to the test of these four points:

(1) Workmanship.—Every part, both large and small, is machine-cut, planed, turned, bored, etc., in special chucks on special machines, many of which are our own design and manufacture. Most brackets and fixings are tongued and grooved and are of such design that should one deliberately tighten a bolt too much, the bolt will break before the bracket. This is a test I often used in the works when doubtful.

(2) Breakages.—It will be readily seen from the above that all "unnatural" breakages are eliminated or reduced to a minimum. "Natural" breakages occur through bad setting or unavoidable accidents, such as a strap breaking, which might cause something to lock and thus smash. To illustrate, if in a motor car running along a road, portions break off until it is a wreck, that would be unnatural breakage, but if two cars came together with a crash, one would be surprised if something did not break; these are natural breakages. So if through bad setting or accident something has to break, our mule is so designed that the broken part is always a minor one and easily replaced. This is the result of careful watching and experience.

(3) Faulty Motions that are not strong enough for the work they have to perform and are therefore uncertain in action, also motions that come into gear too soon or too late. The different motions on Asa Lees' mule, shown by lantern slides, are not easily described in a short article. We issue a small book, in which all the motions are very fully illustrated and described, showing sound lines of design and manufacture, also safety catches and cheeks which prevent motions coming into gear before the proper moment. The design of the mule, having the cam in the centre of the headstock with all the motions operated directly from it, without any links or other intermediate connections, makes it much more certain. Also the headstock is entirely self-contained, having no motions screwed to the floor; e.g., the double speed lever is generally fixed on and screwed to the floor, and it therefore depends on the packings and the strength of the floor boards for its accuracy of operation. In Asa Lees' mule this motion is part of the headstock and is therefore certain in action. I should like to particularise motions of special excellence, viz.:—Spindle reversing motion, twist motion on tin roller shaft, and the new backing-off motion.

(To be continued.)
Mending Flat Arrangement.

( Correspondence Course Student's Answer.)

The most suitable type of building for a mending department is a room which has one side facing north. This side should have windows throughout its full length, the windows to start about 4 ft. from the floor. If the room is very wide, i.e., back from the window, skylights should be arranged on the shed principle, so that the light enters from the north, the other side being boarded up; but, if possible, it is best to avoid overhead light.

The tables, tops best made of beech wood, should be arranged so that when the top is raised the flat part faces east and west, thus allowing the light to fall across the piece. An adjustable electric light over each table would be most useful. For example, in a room with 100 menders it would be necessary to have a head mender, whose duty it would be to book wages, and, with the help of two or three good menders, to help about the place, i.e., in teaching and watching over learners, mending patterns (if not many), mending "fellers," and other of the more difficult jobs. The places to be mended should be marked (if possible in different coloured chalk to other faults) at the taking-in table; they would then be taken to the mender, who would burl and mend them. Next they would be taken to the passers (two women), who sit on a table, the piece being passed over a perch as at taking-in table.

If passed, the pieces are wrapped up and sent to the dyer and finisher.

I think the best method of wage payment is:

1. Ordinary menders by piece;
2. Passers and helpers by time;
3. Thread menders should have a standing wage;
4. Learners should be paid a fixed wage for a fixed period (depending on type of trade). This way is preferable to menders bringing their own learners.

J. M.

Tape condensers are not always introduced to effect greater production, but sometimes to give more uniform quality in the threads, e.g., where long and short hairs are mixed together in a blend a double doffer condenser deals with them in a selective way. The top doffer takes the long hairs and leaves the shorter hairs for the bottom doffer, so that there would be a distinct difference in appearance between the threads spun from the top and bottom spools. However, the tape condenser gives a uniform distribution, and so secures threads of more uniform structure.

561. Designer, for New Zealand Mill, wanted.
BLACK AND WHITE.

Black and white patterns, like Glen checks, herringbones, etc., are always more or less in demand. In spite of strong Yorkshire competition in this line Scotch productions hold their own. Black and white patterns are introduced in (1) Men's suitings and overcoatings, (2) Breeches cloths, (3) Ladies' skirts, costumes and coatings, (4) mufflers, wraps, etc.

In (1) the yarns must be as fine as not to form too great a contrast except in the case of District cloths which are not now much worn. As a rule, black and white patterns for men's suitings should combine to form a grey. For overcoatings, where the American trade is being worked, strong contrasts are permissible. (2) Black and white checks, after the pattern, which as common for trousers last century, are still made for the provincial breeches trade. Here coloured overchecks are often introduced. (3) For ladies' skirts small shepherd check effects with various modifications of the 2/2 twill weave are common. For costumes and coatings, black and white patterns are made (a) with a predominance of white, (b) predominance of black, (c) with square proportions. Plain and shaded effects with weaves introduced add novel features. (4) May be classed on the same basis as (3).

Where these goods are being manufactured—the wool blender, dyer, carder, yarnstoreman, weaving, milling and finishing foremen have all to be very careful. Trouble is often experienced with kems. Re-dyed blacks, dyeing whites mixed with good whites, stains, black running on to white, imperfect bleaching, over-blueing, over-steaming, repeats not matching first pieces, are not uncommon. The yellow-white always goes down very badly with a merchant. On the other hand black covers a multitude of faults, and when used with a good white the contrast helps further to lessen the probity of the discerning eye.

Mr. Howard D. Gordon, Hazardville, Conn., U.S.A., has kindly sent samples of wool treated by his dry gas carbonising process, which are very thoroughly treated indeed. Hitherto this process has been used only for extracting cotton from woollen rags and waste, as the gas was averred to effect the colour of white wool. But this contention seems invalid, to judge from the samples submitted, because the handle, staple, and condition are good, and the usual pellet condition of the wet process product is avoided. They treat 20,000 lb. per week, and do no scouring, but simply carbonise, neutralise, crush, and dust, and then bag the wool.

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Queries and Answers.

Q. 185.—My son, shortly leaving school, talks of being a tweed manufacturer. Could he take a degree at a University which would include the technical subjects necessary to follow tweed manufacturing?

We have no hesitation in saying that if a lad wishes to be a tweed manufacturer the sooner he starts to learn the business in a mill the better. It is no use seeking to learn one business by doing another. University degrees are all very well for teachers with a view to advertising their capacity, but they do not make a man an efficient manufacturer, and hence, instead of spending four years at a University taking a degree which will be useless to him in after life, he had far better be serving an apprenticeship in a woollen mill, preferably not his father’s mill, because he would not get a proper chance in such. He is apt to take up an attitude which is inimical to his best interests, and, moreover, the workers would not treat him as an ordinary apprentice. Universities in textile centres now give textile degrees, but in practical working they are only secured by students who have a smattering of textile subjects; the genuine textile student has to be content with a diploma. Even at a monotechnic, such as the S.W. Tech. Coll., we are not encouraging full-time attendance except for the student who lives at considerable distance from the College. He should come only for half the year, and take the other half in the mill, for part of his apprenticeship only. The students within reach of the College should attend one or, at most, two days per week.

Q. 186.—Please show by the following example the best method of arriving at percentage of silk by weight:

Warp A30 cut Cheviot 22 11 23 56
B 2/60 wor. || 2/20, 2/20 silk 1 1 2
C 2/60 wor. || 2/20 silk 1 1 1.1 2 6 67½ porters.
D 2/20 silk || 2/20 silk 1 1 2 2 6 60 yds.

Weft, 30 cut Cheviot: 17/4, 4, 4, 4, 6, 4, 6, 4, 6, 4, 6, 4, 4, 4, 4, 6 reed.

38 shots
70 thds. in 16 splits = 4½ aver., 17 × 4½ = 74½ porters in 74"
38 patts + 40 thds. (34 w’ln., 4C, 2D) 67½ .. .. 67"
2162 × 60 ÷ (200 × 30) = 21.6 lb. greasy (15% loss) = 18 lb. clean
228 × 60 ÷ (560 × 30) = -84 .. .. (5% loss) = -8 .. ..
844 × 60 ÷ (840 × 20) = 3 .. .. (no loss) = 3 .. ..
38 × 67 × 60 ÷ (200 × 30) = 25.5 greasy (15% loss) = 21.7 .. ..

Silk % = 100 × 3 ÷ 43.9 = 6.85%
Q. 187.—We have been troubled greatly with electrification on the condenser in dry weather. Can you suggest any remedy?

It has become customary to speak of every peculiar behaviour of wool as "electrification," hence some phenomena so described are not electrification at all. Badly-scoured wool is often blamed for electrification, that is, leaving the wool too alkaline. It should be probably neutral or slightly acid in reaction, so we would suggest that more attention be paid to scouring. Artificial humidification, so prevalent in worsted spinning, has never been thought worth while for woollen carding, as without it the only control is by keeping the room cool, but since the carding process is helped by higher temperature, the yarn-maker is between Scylla and Charybdis, or, in Scots, "the deil and the deep sea"; though it is possible that a warm feed end and a cool condensing end might be ideal conditions. The Research Association has considerable information on the subject, but more relating to worsted than woollen spinning.

Q. 188.—Please report on coat returned for shade fading unduly.

We cannot give a satisfactory answer unless we know the dyestuffs and also receive samples of the dyed yarns used. The coat is very greasy and soiled. Dry-cleaning a part restores the colour remarkably well, yet all the colours have faded slightly, and we cannot say that the cloth has been unfairly treated apart from excessive soiling. Even the unfaded parts contain much greasy matter, and it is impossible to say whether this is residual spinning oil unless we examined the new material from which the coat was made. The fading may not be due to faulty dyestuffs, as the dyer may have had difficulty in getting up to the shade, and thus the application of the dyestuffs may not have been such as to give the maximum fastness of the dyestuff used.

(Later) 11 days' exposure of yarns and cloth and observed no appreciable fading. Thus the fading is not excessive for type of shade. The hot summer has made this defect prevalent with bright colours. Bright colours should be selected with great care and fastness tests, which might result in little cloth being made as few bright colours would pass the test.

Re Q. 180 (Thornproof query).—For the Red River Rebellion in Canada (1870) the troops required a cloth that would stand the "wait-a-bit" thorns, and we invented "the thornproof." I have never examined odd files to find particulars, but old Colonel Johnston told me it was 18/18 cut or 15/15 cut or thereby, long Scotch Cross Cheviot of some kind, hard twisted and very hard doubled, woven plain cloth. It simply would not
tew. The inventor was Col. Johnston's father (the original James of our name).

E. S. HARRISON (Jas. Johnston & Co., Elgin).

Re Q. 181.—Our books are a loose-leaf ledger and a stock of "Kardex" card files. In 1st column, quantity ordered; 2nd column, quantity delivered. From these at any moment the undelivered balance may be seen. The rest of the page is made up of 6 columns containing spaces, 4 per unit—customer's No., piece No., lbs. warp, lbs. weft. We use one loose-leaf page for each col.—quality, but keep the grists in separate columns, say, Black Cashmere will have one page, run in 18, 24, 36, and 48 cut; and Black Cheviot another page, etc. Where goods are ordered, the quantity needed is pencilled in; where warped and woven, inked. Thus an addition of the pencilled figures always gives unexecuted requirements. In the stock file, only one colour and one grist is on each card. We have 2 "Kardex" files of 1200 capacity each, and nearly fill them. In these cards each piece as made is marked, and the balance carried down. This gives instantly the stock figure, but says nothing about needs. This double system sounds cumbersome—and is—but to date we have found it the most practical in use. E. S. HARRISON.

Re Q. 181, Have a second yarn book for outgoings. When the piece ticket comes from the office refer to the stock-book, and enter in this new book the quantities in stock not required for previous orders. On the piece ticket enter the Batch No. and the quantity required. Enter the same on the outgoings book, which will then show the total weights of any colours required for present orders. Comparison with the stock-book will then indicate what quantity must be made or what surplus will be over when orders are completed.—T. WELSH, Wellington.

[We are much obliged for these helpful contributions.—EDITOR.]

Relative to our setting expositions, Souter sends the following as useful in finding sett and weight.

For Scotch tweed suiting, 67\(\frac{1}{2}\)" in loom, one-sixth loss, one-sixth shrinkage, common twill setting for 1 cut Gala = 7.8 ends.

\[2 \times 7.8 \times 67\frac{1}{2} \times 1.2 \times 84 \times 16 \div 200 = 83\] oz. per yd.

To find the weight in common twill, divide 83 by \(\sqrt{\text{count}}\). Ends per inch = 7.8 \(\times \sqrt{\text{count}}\).

Ex. 16 cut; 83 ÷ \(\sqrt{16}\) = 20\(\frac{3}{4}\) oz.; 7.8 \(\times \sqrt{16}\) = 31.2 ends.

Re Yorks, Slubbing Dyers' advt. that 10% colours cannot be guaranteed, Smith, Bulmer & Co. say that provided price be paid, colours can be guaranteed.
Evolution of the Raising Machine VIII.

(Conclusion of lecture by Mr H. W. Fawcett (Tomlinsons, Rochdale), Ltd.)

By examination we find that all the rollers are pile rollers and these rotate in the same path as that in which the cloth travels. The rollers revolve at variable speeds upon their own axis with the points of the card lying in the cloth direction, whilst the drum turns at a fixed speed in the opposite direction. In this action we have the same four factors to take into account as in the case of the Single Action machine, i.e. (1) the direction in which the wire points are included with regard to the direction in which the cloth runs through the machine, (2) the direction in which the rollers turn, (3) the speed of the cloth, (4) the amount by which the rollers over-run the cloth. The foregoing clearly shows that to bring about raising action the rollers must over-run the cloth, conversely should the cloth over-run the rollers no raising action can take place. It will be observed that intensified action is caused by increasing the speed of the card rollers or by decreasing the speed of the cloth through the machine. This improved action is undoubtedly the most successful for raising woollen fabrics.

The card roller's action upon the cloth is entirely different to that of the machines already dealt with. In this type of machine the points of the card leave the cloth, the hooks of the former plucking the yarn, drawing the fibre into itself and retaining hold until the rotary motion of the roller releases it. The segmental contact of the cloth upon the roller is very small, and the rotary releasing action leaves the fibres in an upright position. The result of this action is the obtaining of a vertical pile. It also has the faculty of curling the ends of the fibres, which produces a mossy interlocked mat effect. Another feature of this action is the bulk of “handle” obtained. Also the cover or nap produced is more by way of being permanent and will not ruffle or tuft when rubbed in any direction. By the manipulations of the raising rollers speeds this felting action can be accentuated as required. Incidentally, coarse, wiry wools are not suitable media for felt nap raising.

In designing this machine the makers have embodied in it a wide range of speeds easily and positively controlled, so that cloths of the flimsiest character can with confidence be treated and the stability of construction is such as to allow of pieces of the heaviest weight also being raised. Another important feature of the felt nap action is the very small amount of flock of waste produced during the raising process. Pieces can be treated either in the wet or dry state upon the machine, but if the former, a suitable card cloth, which is impervious to the action of water, is usually supplied.

To obtain successful results by raising textiles upon the card wire machine obviously much depends upon the card cloth itself. Great
discrimination must be used in the selection of this. The set of the cards must be considered in conjunction with the cloth and the type of finish required. To some extent experience has standardised this raising agent, but there are instances outside ordinary usage, and these must be dealt with individually. Teazles are graded to encompass cloths varying in character, and a similar set of conditions prevail in respect of card clothing. Obviously a card suitable for raising worsted vicunas, velours, tweeds, etc., could not be expected to function satisfactorily for the raising of Yorkshire or Witney blankets, and, similarly, filleting designed for raising the latter is of no use where the former classes of goods are concerned. Card clothing will only raise fibres up to the limit of its capacity. Beyond this point, it ceases to be efficient and a wasting process obtains. Again, the condition of the card clothing calls for constant attention, as there are various factors in connection with it which mar the efficiency of the machine, viz., the use of too long wire skewers for joining pieces together; the constant running of pieces in the same position on the cylinder, the lack of grinding or levelling, etc. In other words, the card wire raising machine is a machine of precision that calls for skilful and intelligent manipulation if the best result is to be obtained.

WEB DRAWING.

An Anglo-Scot writes:—I was interested in the controversy regarding the Scotch and English method of drawing. The Scotch method with cotton healds is much quicker, although when it comes to wire healds the English method, slow as it is, would be quicker than drawing the Scotch method. Here they start on the back leaf at the left-hand side, pick out the wires with the left hand and the hook in the right hand, whereas in Scotland the hook is in the right hand, starting at the right-hand side, which makes it awkward to pick out the wires, but drawing here is a long drawn-out job. I prefer the Scotch way with cotton healds. I am doubtful, however, if cotton healds would stand the strain of weaving any of the cloths here except flannels, as they are sett so heavy in the loom and there is a great amount of wet work.

An ex-student in South England writes that he looks forward to the delivery of each number, as the articles and correspondence are instructive. The recent notes on the pros and cons of wire and cotton healds were interesting. The disadvantages of wire healds are more labour in assembling and slightly slower drawing operation, while the advantages are less friction on the warp, minimum possibility of misplaced threads and warps of the same draft, but lower sett can be twisted in, only requiring to be re-sleyed. They had experimented with cotton healds, but still prefer wire healds.
Re Mr Kemp's "Shorts Cuts to Peg Plans" an ex-student writes:—The preparation of the draft plan for a 2/2 twill basket is very interesting and is certainly a "short cut" for large designs. I make use very rarely of the 2/2 ends in the warp for basket check designs, because I find that better results can be obtained by making these designs with the 2/2 ends in the weft. By this arrangement the 16 x 16 design reduces to 8 shafts and 48 x 48 design to 24 shafts, so that a saving in the number of shafts is effected. The greatest advantage is in the draft, the ends are evenly distributed over the shafts. I found that when drawing half the warp on two shafts in fine worsted whipcord cloths that the threads were overcrowded and that 4 or 6 shafts had to be used for the alternate threads. Another advantage is that the 3-floats are all on the back, thus giving a smarter effect on face. This method was brought to my notice in making a study of Mr Christie's design notes in "Scotch Tweed," and I am greatly indebted to him for this method, and always use it where possible.

An ex-student writes as follows:—In a recent lecture at Batley on "Observations on the Process of Cloth Manufacture," many points were raised of a controversial nature. The lecturer said he had tested his theories and found them satisfactory. When any defective yarn caused either by shading or cockling in piece-dyes there was always a cry for more shuttles. The lecturer averred that this practice is wrong, because, although mitigating the trouble, it did not cure. He had found that the yarn at the top of the cap was not as sound, hard or uniform in twine as at the bottom. He showed a spindle with two whorls which he had tested alongside an ordinary spindle, and found that the bands at the end of the test period were not worn or strained as much as the single band was. Moreover, the yarn was sounder, and more uniform in every way. He contended that the Research Association's experiment with a longer spindle would be futile, unless means were devised to keep the band tight all through the time. The production might be increased, but the troubles would also be increased. Relative to carding, he said in the old hand carding it was always done point to point and not as in modern machines, where the worker and swift did not work point to point. In his own experiments he had turned the swift and made it work point to point, and the machine minders who did not know what change had been effected, enquired what had happened to the blend, as the product handled better than before. There was no better proof than that observers should immediately note the difference. The yarn was better scribbled and more uniform in every way than previous blends of the same material.
FINAL CALCULATIONS—DIV. I.

(Not more than 5 questions to be attempted, including No. 1 and 2.)

(1) For a manufacturer, receiving mixture yarn on cheese and producing finished cloth, classify items of cost under each heading: (a) production, (b) general expenses or standing charges, (c) costs varying as weight, (d) costs varying as value.

(2) Give plans, skeins, ends and picks, reed width and warp length to produce most economically lined overcoating, 24 ozs. per yard (38 in. x 58 in.), face raised finish concealing the weave, lining clear finish showing twill.

(3) Calculate ounces per yard (38 in. x 58 in.) of equally firm 2/36 fine crossbred mixtures in (a) 2/2 mat, (b) 2/2 twill, 2 ends right cut 2 left, (c) twilled mat, (d) 2/2 twill crow warp back, (e) 2/2 twill satin warp stitched double cloth.

(4) (a) A blanket, 83 in. x 63 in., weighs 3 1/2 lbs.; calculate ends and picks in loom: 11 sks. warp 101 in. in reed, 10 sks. weft, 110 in. warp, 106 in. of weaving, weft weighs 50% more than warp; loss 12 1/2%. (b) In plain, would the above be light, medium or heavy to weave?

(5) (a) If a piece-dyed botany coating is 10% heavier than a similar mixture in the same yarn count and quality, calculate how much wider in reed and longer in warp the piece-dye must be than the mixture, assuming same set in loom and loss in finishing. (b) What limits the setting of ordinary Bannockburn cloth?

(6) Calculate (a) cost per yard (38 in. x 58 in.), (b) price ratio, finished cloth yarn for a botany mixture whipcord 5-1-1-2 step 2 in 2/48 warp at 6s 9d and 2/36 weft at 6s 3d. Assume weaving per yd. 1d per loom inch-pick, and finishing 10d per yard.

(7) Compare cost per ounce of piece-dyed 2/2 twill botany coatings, (a) 12 oz. per yd. (38 in. x 58 in.), (b) 22 oz. per yd. Yarn 2/24 and under, 5s per lb. with 1d per count extra to 2/36, then 1d per count extra to 2/48, then 1d per count extra to 2/60 weaving processes 1s 4d per inch-pick for 80 yds. of warp; dyeing and finishing 1s per yd. + 1d per ounce.

DIVISION II.

(Not more than eight questions to be attempted.)

(8) Define clearly "costs" and "costings." Enumerate all necessary items that must be taken into account, and classify under headings: "materials," "labour," "direct" and "indirect" expenses.

(9) What are the chief advantages of departmental costings? Establish satisfactory system. Illustrate by giving suitable
rulings and headings for departmental books, from raw material to finished fabric.

(10). Discuss principal cloth setting theories. Build up formulæ from first principles, and deduce abbreviated methods. Plot curves on graph paper for respective theories, name cloths to which applicable.

(11) Describe the fundamental principles on which twist theories are based. Supply formulæ for three types of yarns, different in construction and materials, deduce constant factors for obtaining turns per inch, in "soft," "medium," and "hard" twist yarns. Also describe effects of each when woven into fabrics.

(12) A worsted cloth 20 oz. per yard (57 in. x 36 in.) finished. Give counts and setting with 2/2 twill, assuming 10% loss in weight during finishing, shrinkages, length 10%, width 20%, warp length 70 yds., grey piece on the loom 65 yards.

(13) A woollen cloth 16 sks. Saxony, 2/2 twill, has a worsted check-back added; woollen and worsted threads and picks are as 1 : 2; give setting and counts for worsted warp and weft, if same weave face and back.

(14) Compare various methods of changing weights of cloths, when weave is (1) unaltered, (2) altered as well as weight. Find counts and setting for cloth (a) made from 2/60 worsted, 72 ends and picks, woven with 2/2 twill, to be increased by one-third its weight; (b) with the same weight as original cloth but the weave changed to plain.

(15) Find resultant counts, cost per lb., and quantities to produce 1200 lb. weight of folded yarn, 48's worsted, 30's cotton, 120 denier artificial silk, at 6s 8d, 2s 3d, and 10s 6d per lb. resp. For 10 in. of folded yarn, 10½ in. worsted, 11 in. cotton, 35 in. artificial silk. Twisting 8d per lb. of folded yarn.

(16) Supply formulæ and graphs for converting into metric systems:—(a) worsted, wool and cotton yarn systems, (b) oz. per yard (57 in. x 37 in.) to grm. per sq. metre, (c) shillings per yard to francs per sq. metre. Assume 120 francs = £1.

(17) A cloth has 60 threads and picks per inch of 2/36 worsted, 2/2 twill, set 72 in. wide in reed, what settings for (a) 2/5 step 4, (b) 2/2 twill sateen warp back, (c) 2/2 twill double cloth, double twill stitched on 8 x 8, same yarn and approximately same balance and appearance?

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Wool Blending and Carding, 9.20 a.m. Pattern and Cloth
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A MONTHLY JOURNAL DEVOTED TO THE ADVANCEMENT OF TECHNIQUE
IN WOOL MANUFACTURE

PUBLISHED BY THE SCOTTISH WOOLLEN TECHNICAL COLLEGE.

Editor T. OLIVER, D.SC.

No. 6. Vol. V. ] February, 1928  [7/6 per Annunum, post paid or 1/- per Copy

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Editorial Notes

The Specialist lectures for February will be:—

"Recent Developments in Power Looms," by Mr Geo. Mabon, on 9th Feb., at 8 p.m., in S.W. Tech. College,

"A Study of the Hopper Feed," by Mr J. A. B. Mitchell, on 16th Feb., at 8 p.m., in S.W. Tech College.

We regret having to hold over report of Mr Russell's lecture, which secured the largest attendance in recent years, and was followed by an hour's discussion.

We regret to record the death of Mr Ebenezer Prior, sen., of the well-known firm of wool-staplers and fellmongers, Chichester, in his 80th year.

One of the ablest of the pre-war designer-managers (now retired) writes that the contents of "Scotch Tweed" are excellent and interesting, and he exhorts us to continue the good work.
A N.Z. correspondent writes:—Re your par. in Sept., 1927, from an N.Z. correspondent criticising N.Z. wool sorting, I may say that woollen manufacturing has progressed further than his remarks would lead you to believe. Putting all brands, irrespective of quality, into a 20 cut dyeing bin is not done in our mill, which is one of the most successful in the Dominion. We distinguish different brands which are dyed to colours sufficiently dark to cover the stain, and we never have the "future trouble" mentioned by your correspondent. We would not put 56's quality into a 46's bin for 20 cut black, as that would be throwing good wool away. We tried clipping the brands which had been picked out by the sorters (4-7 lbs. per bale), but we could not make the system pay, when the time taken was checked. A system which may pay in Scotland would fail here, as the sorters' wages are 2s 1d per hour. Of two mills mentioned, one working overtime lost £15,000 this year, and the other has not paid a dividend.

Mosgiel Woollen Factory Co., Ltd., N.Z., shows a very satisfactory balance sheet. Net Capital £95,380, Reserve Account £48,000, Employees Benefit Fund £13,150, Creditors £13,750, Profit £16,000. On Assets side, Machinery and Buildings £41,800 (less depreciation £5000 = £36,800), Warehouse Property £6000, Book Debts £25,689, Bills Receivable £2465, War Loan (employees' benefit) £12,000, Government Loan £19,281, Cash £39,200. Goods in process and Materials £45,000. The liquid assets = £58,490, and shareholders will receive 10% bonus + 10% dividend owing to having more than sufficient capital for the business, £2000 to employees' fund and £8000 to reserve.

Fellmongers in New Zealand are complaining of the decline in their skin wool trade. We do not think that there is any real objection to slipe if properly treated, but due to anxiety to get big sheep, quick feeding lambs, and thus rapid return on capital invested, the wool has been allowed to drift into a coarse by-product. Coarse N.Z. slipe has been found very useful for the blanket trade, but as it is lean and somewhat lustrous the blankets made therefrom are never so warm as those made from Cheviot and Down wool, and although the latter come dearer, there is no comparison as to cosiness. The sheep raisers would do well to cross a Down ram on to the half-bred ewe. The product would be quite useful for the mutton trade, and the wool would be finer for general use by manufacturers, i.e., of Cheviot tweeds as well as blankets. The wool grower might argue that the fleece would not be so heavy, but care in breeding would probably counteract that tendency.
The Wool Research Association were showing again at the annual exhibition of the Physical and Optical Societies on January 10/12. The most attractive feature seems to have been Mr A. W. Stevenson's mirror stroboscope. We read that it has recently been applied to the aperiodic motion of wool fibres in a carding machine, an application which we suggested in our pages some years ago. Needless to say, we shall look forward with interest to the results. Other exhibits are a fugitometer, or fading lamp, in which the patterns can be kept at any desired humidity, a fibre stretcher, a fibre comparator, and an ultra-violet lamp for textile analysis.

New Zealand half-bred wool is reported softer and more wasty than in the previous season, and hence better suited for hosiery than the weaving trade. The grease content is less, and the wools are freer from sand, due probably to the heavier rain-fall. Shearing was later, due to broken weather, and the cold snap following after shearing has caused considerable losses amongst ewes. Some newspaper reports, however, say that wool is better all round this year, but much depends upon the point of view.

Troqueer Mills, Dumfries, have been bought for £12,000 (unwanted machinery will be auctioned about 25th Feb.) by Solric D'Fysun Fabrics, Ltd., Carlisle, which was formed in 1923 by an amalgamation of Walter Paton & Co. with Morton Ashworth & Co., Ltd. They have specialised in manufacture and dyeing of an extensive range of household decorative fabrics from casement curtains to novel fashions in upholstery fabrics for curtains and furniture covering. They are best known by their fadeless fabrics. Most of the existing machinery will be cleared out to make room for the 200 looms and auxiliary apparatus suitable for the special work. The firm owns Brookfield Mills, Alva, and Crummock Park Dyeworks, Beith. So the Scotch Tweed trade will be reduced by 112 looms and 14 sets, but since the slump less than half of these have been in use, and as the spinning and weaving machinery was old it was bound to be thrown aside in the natural process. But the dyehouse was fully equipped with new machinery, and this will be used by the new firm. The finishing plant was large and good, and its dispersal is regrettable. As to municipal services, Dumfries is reported to be the lowest rated burgh of like size in Scotland. The authority is willing to change the present D.C. to A.C. electric supply. The water supply is poor in summer, and steps will be taken to bring in a fresh supply to meet the needs of the new firm. It is well to remember that if a firm is busy, municipal charges form a small element of cost per yard of fabric. The burden is only felt by a firm in the initial or ebbing-out stages.
Mr Henry Binns, F.T.I., giving a lecture at Halifax, said that sound judgment is needed for the material basis of prosperity to rise out of what is left from the shock of war. Raw materials are bought, new yarns and fabrics produced, commission dyeing done with much secrecy. The bulk business is conducted with little of the detail becoming public knowledge. The confining of materials and styles implies excluding information from others. Wool goods must be handled as well as seen and described, and their differences cannot be accurately estimated without delicate touch. Judgment may be developed by natural and acquired capacity, specific training, controlling of temperamental tendencies, adequate knowledge of essentials, intuition arising out of subconscious memory in which is stored wider experience than that covered by the actual facts under review. A London piece-goods buyer’s judgment might be ideal from his own and his customer’s standpoint, but he might not have the knowledge of the essential differences for the Bradford trade.

In New Zealand 12 mills operated during 1926-27, value of land, buildings, and machinery £945,775, workers 2380, salaries and wages £369,323, total cost of materials £508,137 (17% less), and value of product £1,053,306 (9% less than the preceding year). 22% more flannel was made and 24% fewer shawls and rugs, and 15% less yarn sold, while the tweeds and blankets were only slightly less. Over £3,000,000 wool goods and ready-made clothing were imported during the year.

Some of the defects which follow on excess moisture in wool goods are loss of weight, tendency to develop mildew, yarn grist finer than when originally tested, but much more serious is the tendency to form weft bars in a piece owing to the damp yarn stretching in process of winding and weaving, and then tending to assume its normal dimensions on drying after the finishing process makes the portion with damp weft tight, and as frequently occurring in short bits make innumerable imperfections. This is a well-known condition to worsted yarn buyers, but it is not so well understood that artificial silk has the same tendency, and the cellulose-acetate variety is the worst in this respect. Atmospheric humidity varies from room to room, and the differences affect the sensitive Celanese filament. The weft store-room reckoned as best suited for the worsted manufacturer is the worst for artificial silk. Most of these rooms have damp atmosphere as helping to reduce the liveliness of newly spun yarn and to make it more tractable for weaving.

Sir Henry and Lady Ballantyne have celebrated their golden wedding at the same time as their son, Colonel David Ballantyne, reached the silver wedding epoch.
Mending has been a heartbreaking experience in Scottish mills this season, due partly to inefficient weavers and partly to difficult work. Some mills have been choked completely. Instances of pieces taking two or three times as much to mend as to weave have been frequent. This experience has not been confined to Scottish mills; there has been much trouble in England too. In one instance there were seven times as many pieces in the pile to mend as there were pieces in the loom. We need complete reformation in the mode of training weavers and darners. Moreover, designers should be better instructed in the powers of a mill, because cloths which cannot be made perfectly should not appear in ranges.

Mr. James Sanderson, of Gala Mills, who died 10/11/27, has left £35,000 to the University of Edinburgh for research in Chemistry and Engineering, £35,000 for erection and maintenance of houses for old residents in Galashiels, £24,000 to various hospitals, etc., £40,000 for certain religious purposes. The total bequests exceed £150,000.

A simple test for Indigo serge depends upon the solubility of Indigo in chloroform. To carry out the test, place a small piece of the pattern in a test-tube, cover with chloroform, and shake. If Indigo is present, the chloroform is given a blue colouration.

Mr. John W. Warburton, research student, Tech. Coll., Bradford, has designed an instrument to indicate yarn quality. A hank of yarn is placed over three pulleys, one of which is rotated by an electric motor, a second is fixed to the frame, and the third is attached to a swivel arm, so that the hank may be tensioned. The hank also passes over the bulb of a fine-graded thermometer. The motor is started, and during the passage of the yarn over the thermometer, frictional heat is developed, increased temperature is recorded on the instrument. By a series of tests he found that the higher the quality of material, the greater this frictional heat becomes, also that after 3 to 4 minutes the temperature remained constant. As heat is developed by frictional contact of scales against thermometer bulb, the finer qualities generate more heat, because the larger number of scales gives a greater number of points of frictional contact. Naturally the instrument is only for comparison of wool qualities in similar yarns or cloths. The apparatus would require an improved temperature measurer and mechanical refinement before any formal relation between the quantities could be deduced. Indeed, assumptions based on a study of diagrams with exaggerated features are of doubtful value. Further study will probably reveal that other properties besides wool quality have been unrecorded.
Problems of the production of the raw material used in textile industries are becoming more apparent, with the result that more attention is now being devoted to the study of the development of the fleece from the point of view of the sheep-breeder. It is proposed to outline here certain biological conceptions of problems which arise in the treatment of wool after it has left the sheep's back, and to indicate how the elimination of certain objectionable characters of the fleece is within the scope of the sheep-breeder's activities.

In the first place, it must be realised that the fleece of the sheep is only one form of the typical covering of mammals, a modification of which in different directions gives rise to the different types or groups of fibres which are found in the coat of the sheep. Certain aspects of the development of fleece fibres can be gained by study of the coat fibres of other mammals, the most common type of unmodified mammalian coat consisting of two readily distinguishable groups of fibres—long, coarse fibres which constitute the outer protective portion of the coat, and fine, short, "woolly" fibres which form the inner, presumably warmth-retaining, portion. The fleece of primitive sheep consists of such a composite coat; and the fleece of the modern domestic sheep may be considered as a modification of the primitive type by the elimination, more or less completely, of the outer coat with a corresponding increase of the inner coat. But certain fibre types apparently derived from the old outer coat still persist, and the present problems are largely those connected with the arrangement of the different fibre types, inter se. The different types may be distinguished according to certain criteria of structure (the proportions of cuticle, cortex, and medulla in the single fibre), or, more satisfactorily, of method, time, and rate of growth. Thus kemp, the remnant of the outer coat in the fleece of modern sheep, is shed periodically, while in some modern breeds, such as the Merino, the wool fibres grow continuously. In others the wool fibres exhibit an intermediate thinning stage corresponding to the shedding in more primitive forms during the late spring or early summer, this being the "rise" which is taken advantage of by the shearer.

The presence of kemp in the fleece is one of the most objectionable drawbacks from the point of view of the manufacturer; true kemp, owing to the method and time of growth, usually lies free in the fleece, and because of its characteristic appearance, can readily be separated in samples from the remainder of the fibres. In this way, it has been possible to estimate
the proportion of kemp present by weight in representative samples of the fleeces of different animals. A great variation in these proportions exists in the different breeds, and it is certain that by careful selection a breeder can establish a strain of sheep in which the amount of kemp in the fleece is greatly reduced. It is possible, therefore, for the breeder, in the case of the kemp problem, to eliminate the cause of the objections of the manufacturer. So far as the rest of the fleece is concerned, its value is affected by the characteristics of single fibres and by the characteristics of fibres in groups. The manufacturer is interested, for example, in the fineness, the length, the lustre, the tensile strength, of individual fibres, while the sheep-breeder is interested also in the density of the fleece and the length of the fibres, which together give weight of fleece. It cannot be said as yet how far these sets of characters are interrelated, but it is possible to derive some information on the conditions of the adult fleece by studying the development of the lamb's coat. It has been observed, for instance, that the lamb's coat usually exhibits a peculiar structure of groups of fibres, which are twisted into spiral whorls; these spirals would appear to bear a certain relation to the characters of the fibres themselves. Thus in certain lamb skins the spirals are tightly formed and small, and the fibres are fine and short; in others the fibres are all coarse and the spirals are large, open and indefinite. Again, in some skins where there are two fairly distinct types of fibres, the finer, short fibres are formed into close spirals, while the long, coarse fibres protrude beyond this layer of spirals and are not grouped in such a noticeable manner. It is interesting to speculate how such types of birth coat are modified as growth of the fibres proceeds.

In some breeds of sheep the coarse fibres in the lamb's coat are soon shed, and the fine fibres continue to increase in length to give rise to the adult fleece; traces of the spiral condition can be found in the adult fleece before the first shearing. In the Wensleydale, each lock of wool exhibits the spiral form more or less throughout its length; this is not a dense fleece. In the Border Leicester generally the locks are spirally formed at the tip, and gradually change to the familiar wavy condition; but if locks near the borders of the fleece, as in the neck region, are examined it is found that the spiral condition persists throughout a greater depth of the staple. In dense fleeced breeds, such as the Corriedale, the staples have spirals at their tips, and these have rapidly changed to give rise to the close crimped condition. Thus a character of the lamb's coat may be related to certain characters, such as density, fineness, and length of adult fleece, and the general problems are con-
nected with the conditions which give rise to different expressions of such characters. In addition, there are numerous specific problems which can only be studied adequately in the animal itself. For example, cotted or matted fleeces are a definite nuisance to the manufacturer; the condition arises by the interaction of certain causes, which in the first place produce a shedding of a number of the fibres. It has been found that certain sheep are more liable than others to do this under the necessary conditions, and that the defect is most likely to occur at certain times in the year. In the case of coloured fibres mixed with colourless fibres in the fleece, their presence is normal to certain breeds of sheep, and is dependent fundamentally on the general question of pigmentation in the animal as a whole, while in the case of coloured sheep, that is animals with wholly coloured fleeces, or piebald fleeces, or fleeces where the colour is found in portions in some definite pattern, the factors which give rise to the particular character have been found to be hereditary in nature. The sheep-breeder can remove, provided he uses the best methods, these causes of objection to his product on the part of the manufacturer. It is the duty of the biologist to examine the manufacturer’s problems from their origin, and to indicate how the sheep-breeder may eliminate their causes when they come within his province.

The closer relationship betwixt sheep breeders and manufacturers has been considered by the Wool Industries Research Association. For example, the standardisation of wool quality and the characteristics of fibres for various fabrics is a problem awaiting solution, and much progress has been made. The Empire Marketing Board has recognised the importance of the question, and has granted a capital sum of £7000 and an annual contribution of £2000 to the Research Association for the investigation of wool quality. To determine wool quality, fineness, length, crimp, etc., must be investigated. This grant, however, will not relieve the necessity for support from the manufacturers, as it will involve additional premises and special staff. But the grant indicates the appreciation with which the institution is regarded. Additional support should be forthcoming from the woollen and worsted trades, and to encourage this the Government has increased its grant to £4800 instead of reducing to £1200 for the current year, as previously intimated. But of course it is of prime importance that the industry should rise to the occasion and help itself, and the financial support required is small compared with the beneficial results which will accrue from adequate support.
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Scotch Tweed Practice Defence.

In the December and January issues of your excellent publication "Scotch Tweed" you make a rather sweeping condemnation of Scotch manufacturers. It arose apparently from the fact that a manufacturer was told by his auditor that prices were too low. It seems to me that you entirely missed the point in reference to a 38/6 costume length being retailed at 13½ guineas for the completed costume. What will strike the majority of people engaged in the manufacturing end of the trade is the amazing difference in the prices. Where does all the profit go?—certainly not to the manufacturer. Surely the costume should be sold cheaper to encourage trade, or, if not, then the manufacturer is entitled to more than 38/6 for his share of the production. As for inefficiency in the manufacturing processes, while I admit that economy may be practised in many ways in a mill, you must not forget that it can be carried to such an excess that the virtue therein becomes a vice. I should like to point out incidentally that a lot of economies are required to effect a saving of 3d per yard. You suggest that more attention should be paid to the restriction of colour elements, and in making that suggestion, seem to forget that the commanding position occupied by the Scotch Tweed trade in the woollen world to-day is due, not to the quality alone, but to the great variety and blends of colours used in the production of their goods. I'm afraid you will find that, if you practise economy in colours, your customers will retaliate by practising economy in their order. Again, if you limit the number of colours in mixtures to a certain number, and thus lower the price of the yarn, and accordingly the cloth, your profit remains the same—unless you charge the same price as for multi-coloured mixtures. Some manufacturers run a cloth ¾ or ½ white, but the cloth is priced accordingly, and is cheaper than it would be if composed wholly of mixtures—but—that is not economy! I presume your idea is that the smaller the number of colours, the larger the dyeings, and therefore more economical, likewise the smaller the number of mixtures the bigger the batches, with a further saving. That is quite true within limits, and I should think is realised by all manufacturers, but what I wish to emphasise is that it can be carried to excess. Another point you forget is this:—Suppose one mixture contains colours A. and B., and another C. and D., and another E. and F., then a mixture of A.B. C.D. E.F. containing as it does 6 running colours, is quite in order. The waste comes in only when dyeings are made for a very limited number of mixtures, and are, in consequence, very small. Manufacturers must
cater for their customers' requirements to a certain extent, and I'm afraid the day is still far distant when a manufacturer can show a customer and say, "You must buy these cloths and colours as I have made no others this season"!! A case is also referred to in your magazine of a customer keeping ranges though not ordering them. Fortunately, manufacturers in general have more backbone than to allow this sort of thing, and would probably rather lose the account than permit it.

"Scotch Tweed."

We are glad that at last our "strong" remarks have provoked a protest, and we could not welcome a better critic than our contributor. But it is always a favourite mode of criticism to push statements beyond the limits of their application. We have never averred that all Scottish woollen practice is faulty, only much of it is susceptible of improvement. We did not belabour the 38s 6d/13½ guineas "example, as its quotation seemed sufficient to place the blame on the retailer, and we have been citing countless examples of the extravagance of cloth and garment distribution. We are glad to hear that our friend has the whiphand over the merchants regarding undue retention of ranges and unnecessary multiplicity of colours. But "one swallow does not make a summer," and we know many manufacturers who are groaning under the burden imposed by thoughtless and inefficient buyers. Wherever a mill is wholly controlled by its selling organisation, pattern expense is apt to run riot. We have been informed by a manufacturer that of a special fancy yarn, six times as much weight was used in patterns as appeared in pieces sold—i.e., £300 in patterns to £50 in pieces. Can that be justified? Such instances may be multiplied. The average Scotch mill does not run four broad looms steadily for each narrow pattern loom working almost exclusively on ranges, while the broad looms make most of the samples. We suggest that the "commanding position" is held by the merchant dictators and not by the manufacturers. We do not condemn colour profusion provided it is helpful, but some Scotch styles approximate to the condition of a greydyeing mixture, because of the mutual destruction of the colour qualities through sheer multiplicity. We do not deny that economy as well as extravagance may be a vice. We have quoted Kynoch of Keith as having found the virtue of economy. In his covering letter our friend states his high opinion of their management. But he has great statistics at his disposal, and yet he contents himself with mere qualitative statements. We have staked our reputation on quantitative statements, and we wish to have them refuted by our critics if they are wrong.

Editor.
The Breast Doffer is most important, and a great deal depends on its efficiency. Its working may be the deciding factor between a fair profit or a considerably reduced margin. One of the chief difficulties with breast doffers is that they get broken-backed comparatively soon, i.e., the angle of the wire gets pulled straight. When this fault becomes very pronounced, we see balls of fibre varying between the sizes of a pea and a walnut, according to the state of the doffer, dropping to the floor between the breast and doffer. When this fault begins the doffer should be knocked off irrespective of length of wire. This trouble may be caused by wrong speeding combined with wrong setting of the fancy, and also by allowing the points to become dull, so one must be sure that the doffer is really broken-backed before condemning it. Most of this trouble is in the low class trade with large production and high speed breast doffers with coarse thick wired cards. A bad doffer will easily make as much waste in a few weeks as would cover the cost of a new one. Many engineers are not allowed to throw off cards until given permission. In the fine trade a broken-backed card is not so much in evidence, but where it is, knocking off should be followed without delay. The finer wools roll and nep in greater profusion, and the neps are considerably smaller than those previously mentioned, but the finer card wires do not allow them to fall on the floor, but carry them forward to be dealt with on the other parts of the machine. It would be better if the cards would reject them as they do the larger balls in the coarse qualities. Thus one should be very particular about sharpness, condition, speed, etc., of the breast doffer in the fine trade, because these neps are very difficult to card out, also necessitating finer setting and consequently more breakage on the other parts of the machine. The counts of the cards are generally the same as for the breast cylinder, but many carders order them slightly finer counts owing to the smaller roller making the cards opener at the extreme point. If we neglect stretching counts, as they should be equally stretched on both cylinder and doffer, they vary according to the sides of similar triangles, e.g., with a 50" Breast and a 30" Doffer, and the cards ½" from crown to point, the counts being 100s in both cases when nailed—

\[
100 \times \frac{15}{15.5} = \text{Roughly 96s face count of doffer.}
\]

\[
100 \times \frac{25}{25.5} = \text{Roughly 98s face count of swift.}
\]

Thus there is little to choose between them, and it would be better to allow the doffer this, as a doffer too full of wire defeats rather than helps the clearing of the breast cylinder.
The chief disadvantage is that the smaller doffer makes the angle of the wire less effective, and doffers 20 or so keener in angle than the swift would be better than to increase the wires count ways. For the benefit of those who think it advantageous to increase the doffer and worker counts I would add that they are generally increased by 5 counts such as 100s swift 105 doffer, 80 swift 85 doffer, etc.

E. Stephenson.

(To be continued.)

LICKER-IN CLOTHING.

In the notes on carding machines in December issue of "Scotch Tweed," p. 118, we were particularly interested in reading those on licker-in clothing. We must say that we do not agree with the remarks made by your contributor in regard to his criticisms on Garnett wire as a clothing for licker-in rollers. In the first place, we wish to point out that many firms who have had their licker-in rollers covered with Garnett wire have had them clothed with too fine a wire, i.e., with too many points to the square inch. If some of them would try a coarser and stronger wire with longer teeth and fewer teeth to the square inch, they would find that they would have far less trouble with filling up with grease, and that would mean they would have far less frequent cleaning. Secondly, they would get an extremely good clothing for the opening of long wools, a clothing which would be equal, if not superior, to the licker-ins with the wood lag covering. Thirdly, we note that your contributor says that "Garnett wire is useful, but its usefulness does not outweigh the bother and expense of getting the rollers recovered." This is a statement which we certainly cannot understand, for we may say that the charge for re-clothing a licker-in is considerably less with Garnett wire than it is with either wood lags or leather foundation fillet, and it is not a troublesome matter to re-clothe, for any intelligent man can re-clothe a roller in a screw-cutting lathe in a few hours, and we believe that there are several firms in the South of Scotland who can re-clothe licker-ins with Garnett wire quickly and at a reasonable price. We shall be glad to submit samples of various types of saw tooth licker-in wires either to you or to your contributor or any other interested parties. We must apologise for troubling you, but we think it is only fair to ourselves, as the original makers of Garnett wire clothing, that we should not allow these criticisms to remain unanswered.

P. & C. Garnett, LTD. (Cleckheaton).

[We do not necessarily endorse a contributor’s statements and we have pleasure in publishing above information.—Editor.]
I have not spoken of what is commonly offered in connection with this problem, because much of what is adduced is subsidiary, and not really essential. It is often asked, "What should a boy know on entering the woollen industry?" I may say that it is not so much what is known, but how it is known, that is important. The chief function of education is to "draw out" and develop latent faculty. Much of the instruction given in schools and colleges imparts information, but with scarcely any education, tending to hinder mental movement by clogging the mind with inert matter. An educator whose mind is stagnant can impart information without effort, but the drawing-out of the faculties calls for vitality and initiative on the part of the teacher. Where paths of least resistance are followed, the continuous description and explanation deaden the minds of hearers. So a man who has studied subjects entirely foreign to the industry may be more efficient in industry than one who has studied a dead system of technical instruction, however much it may appear to bear on his work.

But provided the studies are not too narrow in outlook, the closer the relation to the work the more active the interest is likely to be. Every study exercises perception, imagination and reason. Perception and imagination are stimulated in youth, and should develop as time goes on, but reasoning is necessarily more developed in mature years. These gradually make for the formation of a fund of common-sense which solves many problems in a better way than unaided academic training will do. The classics and Euclid have been lauded as unrivalled subjects for training the mind, but without hesitation I assert that the Scotch Tweed industry presents countless problems which are equally well calculated to sharpen the intellectual faculty.

In the discussion, to which Messrs Alex. Fairgrieve (the Chairman), Colledge and Christie contributed, the following salient features emerged. It would be to the advantage of the trade if beginners could be initiated in a wider range of branches. More practical instruction should be given in the Technical College to the ordinary worker. There is also a growing tendency for apprentice tuners to seek to learn only the little bit that affects the daily routine they are called to perform, on which the lecturer commented that there was nothing so pathetic in confession of helplessness as the advertisement for, say, a Dobcross tuner, as if a tuner who knew the principles of his business should not be able to tune any of the three principal looms in the Scotch Trade. He advo-
cated that the Tech. College students should have free access to a small mill, and get practical training in every main branch. The Chairman spoke of the difference of spinners. One man never seemed to be hustled, and was making 10s/15s a week more than his neighbour, who was always in a broil. There should not be any difficulty in the way of a boy learning all about yarn manufacture, and so becoming an all-round man. The lecturer described the admirable scheme of apprenticeship in vogue with Messrs D. Ballantyne Bros. & Co., Ltd., Peebles and Innerleithen, in which a boy takes about 60% of his apprenticeship in his main department and spends the remaining part in cognate departments and at the Technical College.

**Water Soluble Halogen Hydrocarbons IV.**

*(Abridged Report of Lecture by Mr Percy Bean, jun., M.Sc., B.Sc. (Manchester), in S.W. Tech. College, 27/10/27.)*

In scouring high-class worsteds, the oil is usually neutral and small in quantity, not saponifiable by alkali carbonates. A solvent should be useful in removing the dirt, rendering alkali less necessary. Any reduction in alkali is an advantage in process. In scouring lower qualities there may be colour bleeding due to poor dyes, dyeing in the grease, etc., or low-grade oiling with much mineral oil. Often necessary to scour such at low temperature to avoid bleeding, thus losing the advantage of the lower surface tension of a warmer liquor. A solvent would again reduce the surface tension and increase the emulsifying power. Much mineral oil tends to prevent formation of emulsion, and it is only removable by emulsification or solvent. Caustic soda may be used instead of sodium carbonate. The substitution of the solvent will cause less damage to the product. Some have adopted solvent in alkali without any soap. This, while adaptable for certain goods of low cost, does not give equal results to those obtainable when solvent is used in conjunction with soap. Soap and solvent are both neutral, not injuring wool; while the free use of alkali gives tender harsh yellow effect.

In scouring raw wool some use two bowls, others three, four, five or six bowls, but four bowls are quite efficient. In the first the previously-wetted wool is run through weak soap bath, second and third bowls contain soap of the usual washing strength with a little solvent, the fourth bowl very weak soap solution without any solvent, to rinse out any remaining impurities and effect a soft, lofty handle. When wool is very
greasy a little solvent is advised in the first bowl. This should first be well mixed in a pail of warm water. The percentage varies with quality and amount of wool. The scourer soon determines the quantity. When using a solvent the quantity of soap may be reduced by one-third. As scouring proceeds, the scouring liquor is refreshed from time to time by adding 3 ozs. of solvent in solution at a time. By this process wool should be quite free from grease and odour, and have a superior appearance to the old process. The new process is also adaptable to yarn scouring. In the first bowl soap and solvent, using two-thirds of the former strength of soap and 8-10 ozs. of solvent, stirred in half-pailful warm water before adding, and then stirred in the bowl before entering the yarn. The bath is replenished by a pint of soap solution, half strength, with 2 ozs. solvent, per 100 lbs. yarn. For knitted goods, similar treatment is advised. In using with sodium carbonate the alkali should be dissolved in boiling water, and the solution cooled down before adding the solvent. Stock solution:—30 lbs. soda ash in 100 gallons water, 10 lbs. solvent added. 20 minutes steep in this solution, thrice diluted, is a good preliminary to scouring and milling knitted goods.

With regard to woollen and worsted pieces, 3-7 ozs. tetralene for every 200 lbs. of cloth should suffice. Smooth worsted pieces contain only little grease, and will not require as much as heavier woollens. In the latter class solvents are most valuable, and in all cases the soap may be economised by one-third. In milling worsted goods, 4 ozs. of solvent in solution, well stirred into each can of melted soap, reduces the time of milling. The milling action is much increased by the better penetration. Soap is not a good penetrant of wool, because wool and soap are both colloids, and colloids do not diffuse through colloids. The solvent is used also in the kiering of cotton goods for removing tar and paint stains, etc.

The Scottish woollen industry has had a very much better season than the preceding, but the business has fallen away considerably at the close, and the new winter season has been hanging fire, probably due to the merchants having over-bought in the previous season, and also from not knowing the probable trend of fashion. That seems to be the greatest difficulty in the fancy trade nowadays. There are so many freak styles which have a crowded hour of glorious life, and as a consequence impose great strain on mill resources to give delivery in time to avoid cancellation. The variation in rate of supply of orders makes fancy woollen manufacturing unprofitable to all concerned.
The world wool supply will be smaller for the forthcoming season. From the record clip in Australia of last year there will be 250,000 bales less this season. There will be a small increase in New Zealand and a slight decrease from South Africa, and there will be 30,000,000 lbs. less wool from South America. So that there is every likelihood that the better trade conditions will be throttled by increased cost of the raw material. But it is likely that there will be no great inflation of prices, as the wool trade learned a lesson three years ago. At the last London sales, wool has gone up 5–10%, so that whenever there is an improvement of trade it is quickly checked by the increased charges.

**Current Prices.**

**Wool Prices.** Unwashed Blackfaced, 12½d; Cheviot, 17/18d, Half-bred, 13½/16½d; Fleece washed Southdown, 28½d; Dorset, 24d; Shrop, 23d; Suffolk, 22d; Oxford, 21¼d; Welsh, 13/16d. **Skin Woods:** 64’s (super) yield 70%, 39d; 60’s (strong) yield 73%, 35d; 58’s (come-back) yield 75/80%, 33/36d; 56’s (super ×) yield 80/85%, 31/33d; 50’s (first ×) yield 85%, 24½/25½d; 46/48 (second ×) yield 88%, 21d.

**Top. Quality No.** 70 64 60 58 56 50 48 46
Price. 58 55 52 47½ 43 32 27 25

**Worsted Yarn.**

Wht. 2/24 68 64 61 55½ 50½ 41 36 34
Wht. 2/36 72 68 65 59
Wht. 2/48 76 72

18d extra for mixtures, 21d extra for marks in Botanies.

**Woollen Yarns,** white (with one-sixth sinkage) — Super Saxony 56 cut, 75d, 42 cut, 68d; Strong Saxony 30 cut, 62d; Super Cheviot 36 cut, 53d; Medium Cheviot 20 cut, 40d; Strong Cheviot 15 cut, 34d; Blanket, 10 cut, 24d.

Subtract 3d from Merino and 1¼d from Crossbred for wool to dye, and then add 6d (black) to 9d for solid shades, 9d to 12d extra for mixtures. Mixtures involve more care and reduce output through the carding machines having often to stand while batches are corrected to standard shades.

**Cloth.** Botany worsted 64’s (Indigo piece dye). **“Pinhead.”**

<table>
<thead>
<tr>
<th>Weight</th>
<th>16</th>
<th>18</th>
<th>20</th>
<th>22</th>
<th>16†</th>
<th>14†</th>
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<tbody>
<tr>
<td>Count</td>
<td>2/24</td>
<td>2/26</td>
<td>2/22</td>
<td>2/18</td>
<td>2/32</td>
<td>40 cut</td>
</tr>
<tr>
<td>Price</td>
<td>9/6</td>
<td>10/2</td>
<td>10/10</td>
<td>11/6</td>
<td>10/8</td>
<td>12/-</td>
</tr>
</tbody>
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† In woollens, standardization is impossible, but a good 14 oz. Scotch Saxony has been selected and for monthly comparison costing worked on a fair basis if silk introduced 2¼d should be added for every unit percent. of silk by weight.

**Terms.** Wool sales, net 14 days; Yarn, Woolen, 2½%; 1 clear month; Worsted, net, 1 month; Cloth 4% next month, 3⅓%, 3⅓%, 2½% (on 4th month)
ALTHOUGH of value for other purposes, an important use of this colour is for the production in conjunction with Alizarine Cyanine Green G Conc. of grey shades of excellent fastness to light and milling.

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CROSSBRED NOILS.
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ALL DESCRIPTIONS.
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FULL RANGE STANDARD TYPES WOOL SCOURERS
AND CARBONIZERS.

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REDUCES WASTE
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Steel Blade Tape Condensers with Two or Four Heights of Surface Drums.
Double Doffer Condensers with Doffers from 20 in. to 36 in. Diameter. Surface Drums in Two or Four Heights.
Single Doffer Condensers.
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SPEN VALE WORKS.
HECKMONDWIKE, England.
Adaptability of Design and Relation to Sett II.

(Lecture by Mr D. R. Christie, A.T.I., in S.W. Tech. College.)

Probably the most adaptable of the double cloth designs is the double plain 1 face 1 back. This weave is used extensively in designing of suitings, trouserings, overcoatings, costumes, and mantle cloths. These include fabrics which are for the most part developed on totally different lines, and this weave can be readily adapted to each particular type. For suitings and trouserings it is used mainly for the production of neat stripes and checks. The weave lends itself to considerable variation in the development of hairline stripes and to checks of the bird's eye variety. As a double cloth it admits of greater variation in colour schemes than single cloths.

In the designing of costume and mantle cloths its adaptability for figuring has been well illustrated by designers of these. The designs are so arranged that the two cloths are interchanged, and practically any form of figure design can be developed. Again, each cloth may be coloured by using different arrangements of two or more colours and thus yield effects not obtainable by single cloth figuring. It is also possible to increase the number of effects by using single-cloth designs in conjunction with the double plain. The weft crow twill forms the basis of practically all the double plain figure designs. This base weave can be readily changed into 2/2 twill, 3/1 twill, and celtic, and also remain as a section of the design. It is thus possible to have a considerable variety of effects combining one or more of these with sections of the double plain. The introduction of the single cloth weaves is admissible, as the double plain when used for costume or mantle cloths is made in the common twill sett or nearly so. The double plain is not confined to cloths made on the "one-and-one" principle, but is used in double cloths constructed on the two-and-one and three-and-one principles. Although these have not such a wide application, yet they may be used for special structures.

Before dealing with checkback structures, I would draw attention to a few special weaves to illustrate the influence of setting. Very often it is possible to obtain two or more distinct structures with one weave, as has already been shown with plain and twill cloths. A and B illustrate weaves of the whipcord variety, yet both may be set to bring out the 2/2 twill elements, which at first may not be evident from their general appearance. Weave A (5/3 step 2) is useful for whipcord riding tweeds when suitably set, e.g., 36/56 cut warp and weft 68 ends and 50 picks. It can also be made to show 2/2 twill backed with weft 1 face 1 back if set with twice as many picks.
as ends, say, 34 ends and 68 picks in the same yarn. B (6/3 step 2) illustrates another whipcord structure, but this again may be made to show 2/2 twill on face by setting with approximately twice as many picks as ends. The design is a 2/2 twill pseudo or imitation weft back 1 face 1 back.

Then, again, suppose 2/1 twill single cloth one grist only, and heavier cloth required but still to show prunelle face and to be as suitable for developing figure styles as the prunelle. Weave selected 3/3 step 2, and start 1 pick up for figure section. This is a weft prunelle backed 1 face 1 back, and it is suitable for figuring by interchanging wefts coloured 1 and 1 weft. Also it admits of greater weight being obtained.

C illustrates a design of the weft rib structure, and consists of plain and 2 and 2 picks alternately. The design is of the reversible rib variety, as both face and back have the same appearance. To develop the weft rib structure the cloth must be made with considerably more picks than ends, i.e., on the two-weft principle. In this form it has been widely used for stripe styles in worsted suitings and trouserings. It may also be used for a fine cord stripe by oversetting the warp, because it is made up of two threads each of 3/1 and 1/3 interlacings. D yields three distinct structures by varying the sett. In the first place it may be treated as a warp back 1 face 1 back with broken crow face and back when \( c = 2p \). Secondly, it gives a double plain cloth in "square sett." The third structure is the more unusual, because the sett for the warp back is reversed so that \( p = 2e \). The advantages of the third setting are to be found in raised cloths—the close wefting gives a good foundation for producing a dense pile, while by the interlacing of the weft firmness is retained. This structure is recommended for velour and other styles of finish in which a full dense pile is required. E and F can form the basis of figured designs, (a) and (b) sections being added to any motive, and the principle has the merit of requiring few leaves to produce a large design, which appears to be made on a Jacquard.

The checkback overcoating is probably the most interesting of Scotch tweeds from the standpoint of designing and setting. This is due to its being a compound structure, and to the variations that can be made in each cloth. The cloths to be combined may differ in quality, counts, weave and sett. Variations in one or more of these fabrics are to be found in
most checkback fabrics. The stitching is usually by extra warp threads, and practically any two cloths can be combined and the stitching be made satisfactory. Each cloth is made in qualities to suit the type of fabric required, thus we find cheviot and saxony, worsted and saxony, worsted and cheviot as popular combinations. In producing the compound fabric various factors have to be considered so as to obtain a well-balanced cloth. The relative setting of the two cloths are governed by the arrangements of the face and lining threads and picks. The more common of these are 1L 1F, 2L 1F, and 3L 2F (L = lining, F = face). When any one of these arrangements is decided upon and the design prepared, then the counts of the two cloths are determined from a consideration of the weave and proportion of face and lining threads. The simplest type is one in which the weave is the same on both sides, as the principal factor then to be considered is the arrangement of face and lining threads. In the "one-and-one" arrangement both counts are usually the same, although it is not uncommon to have a finer count for lining. When the "two-and-one" arrangement is used, then as setting is proportional to the √ count, and as the relative setts for the two cloths are fixed by the arrangements the lining-face counts ratio is obtained by squaring the relative setts thus: $2^2$ and $1^2 = 4 : 1$. For the 3 and 2 arrangement the counts ratio is 9 : 4. In practice considerable variation from the above ratio is to be found, due to the fact that fabrics have to be made to come a certain weight and to the counts that are available for the various cloths. The following table gives an illustration of the scope that the designer has in dealing with these cloths.

(To be continued.)
DOBCROSS DOBBY—IV.

The dobbi is driven at a regular speed from the crank shaft. There are no eccentric wheels needed to give the necessary dwell to the healds during shedding. The vibrator is constructed in such a way that the wheel, when acted on by the cylinder, changes position during half a revolution of the crank shaft, and remains stationary, being locked in position, during the other half. Thus the pause of the heald movement during the passage of the shuttle across the race is obtained without any special time in the movement of the dobbi. The eccentric motion of the heald is also obtained by the construction of the vibrator. The point where the connecting lever is fixed to the wheel moves in a half circle while the wheel is changing position, and the time given to the lever while describing this half circle is slow at first and gradually increasing in speed to the top of the circle, and slowing down again till the wheel comes to rest. This time gives the desired motion to the healds, starting their movements slow and increasing the speed so that they are moving quickest when half-way through the traverse, and slowing down again at the finish of the movement. A special feature of the vibrator lever is that while performing its main function of changing the position of the healds it also gives the desired eccentric movement to the healds while changing. Also, it gives the necessary dwell to the heald after changing without any additional mechanism in the dobbi. There is another feature in the Dobercross shedding which claims attention, as it allows the time of shedding to be varied to a considerable extent. The vibrator wheel in turning does not act immediately on the heald; the movement of the heald does not begin until the point where the connector lever fixed to the wheel rises above the centre line, and the heald is at rest again before the wheel is locked in position below the centre line, so that, although the time taken by the vibrator wheel in changing is equal to half a revolution of the crank shaft, the time taken by the healds during their movement is equal to \( \frac{1}{4} \) of a revolution of the crank shaft; this quick movement of the healds facilitate early shedding.

Where the dobbi is set so that the boxes are half-way through their traverse at the beat-up, and the cylinder of the heald section is set in line with the box section the weft is beat up before the warp crosses in changing the shed. Any advance from this position of the heald section cylinder will cause the weft to be beat up on a cross shed, the number of teeth advanced determining the position where the shed crosses. With the cylinder set 5 teeth in advance the healds are through their full traverse when the lay is \( \frac{1}{2} \)" back after the beat up, and the shed crosses 1" before the beat up, while
when the heald section is set 7 teeth in advance the healds are through the traverse at the full beat up, and the shed crosses 2·4" before the beat up. In working heavily wefted pieces the weft stays better in position when beat up on a crossed shed, and makes wefting easier. Also, when the healds are through their traverse at the full beat up, the strain of the beat up is distributed on all the warp threads, instead of being thrown on those which are stationary, which is generally half of the warp. When the heald cylinder is working 5 teeth in advance, the lay has moved from the back 1" when the vibrator wheel begins to move, and 1·9" when the healds begin to move. With the heald section 7 teeth in advance the lay has only advanced 3" when the vibrator begins to move, and 9" when the healds begin to move. So it is not advisable to go beyond this position, as time must be given for the shuttle to clear the shed before movement begins.

G. MABON.

LOOM TROUBLE.

With reference to your Yorkshire reader's loom trouble, and in addition to Mr Mabon's excellent remarks on the subject in January Scotch Tweed," I would like to suggest that your correspondent examine his dobbie just after the lock knife has engaged, and see if there is any upward lift on the vibrators that are engaged on the bottom cylinder. If there is, then the lock knives will have to be lowered by filing the raised portions of the swivel (into which the blade set screws are screwed) until the knife almost touches the top of the vibrator tongue. If this filing is done so that the front of the knife is slightly lower than the back, it is a distinct advantage, and should keep the bottom vibrators rigid from start to finish. Your correspondent understands, I presume, that the lock knife has nothing whatever to do with the vibrators engaged on the top cylinder. The bowls attend to that. FOREMAN.

[We are much obliged to our esteemed contributor for his help from time to time.—Error.]

MIGRATIONS.

David Tait, from Greengates Worsted Co., to Hollingworth, Wood and Co., Huddersfield (designer); A. D. McDougall, from James Johnston and Co., Elgin, to Caledonia Woollen Mills, Ireland (general manager); Adam L. Scott, from Portree Wool Mill, to Walter Mercer and Son, Ltd., Stow (director); John M. Lyon, from Scotts (Dumfries), Ltd., to James Johnston and Co., Elgin (assistant, manager); Dickson Dalgleish, from Ettrickbank Mill, Selkirk, to John Crowther and Sons, Ltd., Milnsbridge (assistant, designer); — Denholm, from Oamaru, N.Z., to Albany, West Australia (manager).
GLEN STRIPES AND CHECKS ARE TYPICAL SCOTCH TWEED PRODUCTIONS. IT IS SOMETIMES STATED THAT THEY ARE AT TIMES VERY FASHIONABLE AND THEN GO COMPLETELY OFF. THIS IS NOT ALTOGETHER TRUE — A NICE "GENTLEMANLY" GLEN RANGE CAN ALWAYS BE SHOWN TO ADVANTAGE, AND A SCOTCH SET IS HARDLY COMPLETE WITHOUT A FEW. THE DIFFERENT VARIETIES OF GLENS THAT GO THE ROUND ARE TOO NUMEROUS TO MENTION, BUT CHIEF AMONGST THEM ARE: (a) 1 Lt. 1dk. 2lt. 2dk.; (b) 2lt. 2dk. 4lt. 4dk.; (c) 1lt. 1dk. 3lt. 3dk.; (d) 1lt. 1dk. 4dk.

Weaves employed are the plain cloth, common twill, 2/1 twill, celtic and 3/3 twill. Then a combination of weaves may be introduced, such as 2/2 twill diamond, in the 1lt. 1dk. section, and the celtic in the 2lt. 2dk. section.

A very good Glen effect at present in vogue is made half-marl half-solid. The following may serve as examples:—Warp: 1Wht. 1Bik.||Wht. 4Wht., 4Bik.||Wht. Weft: 1Bik. 1Bik.||Wht. 4Bik. 4Bik.||Wht. A small weave to give an "all-over" effect is possible as the scheme is contrasting warp and weft, and a stripe effect is obtained with the 3-2-1-2 step 2 twill. Formerly 1 lt. 1dk. 2lt. 2dk. common twill Glen was in disfavour owing to the 2-and-2 section showing a hair line. Designers have overcome all this by alternating the 2-and-2 to show warp and weft effect, and have thus given this style a new lease of life.

For fine grade Saxony suitings the celtic Glencheck is hard to beat with crammed silk lines, generally cutting themselves and the ground—no fancy weaves or colour schemes are required. The quality, if it is there, and the Glen weave may be relied upon to do the trick. For heavy Saxony coatings, Glens in soft contrasts or "tone and tone" effects or black and white and greys are very popular. The Americans make a strong feature of this cloth.

For ladies' cloths fashion is an important factor, and if a Glen season turns up the weave in its original form is mutilated beyond description. Silk and worsted fancies give way to mohair spots, loops, curls, etc. So far The Glen check has not encroached to a great extent on trousering, but "plus four" trousers afford ample scope for development in this direction. Glens are popular in rugs and shawls, although, of course, they are really classed as plaids.

Several important woollen firms in Canada (Canadian Woollens, Paton Manufg. Co., Barrymore, etc.) are reported to be forming a combine to resist foreign competition.

Sir Wm. P. Raynor (T. Hirst, wool merchant) left £317,000.
Queries and Answers.

Q. 223. Can you recommend a waterproofing process to stand the German Custom House test of filling a bag of cloth to a depth of 6 ins., and no water should pass through in 6 hours. As the bag will hold 2-3 gallons of water, it is a very severe test. "Waterprufo" sometimes gives satisfactory results, but is not reliable. The proofing is destroyed by subsequent dry processes such as cutting.

Aluminium acetate is as satisfactory as any, but the advice to dry at a gentle heat given in most text-books is probably wrong, as better results would be obtained by severe drying. The statement that "Waterprufo" is not reliable is possibly not a defect in the substance, but due to variations in the cloth. The pieces which show the defect may have pinholes in them, thus the defect may be localised or it may be general. Waterproofing is more a question of weave, setting and materials than a question of chemicals, while cropping of course would affect the result. Aluminium acetate may be used, and the goods severely dried as the last operation. The cloth should be closely woven, preferably in small sateen weave, but the more durable 2/2 twill has been chiefly used with the warp set almost twice as closely as the weft. Closely woven cloth absorbs less waterproofing material, and that leaves the cloth with a better handle. The cloth is steeped in the aluminium acetate solutions, and the goods severely dried as the last operation in finishing. The aluminium acetate decomposes, acetic acid escapes, and the insoluble basic aluminium acetate is deposited on the fibre in a finely-divided state. The shower-proofing is dependent on surface tension. Waterproofing makes very little difference to homespun cloths. The British Government test seems quite as severe as the German. The former consists of allowing 60 drops of water to fall from an elevation of 6 feet on the same spot of stretched cloth, and there should not be any moisture perceptible on blotting paper placed underneath the cloth. A loose woven homespun only withstood 4 drops when "waterproofed," and 3 drops untreated, and yet the long hairs of the cloth resist ordinary showers quite well, showing that the test is not satisfactory.

Q. 224. As sulphur dioxide bleach produces a temporary white with disagreeable odour, we prefer hydrogen peroxide bleach, which is quite good on loose wool, but in bleaching yarn hanks, tied with cord in string form, soaked in tank, the parts round the tied parts are liable to be unbleached owing to bad penetration, and as some of the yarns are very yellow it is very difficult to get a passable white. In the hydrogen peroxide bleach (using 100 vol. peroxide), and working the
bath about 12 vol. strength at normal temperature and making alkaline with sodium silicate, we find that the bleach obtained is not sufficient and has usually to be completed by sulphuring. Text-books do not go into details sufficiently. Please advise.

Heat the bath to 120°F., using lead steam pipe and adding hydrogen peroxide sufficient to give 1½-2 vol. strength. Add sufficient sodium silicate to make the bath neutral, then add as much again. The amount required should be carefully tested on a small scale, and after that it will be found that the amount required will be fairly constant. The yarn hanks should not be tied with string or anything else. Just lay them carefully into the bath and gently press them under the liquor. The bath can be run off each time with the above strength of peroxide, but even if not, there is no danger of entanglement. But hydrogen peroxide alone cannot give as good a white as peroxide combined with sulphur dioxide bleach.

Q. 225.—Can pure olive oil and water be emulsified without use of ammonia or alkali, or does the water eventually evaporate leaving free oil?

They can be emulsified without alkali by stirring up, but the emulsion does not last very well. Of course, the water evaporates even from an alkaline emulsion when spread over wool, owing to the great surface exposed to the air in carding, and careful observers say that there is practically no extraneous water left in the wool long before it leaves the carding machine.

A Manchester writer points out that far too much outcry is being made about reducing costs in spinning and weaving sections of the industry, while the finishing and selling sections are allowed to continue exacting excessive amounts without more than formal protest. He points out that finishing costs in America are half those in England, in spite of wage-rates being double.

The Cotton Employers' Associations propose an all-round wage reduction of 12% and to increase the working week to 52½ hours, and 25% reduction in piece-rates. They aver that the decrease in production which has followed decreasing the hours from 55½ to 48 has contributed largely to our difficulties in competing with the world's trade. The Committee recommend (a) that companies whose finances place them outside the possibility of competition should readjust their finances so as to clear the position and not to resort to schemes which can only be regarded as moratoria; (b) that representations be made to the Government to reduce expenditure on social services, and local authorities to reduce municipal expenditure; (c) that bleaching, dyeing, and finishing organisations be asked to co-operate; (d) that merchanting should be brought to higher efficiency.
XXI

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Intrinsic Weaving Factors.

(Lecture by J. T. Wright, on 12th Dec., in S.W. Tech Coll.)

The three essential motions in weaving are shedding, picking and beating-up. Using these alone, a cloth might be said to be woven, e.g., in the handloom, where the auxiliary motions of the powerloom are omitted altogether, or only intermittently performed. To make weaving more continuous and uniform, the auxiliary motions of letting off warp and taking up cloth have been added. The weft indicator enables the weaver to give more attention to the warp, since warp stop motions have not yet been adopted to any great extent in the fancy woollen trade, because of the shortness of warp and the comparative coarseness of yarn on the average; but largely because the increasing complexity of the patterns still demand one weaver per loom in spite of all the contrivances designed to make weaving more automatic.

Shedding motions in tweed looms may be one or other of two kinds, lever and wheel dobbies. The former is on the Hattersley and Hodgson looms, the latter on the Dobcross. Comparisons between the types usually begin and end with the merits and demerits of the kinds of lagging and chaining used. The wheel dobbey uses a heavy metal chain and card with metal bowls and bushes to indicate the lifts. The labour of making up such a card tells against it, though its certainty when made up is in its favour. It seems strange if the Dobcross people can devise no better fastening for their lags than the cumbersome connecting link and split pin. The weight of the metal lagging is sometimes held to require much extra power to move; but it will take less power to move the small part of a metal card in motion at one time than to move the whole of perhaps hundreds of wooden lags. The inertia of a long wooden card or chain hung over wooden rollers or huddled in a cradle on the floor must be considerable, and the wooden card is moved suddenly and intermittently, whereas the metal card is moved slowly and continuously. The balance of power may therefore quite easily rest in favour of the heavier material.

The essential differences are in the dobbies themselves. It is not a case of using different means to attain the same end, a lever versus a wheel. Their actions are totally different, and though both types form sheds, the ends attained are not quite the same. The wheel dobbey gives an unmistakable dwell to the shafts in their top and bottom positions. The cylinders operating the vibrator levers are toothed for about half their circumference, and as they are driven from the crank shaft at crank shaft speed, the change and dwell of the shafts will be about equal. Observe, however, the nature of the dwell.
When a top or bottom cylinder turns a vibrator, the connecting lever pin is placed in such a position that the shaft is locked in its top or bottom position till a change is required. The work done in changing a vibrator occupies but half a rev. of the shaft, and no more work is done on the vibrator till a change is required. The tension of the warp on the raised or lowered shaft requires no effort on the part of the dobbey to balance it. The shaft is locked. In the lever dobbey the dwell is not distinct. When the shaft is down and has to remain down for two or more shots the hooked levers engage with the snick bars, and a permanently open shed is formed which does not require constant effort on the part of the dobbey to maintain. But when a shaft is raised the effort of supporting it in that position is imposed on the dobbey throughout part of the dwell. At this point all the power available should be released for picking. This happens with the wheel but not with the lever type. Then in the latter there is the unsteadiness of the top shed line, as the effort to support shafts remaining up for two or more shots is transferred from one knife to the other. To this again add the continual movement of the balk levers on their pivots, and it will be seen that the lever dobbey lacks the economy of effort and friction of the wheel dobbey. It is noteworthy that looms with levers for shedding now have wheels for the box motions where a steady dwell is required at both ends of the traverse. Thus we infer that the lever dobbey would be most usefully employed on weft faced weaves where the warp is down for most of the time, or for warp faced weaves when woven back up, since the dobbey has little to do with shafts remaining down and for short floated or broken weaves requiring constant movement of the shafts, so that the continual motion of dobbey parts will not result merely in so much wear and waste of lubrication, but in the useful raising and lowering of the shafts. The wheel dobbey would suit the longer float weaves where the shafts may be either up or down for several shots between each change. The lever type would work these weaves quite well, but its action on such is wasteful. Yet, while the wheel dobbey seems more economical in action on these or any other weave, it always seems in principle a somewhat unsound mechanism, with too much scope for things to go wrong. The correct working of the dobbies is too dependent on comparatively long periods of exact contact of moving parts. The bowls of the card and chain are moving through the arc of a circle when they contact with the indicator levers. Yet these levers must be maintained with little variation in height through half the revolution of the crank shaft. Perfect movement of a shaft up and down is dependent on the accurate engagement of a large number
of teeth in two cylinders with the teeth of the vibrator wheel. The accuracy of the contact depends largely on the heights and settings of the lag cylinder and the lock-knife; the cylinder is one, the lock-knife is one, the vibrators are many, but each vibrator, old or new, must have almost precisely the same height above or below the knife and the same contact with the chills. When the box and card chills are differently timed, both cannot have perfect contact. Each chill serves many vibrators, and one defective tooth may make a useless chill. That the dobbý works well is a triumph of metallurgy, not of mechanics. In this respect the lever dobbý scores. The indication of a lift is simpler, and once contact between the hook and the knife is obtained, the lift is a steady pull with nothing to deflect its strength or direction. The inferences here would be that age and usage would gradually diminish the size of the shed given by a lever dobbý, whereas little differences would be noticed on a wheel dobbý of any age so long as the vibrators got round at all.

The timing of the shed is a question requiring some consideration. Early shedding is practised so that beating up the weft takes place on a crossed shed. This is said to equalise the strain on the warp during beating-up, as well as facilitate heavier wefting. Late shedding is practised on plain cloths to prevent beating up on a crossed shed, since all the yarn changes every shot, and because of this the strain on the warp is equal in any position. Then sometimes the equalisation of warp strain during beat-up is sacrificed to obtain loom cover on the cloth. Loom cover is said to be produced by the beat-up taking place when part of the warp is at a much higher tension than the rest. This is said to give a slight motion to the few shots previously inserted, causing them to move over the tighter of the warp threads. These threads, being now free from restricting pressure of the reed wires, take up the line of least resistance and spread out over the empty spaces left by the reed dents. This is illustrated by pulling a thread out of a piece of cloth to imitate the reed mark. If a slight pull is given to the thread on each side of the space, it will be seen that they move slightly together, partly filling in the space. Now both these theories of early shedding and of cover are founded on the belief that the lay is travelling at a considerable velocity when beating up, and that there is a sudden impact between the lay and the fell of the cloth. The beating up position is the point when the lay is furthest forward. The top shaft crank, which moves it, will be at front centre. From top or bottom centre to front centre (according to direction of rotation), the lay is in a state of retardation, and its velocity declines progressively as it moves towards front centre. From
front centre to top or bottom centre it is in a state of acceleration, and reaches its maximum speed when passing over top or bottom centres. But between retardation and acceleration the velocity is zero, and the lay is momentarily but nevertheless still. And that is the beating-up position.

(To be continued.)

CANADIAN WOOL.

The Canadian Government is proposing to survey the different provinces relative to sheep and wool growing. That a prominent live stock man declares that Canada has reached such a high standard in sheep rearing that it no longer requires importation is a good illustration of the adage "Where ignorance is bliss 'tis folly to be wise." As a matter of fact, Canada has barely learned the alphabet of wool raising. A great effort is being made in B.C. to start a worsted mill with the help of a Yorkshireman. The defect of the plan is that a worsted spinning unit is so large and restricted in its range of operation that it will be very difficult for a selling agency to dispose of the product. The promoters would have done far better to have started a small weaving and finishing mill, buying the yarns from abroad until a business was properly established of sufficient dimensions to take up satisfactorily the product of a combing and spinning mill. Unless a combing plant is provided it will be useless for using Canadian wool, but there is not nearly as much wool raised in Canada west of the Rocky Mountains as is grown in little Selkirkshire. But the project, which starts with the "top," will likely end in the city of Victoria having a museum of textile machinery at a cost of £25,000. Total capital, £50,000 subscribed (£8000 by Yorkshire manager). The programme is too ambitious for the funds in hand. Our friend, Mr W. H. Cochrane, formerly of Galashiels, says that Scottish manufacturers should seek to establish themselves on the Western sea-board, as there will be rapid development in Western Canada, and great increase in tourist trade from U.S.A. (£40,000,000 per annum spent in Canada.) He thinks Cheviot sheep should be introduced to B.C., as the climate would be admirably suited to them.

The current public pessimism which has held sway in textile circles for the past seven lean years may have caused some political bias towards the securing of a Safeguarding of Industry Act, but it has had a very disconcerting effect on business. Everyone has bought from hand to mouth. There has not been time given for mills to do the work, and hence people have had to do without new goods. The pessimism causes would-be-purchasers to delay till cheap sale times.
Yarn Twine Directions.

There are two directions of twine in yarn, viz., right and left hand, or ordinary and reverse twist. Most yarns are spun ordinary twine, the spinner being informed on the batch ticket when reverse twist is wanted. Occasionally a few lbs. of yarn are required for immediate use of opposite twine to any in stock, and the spinner is called to change over the direction of twine in 40/50 lbs. of a stock batch, this make-shift being the quickest way of making required yarn in emergency. This changing of twine is all right on small hurried lots, but is seldom undertaken on large batches. To discuss some important points in this unusual part of the spinner's work, the process may be divided into two sections:—(1) Reversing the direction of twine but leaving the grist unchanged, (2) reducing a yarn to a finer grist yet keeping the same direction of twine, e.g., 14 cut ordinary to 17 cut ordinary. (1) is simpler, while (2) is only practicable when there is little difference between the first and final grist.

(1) Changing Twine Direction.—The strength of any yarn is governed by the twist inserted by rotation of spindle. The degree of twist can be calculated from the total revs. the spindle makes in one complete draw. The spinner decides the number necessary for each grist. The writer uses Platt's Indicator, taking the readings from a normal running spindle. For this work an ordinary Platt's twisting mule (rim at back type) can be employed. The spinner knows the rims, wheels, etc., for a certain grist. The scroll ropes are taken off, the carriage being driven by means of the quadrant band through fixing the guide pulley to the scroll shaft. Drag pinions are used so that the rollers and carriage will travel at the same speed; further, the length of draw must be adjusted to remove snarls on the spindle point when the carriage stops. The yarn to be changed over is not dragged in passing from the cops on the back board to the rollers. As a simple illustration, take an example of 14 cut with 684 turns reverse to be changed to 14 cut ordinary. This divided by 76° stretch gives 9 turns per inch. The mule should be adjusted so that the spindle will record 1368 revs. in opposite direction, of which 600 turns are inserted on slow speed (carriage travelling) and 768 turns on the quick speed (carriage stationary). The actual change-over in twine direction should not occur when the carriage is running, but should always be timed to take place when the latter is standing at the end of the stretch.

(2) This is more difficult, especially if much drafting is required and the stock yarn is hard twisted, e.g., 20 cut may be pulled out to 30 cut if the former was made with not more
than 500 revs. per draw. Starting with 20 cut (62½ yards per ½ oz.), to be reduced to 30 cut (94 per ½ oz.), same direction of twine. First spin out to 24 cut (75 per ½ oz.), with reverse twist 1000/1100 revs. Thus the original twist (500 turns) will be flung off and the final 30 cut ordinary twist may even be obtained in the next process without any further alteration in the mule gearing. In certain cases a little more head twist may be required to give desired strength in the finished thread. In conclusion, the principal factors requiring consideration are delivery for the final grist, the arrangement of turns and twine, direction in each process to keep within the proper range of change wheels and rims. I have always found this method best for heavy grist with an alteration of a few cuts, but in finer yarns, when more extension is wanted, frequently in the opening out the yarn runs to "points," making a bad spin.

JOHN DRYSDALE (Tillicoultry).

On 15th December a round table discussion took place in the Library Hall, Innerleithen, on problems like the origin of the 300 yard cut and explanation of rules, slips = weight × grist ÷ 18, also = porters × ells ÷ 72. Shrinkage in dyeing and take-up in twisting were also discussed. It was said to be easier to weft a web with greasy yarn than with clean yarn owing to the shrinkage in dyeing, which also made the piece heavier owing to the grist being slightly heavier. Dark colours spin worse than light colours, because the former take more dyestuff and more boiling for fastness to milling. Marl yarns (1 greasy 1 clean) are not so regular as when both yarns are greasy or both clean. It was pointed out that at the Textile Exhibition in Edinburgh the winder was tying all thumb knots, that was rightly considered an unfortunate demonstration. In making a batch half-hosiery losing 10% oil and the other for tweeds losing 16% oil, the correct result would be obtained by varying grists to correspond. In weaving 2/2 twill it was averred that on 8 shafts the strain was better distributed on the doby and made a better job than on 4 shafts, and the threads had more room to work. Similarly a plain cloth is better on four than on two shafts. It was also pointed out that when warping from large bobbins the yarn comes off at first easier than when the bobbin is smaller, so that the last section runs on to the warp mill tighter than the first. It was suggested that slightly bevelling the warp mill would counteract the tension difference. The discussion was so successful that in the meantime it is decided that these should replace the customary lectures.
FINAL WOOL DYEING, 1927.

(Not more than seven questions to be attempted.)

1. Describe methods of producing an unshrinkable finish on woollen materials. Indicate the physical and chemical action of the treatment on wool fibres.

2. Describe methods for dyeing solid and two-coloured effects with various classes of dyes on cotton and wool fabric. Indicate the use of Katanol W in this connection.

3. What is the effect of caustic alkalis on wool? Describe various methods now available for protecting wool from deterioration when in contact with caustic alkalis during dyeing processes.

4. Describe the theoretical principles underlying the application of acid dyes to wool.

5. Describe the construction of two of: (a) A machine for milling woollen fabrics, (b) a crabbing machine, (c) a machine for dyeing loose wool.

6. Describe the methods and machinery employed for scouring loose wool.

7. What are the essential features of: (a) carbonising, (b) raising, (c) artificial daylight, (d) wetting-out agents in relation to the treatment of wool materials?

8. Compare the chief physical and dyeing properties of wool, viscose and cellulose acetate silk fabrics, and discuss the uses and possible use of artificial silks in the woollen industry.

FINAL FINISHING, DIV. II.

(Not more than eight questions to be attempted.)

1. Describe the operation of scouring and milling a 13 oz. worsted flannel, give a description of the milling machine used, and how you would determine the amount of milling necessary.

2. What class of goods is particularly subject to be “rigged” or machine marked? What is the cause of, and the remedy for, this defect?

3. Describe the effect that the scouring liquor has on the colours when excessive heat is used. At what temperature would you scour fabrics made from: (a) clean yarn, (b) greasy yarn.

4. Describe each of the operations required in finishing any three of the following fabrics:—Worsted dress serge, cotton warp silician, cheviot woollen dress tweed, alpaca lining, cork-screw coating.

5. Describe the operations of crabbing and blowing, and state the effect each has upon the appearance of the cloth.
(6) Describe the action of milling machinery, and by means of sketches show where the "fulling" takes place, and how the amount of shrinkage is regulated. What special characteristics of weave, yarn and cloth structure are desirable in cloths requiring excessive milling?

(7) Describe methods of testing alkalis, scouring soap and milling soap, for purity, and water for hardness, and organic matter. Describe the action and defects caused by hard water when used for various textile purposes.

(8) (a) Explain with sketches the action of a Moser raising gig, and discuss its advantages over a teazle gig. (b) What is the effect of "Dry" and "Wet" raising? Which method is employed in raising a blanket finished reversible?

(9) Describe fully the processes and the object of each in finishing a piece dyed clear cut crossbred serge; also the defects likely to occur at each process from loom to warehouse.

(10) Sketch and describe a continuous hydraulic pressing machine, and compare the resultant "finish" to that obtained with a vertical press.

(11) Sketch and describe an automatic clip stenter and enumerate precautions to be taken to avoid faulty pieces.

Comelybank Mill, Galashiels, is given by a power engineer in a recent commercial article as an instance of successful conversion from steam to electric power. A group of five mills, including the above, involved a conversion cost of £20,000, and the electricity charge is £600 a year more than the steam power cost, yet £12,000 increased value of product is obtained, and £2000 sum is saved in maintenance charges of the power plant at the mill. While it would be quite easy to verify the last statement, it would be very difficult to assess the increased value of product, which is dependent upon so many variables. In U.S.A. twenty years ago 10% of the power was electrical, while now, when the total power is increased 2½ times, the electric section absorbs over 60%, or 15 times more than at the former date.

Taconic Mill (Jas. & E. H. Wilson, Inc., Pittsfield, Mass, U.S.A.) was sold by auction in December for £2400, and Beloit Mills for £5000, including water power rights valued at £16,000. The sale of other land and machinery brought £6000 more. The plant and machinery was sold at very low prices piecemeal. The assessed value was £75,000, and replacement value was reckoned at £200,000. So American conditions seem just as bad as ours in spite of the protective wall to help trade.
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VARIATIONS IN CAP SPINDLE SPEED
AND
STROBOSCOPIC OBSERVATION OF SPINNING.

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VARIATIONS IN CAP SPINDLE SPEED
AND
STROBOSCOPIC OBSERVATION OF SPINNING.

Introduction.

The thanks of the Association are due to Leeds University (Textile Department) for arrangements by which Mr. Howard Priestman was enabled to devote services originally retained by the University to collaboration with the whole time staff of the Association for the purposes of spinning research.

The following paper describes first the development of an apparatus called a stroboscope by means of which it is possible to see the actual movements of the yarn, spindles, etc., with the naked eye.

Demonstrations will be arranged, and it is thought that some members will wish to have these instruments for the purpose of adjusting their spinning frames, and for the instruction of employees.

The paper then shows, as the first result of investigations with this stroboscope, that the varying pressure of the tape on the flanges of the whorles is an appreciable cause of variation of speed and twist. Full proofs, tables, etc., are given in support of this statement. There is also a definite loss of power from the same cause.

The avoidance of this defect is considered and it is shown that a guide bowl for the tape is a complete cure. The use of larger whorles (with higher cylinder speeds) is also an improvement.

Among other matters touched upon are the effect of tape thickness on calculated speed and the necessity of gauging whorles accurately.

Definitions.

Throughout the paper the spindle tubes are referred to briefly as the spindles.

"Standard" speed refers to the speed which would be found by the simplest form of calculation, without allowing for tape thickness, tape slippage, errors in whorle and cylinder diameters, small variations in cylinder speed, etc.

[It is shown that with special thin tapes this "standard" speed is practically reached].
Part 1.—SUMMARY.

Spinning Research.

It is nothing new that research work undertaken to discover the reason for some special fact should lay bare faults which exist in quite unexpected places. It is well known that many things not yet perfectly understood occur during the winding of yarn on to cap spinning spools and twisting bobbins. Investigations begun by the Association in order to elucidate the more obscure spinning theories have already resulted in the discovery of some practical points which it is worth while to publish, even before the original objects of the experiment are cleared up.

The Revolving Mirror.

In order to see what happens during the winding-on process already mentioned, it was decided to illuminate the spindles of a sample cap spinning frame (Fig. 1) with 6,000 flashes of light a minute. By this means, if the spindle were revolving at exactly the calculated speed (6,000 r.p.m.) it would, of course, appear to be standing still. Now, since the yarn has to be wound on to the bobbin, it is not going round the spindle as fast as the spindle itself moves. Therefore as the spindle appears stationary the yarn would appear to be rotating so slowly in a reverse direction that it would be possible to see exactly what happens when the yarn begins to lick up the cap.

In order to do this a mirror polished on both sides was attached to a spindle. An arc light was focussed on to it, and, after several ineffectual attempts to obtain a regular speed through electric motors, this mirror was driven direct from one of the spindles at such a speed that 3,000 r.p.m. were obtained. As the mirror was double-sided this gave 6,000 flashes per minute. Theoretically the result was exactly what was expected. Spindles running at the same speed as the mirror flashes appeared to be standing still, but it was immediately discovered that all the spindles were not running at the same speed, because some of them gained whilst some of them lost, and one or two appeared to be stationary.

Variation in Speed of Spindles.

The number of faults which are due to irregular twist had long ago made it certain that many spindles in a frame varied in the speed at which they revolved, but one was surprised to find that almost every spindle was running at a different speed from the others. In the past it has generally been concluded that any particular spindle which was making bad work by running too slowly had been imperfectly oiled, but it was quite clear at the outset of this experiment, that this was not the case in the spindles under examination. In addition to bad oiling there are four important factors which are likely to affect the speed of the spindles. In the first place there might be a slip of the tape on the whorle, in the second the whorle itself might be larger or
smaller in diameter than it ought to be. Thirdly the tape might be rubbing on the upper or lower flange and thereby retarding the rotation of the spindle, and fourthly the friction of the spindle on the washer due to the downward pull of the tape may also affect the speed. It is the purpose of the present paper to explain what part these four things actually play in spindle speed variation.

Control of the Mirror.

A good many devices were tried in order to get an absolutely regular speed on the spindle which carries the mirror. When a separate small motor was used for this purpose, even the very slight variations in the current from the mains was sufficient to introduce a margin of error far too large for the desired purpose. A very simple piece of apparatus was therefore erected so that the mirror might itself be driven direct from the tin roller or cylinder which drives the spindles. This arrangement was an immense improvement on the previous methods. Subsequently a heavy balance wheel was attached to the mirror spindle for steadiness, and the driving tape was run on a conical pulley up and down which it could be guided for speed adjustment by a screw. Far better results were obtained.

Method of Measuring Speed.

The only difficulty still remaining was to discover the actual speed at which the mirror was running. This is done in a way which is so new to the industry that it deserves very careful description. In order to run a spindle at 6,000 r.p.m. with three-quarter-inch whorles, driven from a ten inch tin cylinder, the cylinder must be running at a speed of 450 revolutions per minute. These figures are the basis of all the following calculations.

Round the tin cylinder is pasted a piece of paper, equally divided into forty parts, every division of which is indicated by a prominent black dash. With the cylinder running at its normal speed of 450 it is clear that 40 times 450 or 18,000 dashes must pass any given point every minute. If the mirror illuminates them 6,000 times per minute, every third mark will arrive at exactly the same place every time the mirror flashes. By such an arrangement, therefore, the marks on the cylinder appear to be standing still, provided, as has already been said, the flashes are exactly 6,000 a minute.

But in addition to the paper band divided into 40 parts, there is placed adjacent to it another band divided into 39 parts, each part being marked by a conspicuous dot. This number is, of course, \( \frac{21}{2} \) per cent. less than 40, and in order to make these marks appear stationary—in other words to illuminate every third of them as it reaches a certain point—it is necessary that the mirror should be rotating \( \frac{21}{2} \) per cent. slower than before.
In addition to these two bands, there are five others carrying respectively 38, 37, 36, 35 and 34 equidistant marks. 38 marks is 5 per cent., 37 marks is 7½ per cent., 36 marks is 10 per cent., 35 is 12½ per cent. and 34 is 15 per cent. less than 40. By moving the tape up and down the cone pulley on the mirror spindle it is possible to adjust its speed so that each of these bands in turn may be made to appear stationary and as each appears stationary the mirror must be losing on "standard" speed by exactly the corresponding percentage. In other words, the speed of the mirror in relation to speed of the cylinder can be accurately observed.

Now suppose the frame to be running with the spindles moving at a calculated speed of 6,000. The fact that actual twist is known to be nearly 10 per cent. below calculation should prepare everyone for the first fact that was observed. Not a single spindle was rotating at 6,000.

**Allowance for Tape Thickness.**

Before going further it ought to be emphasised that for calculation purposes, and in practice, the diameter of any pulley used in driving is not the actual diameter of such pulley, but the actual diameter plus the thickness of the belt or tape. Therefore a whorle, three-quarters of an inch in diameter or 0.750 inches, should not in practice be reckoned of that diameter, but should have added to it one thickness of the tape, which in most cases will be found to be 40 thousandths (0.040) of an inch.

For calculation purposes a normal three-quarter-inch whorle does actually behave as if it were about 0.790 inches diameter. Therefore the best lubricated spindles should actually be running at 5.3 per cent. less than is shown by an ordinary calculation in which the whorle is calculated at its real diameter. The figures given below show this to be very nearly the case. Spindles which were rotating properly were actually making slightly more than their calculated speed on this basis, but if the ordinary kind of tape was replaced by one of thin cotton or thinner silk, the speed of the spindle immediately increased, although both the tension and the friction on the whorle were slightly less.

As a matter of fact, when the mirror was flashing at such a speed that the 5 per cent. ring of dots appeared to be stationary, two or three of the spindles driven with ordinary tapes did actually appear to be standing still or very nearly so. One of them was actually gaining slightly and two others appeared to be slightly losing ground. But of six spindles running, three were losing a great many revolutions per minute.

**Alternate Spindles Lose Speed.**

It only needed very brief examination to show that the spindles which were losing were invariably those on to which the tape led. It was the left-hand spindle in all cases that was running to calculation. This, of course, at once gave rise to the suggestion that the leading on of the tape had something to do with the lack of speed of all the right-hand spindles.
Tape Pressure on the Flanges.

Examination showed that in all cases the tape rested on the lower flange of that spindle, and the speed of the mirror had to be reduced first by 7½ per cent. and then by 10 per cent. before those spindles appeared to be stationary. But if a hand were placed underneath the tape so that the tape were guided exactly on to the centre of each right-hand whorle, in spite of the added friction on the tape, the spindle at once increased in speed to such an extent that it was rotating at exactly the same speed as its left-hand neighbour. Alternatively, if the tape were deflected downwards by a weight so that it was rising to the whorle, it bore more hardly on the lower flange and thereby reduced the speed until the spindle was losing 12½ per cent. on calculation.

Effect of Traverse—and Adjustments.

Now it is obvious that in every spindle the tape which rises from the cylinder to the whorle strikes the whorle at a different angle at each alteration of the traverse. Therefore in a frame with a long traverse, no matter how well the cylinder and the tension pulleys are arranged, there is certain to be an alteration in the speed of alternate spindles as the lifter falls and rises. This will be more noticeable in cases where the tape is considerably deflected downwards; for example, the relative heights of cylinder, tension pulleys to lifter rail and the width of the frame may cause considerable differences in this respect, as also if on one side of a frame the lifter is falling whilst on the other side it is rising.

Effect of a Guide Bowl.

Fortunately these causes of speed variation may be obviated by a very simple device. If a bowl is placed with its upper surface on a level with the centre of the whorle, it will be found that all the right-hand spindles will then continue to revolve at the same speed throughout the rise and fall of the lifter, no matter how great the traverse may be.

—And Larger Whorles.

It has also been shown that increasing the diameter of the whorle effects an improvement, though not a cure. The speed or diameter of the cylinder would have to be increased in proportion.

Effect of Twist Variation.

Reference should now be made to the Association’s pamphlet No. 7 on Periodic Faults.

It was shown there that under certain conditions a regular variation in twist may give rise to peculiar bars in the finished cloth. On page 7 of that report a case due to varying lubrication with the rise and fall of the lifter rail, was reported.

The present paper shows that another cause also connected with this motion exists.
That all cap yarns do not give visible defects must be attributed to the facts that the variation is more pronounced only with certain adjustments of the frame, and that in any case the width of the cloth must have a certain relation to the rise and fall of the lifter rail, to bring the effect out fully. The question of whether the yarn has become set (Association Publication No. 12) before use is also important. It need scarcely be argued, however, that short of actual defects there is here scope for improving the uniformity of cap yarn generally.

Other Causes of Variation, e.g., Whorles.

It might also be noticed that standard whorles as delivered new, may easily vary in diameter. In the present instance the variation was over 1%: old whorles might, of course, vary more.

Another variation is due to the difference in winding on to a small or large diameter, e.g., the base and nose of a spool, or a full and empty bobbin. Again, variation in the length of yarn in the balloon occurs as between the base and nose of a spool, for owing to the varying drag the yarn takes a different curve. These matters will be investigated.

Power Loss.

There is a definite power loss due to flange friction of about 0.015 h.p. per spindle in the particular frame tested.

General Conclusions.

There is a regular variation of speed in alternate spindles of a cap frame, with the rise and fall of the lifter rail, and it is due to the pressure of the tapes on the flanges.

This variation is in addition to any constant defect such as incorrect whorle diameter or faulty spindles.

It may be cured by a guide bowl, or partly cured by a larger whorle.

The yarn from the alternate spindles on to which the tape first runs is less regular in twist than that from the others.

A simple apparatus has been devised, and will be available to members, by which speed variations can be seen.

Part II.—DETAILS OF EXPERIMENTS, SPEED TABLES, etc.

The following tables and the curves in Fig. 3 show the speeds of the spindles under various conditions.

Arrangement of Spindles.

The numbering of the spindles for reference is shown in Fig. 2. Nos. 1 and 2 are used for the mirror drive as explained in Part III. of this report. The three remaining pairs, of which the speeds are recorded,
differ from each other in the arrangement of the running-on tape. That leading to spindle No. 6 was as left by the makers; that to No. 4 was led over a bowl rising and falling with the lifter rail and guiding the tape on to the centre of width of the whorle all the time; No. 8 was led under a fixed guide to give the equivalent of a badly aligned frame. The run of the tapes is clearly seen in Fig. 3, where the tapes are shown by full lines when the spindles are at the top of their travel and by dotted lines when they are at the bottom. Alongside each diagram in Fig. 3 are curves showing the speeds given in figures in Table III. The improvement on No. 4 and the bad effect on No. 8 are obvious. In both cases the effect persists to a much smaller extent in the second spindle of the pair.

**FIG. 2.—PLAN OF SPINDLES.**

**TABLE I.**

**CAP SPINDLE SPEEDS.**

Details of Sample Run.

This was the first complete run and is without corrections for whorle diameter or observational errors. The figures, especially those marked *, were corrected in subsequent runs, both being considerably too low. Tables III. and IV. are based on several runs and corrected for whorle diameter. For method of calculating loss see Part III.

<table>
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<tr>
<th>Spindle No.</th>
<th>Tape deflected beyond normal.</th>
<th>Coming from</th>
<th>Normal (from cylinder).</th>
<th>Guided by bowl (from cylinder).</th>
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<tr>
<td>8</td>
<td>*</td>
<td>8</td>
<td>6</td>
<td>5</td>
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<td>1</td>
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*Spindles 2 and 1 for mirror stroboscope.*
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<tr>
<th>Spindle Number</th>
<th>&quot;Standard&quot; Speed R.P.M.</th>
<th>&quot;Standard&quot; Loss Nearest mirror speed' Per cent. Revs.</th>
<th>Difference Counted</th>
<th>Actual Net Speed R.P.M.</th>
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<td>Lifter at 30.2&quot; from floor to centre of whorle.</td>
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<tr>
<td>8</td>
<td>6000</td>
<td>12 1/2</td>
<td>750</td>
<td>-8</td>
</tr>
<tr>
<td>7</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+28</td>
</tr>
<tr>
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<td>6000</td>
<td>7 1/2</td>
<td>450</td>
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<td>3</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+36</td>
</tr>
<tr>
<td>Repeated above, lifter still at 30.2&quot; from floor to centre of whorle.</td>
<td></td>
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</tr>
<tr>
<td>8</td>
<td>6000</td>
<td>12 1/2</td>
<td>750</td>
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<td>6000</td>
<td>7 1/2</td>
<td>450</td>
<td>+0</td>
</tr>
<tr>
<td>Lifter at 29.2&quot; from floor to centre of whorle.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>6000</td>
<td>10</td>
<td>600</td>
<td>+30</td>
</tr>
<tr>
<td>7</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+24</td>
</tr>
<tr>
<td>6</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>-82</td>
</tr>
<tr>
<td>5</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>-8</td>
</tr>
<tr>
<td>4</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+76</td>
</tr>
<tr>
<td>3</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+52</td>
</tr>
<tr>
<td>Lifter at 28.2&quot; from floor to centre of whorle.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>-48</td>
</tr>
<tr>
<td>7</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+52</td>
</tr>
<tr>
<td>6</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>-76</td>
</tr>
<tr>
<td>5</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+2</td>
</tr>
<tr>
<td>4</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+84</td>
</tr>
<tr>
<td>3</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+44</td>
</tr>
<tr>
<td>Lifter at 27.2&quot; from floor to centre of whorle.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+20</td>
</tr>
<tr>
<td>7</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+38</td>
</tr>
<tr>
<td>6</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>-10</td>
</tr>
<tr>
<td>5</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>-0</td>
</tr>
<tr>
<td>4</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+72</td>
</tr>
<tr>
<td>3</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+42</td>
</tr>
<tr>
<td>Lifter at 26.2&quot; from floor to centre of whorle.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>-42</td>
</tr>
<tr>
<td>7</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+24</td>
</tr>
<tr>
<td>6</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>-84</td>
</tr>
<tr>
<td>5</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+8</td>
</tr>
<tr>
<td>4</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+16</td>
</tr>
<tr>
<td>3</td>
<td>6000</td>
<td>5</td>
<td>300</td>
<td>+38</td>
</tr>
</tbody>
</table>

Tape is .040 inches thick, i.e. 5.3% of .75 inches.

**Explanation of Table I.**

The second column of the above table represents the "standard" speed of six spindles with three-quarter inch whorles driven from a ten inch cylinder running 450 revolutions. They should, of course, always be going at the same speed whatever the height of the whorle above or below the top of the tin cylinder. The last column gives their actual speed, the middle columns showing the method by which that speed is calculated. In spindle No. 8, it is true that the tape was purposely
N93

n°5

Is gi

COWES SHOW

SPINDLE SPEEDS

WHEN CYLINDER IS RUNNING AT 450 RPM.

CYLINDER ID.

WHORLE 7.5

TAPES.-

___

NOMINAL SPINDLE SPEED 6000 RPM.

TO

OP 4

GUIDE ROLLER CORRECTING ALIGNMENT

FROM 14,6

NORMAL ALIGNMENT

EFFECT OF TAPE ALIGNMENT ON SPEED OF CAP SPINDLES.

EFFECT OF TAPE ALIGNMENT ON SPEED OF CAP SPINDLES.

FIG. 3.

EFFECT OF TAPE ALIGNMENT ON SPEED OF CAP SPINDLES.

EFFECT OF TAPE ALIGNMENT ON SPEED OF CAP SPINDLES.
deflected so that it rose at rather an unusual angle to the whorle when the lifter was in its highest position, 30.2" above the floor. In that position, it will be observed that spindle No. 8 was running at only 5,242 revolutions per minute, instead of 6,000 obtained by the usual calculation. If the figures with the lifter in five different positions are examined, it will be observed that there is a steadily increasing speed on that spindle until it reaches the very lowest part of its traverse, when it again begins to lose on calculation, because the tape is now rubbing on the upper flange instead of on the lower.

Spindles 5 and 6 are standard and behave in a more or less normal way, but even in them the right hand spindle loses more at certain positions of the traverse than ought to be the case. This is so even if tape thickness is allowed for and the whorle calculated not as three quarters of an inch but as 0.790 inches.

Spindle 4 (with bowl) is practically corrected for bottom flange friction, but, of course, not for top flange. In order to make these facts more plain, the various speeds of each spindle with the lifter in different positions is set out in a more condensed tabular form.

**Table II.**

*(Being a summary of Table I.)*

<table>
<thead>
<tr>
<th>Spindle Number</th>
<th>Height of Whorle from floor</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>30.2&quot; 5736 5770 5692 5542 5728 5242</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>29.2&quot; 5752 5776 5692 5618 5724 5430</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>28.2&quot; 5744 5784 5702 5624* 5752 5657</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>27.2&quot; 5742 5772 5700 5690 5738 5720</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>26.2&quot; 5738 5716 5708 5616* 5724 5658</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Whorle Diameter.**

In this Table all the figures are transferred direct from Table I., but it must be remembered that each whorle differs slightly in size from its next door neighbour. Although the difference is very slight, one or two thousandths of an inch must alter the number of revolutions to an extent that is easily counted by the method here adopted.

The diameters on the crown of the various whorles are as follows:

<table>
<thead>
<tr>
<th>Spindle No.</th>
<th>Diameter</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>.754&quot;</td>
<td>.746&quot;</td>
<td>.756&quot;</td>
<td>.756&quot;</td>
<td>.752&quot;</td>
<td>.751&quot;</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>.754&quot;</td>
<td>.746&quot;</td>
<td>.756&quot;</td>
<td>.756&quot;</td>
<td>.752&quot;</td>
<td>.751&quot;</td>
<td></td>
</tr>
</tbody>
</table>

**Cylinder Diameter.**

The circumference of the tin cylinder was measured by a steel tape measure at the point passed over by driving tapes, but the variation was found to be negligible.

<table>
<thead>
<tr>
<th>At part driving spindles</th>
<th>Circumference</th>
<th>Difference from 10&quot; dia. cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 &amp; 4</td>
<td>31 1/2&quot;</td>
<td>+.18%</td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>31 7/8&quot;</td>
<td>+.02%</td>
</tr>
<tr>
<td>7 &amp; 8</td>
<td>31 7/8&quot;</td>
<td>+.07%</td>
</tr>
</tbody>
</table>
Table III. Corrections.

In Table III, allowance has been made for errors in whorle diameter, the speeds being those at which a .750" diameter whorle would run under the same conditions. The readings were plotted on squared paper and smooth curves drawn in the usual way. Table III is based on these curves and the curves themselves are reproduced in Fig. 3. Further, the figures given are not one set of readings, but the result of three, and in some cases more, sets. As before, they are for a tin cylinder speed of 450 and a nominal or standard spindle speed of 6,000. The top figure in each case is the speed in r.p.m. and the lower figure the percentage below the standard speed of 6,000 r.p.m.

### Table III.

**Corrected Spindle Speeds—Averages taken from Curves, and Corrected for Whorle Diameter.**

<table>
<thead>
<tr>
<th>Height of whorle from floor</th>
<th>Spindle No.</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>30.2&quot;</td>
<td>29.2&quot;</td>
<td>28.2&quot;</td>
<td>27.2&quot;</td>
<td>26.2&quot;</td>
<td></td>
</tr>
<tr>
<td>% below &quot;standard&quot;</td>
<td>5780</td>
<td>5775</td>
<td>5775</td>
<td>5775</td>
<td>5775</td>
<td>5765</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.7</td>
<td>3.8</td>
<td>3.8</td>
<td>3.8</td>
<td>3.8</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5740</td>
<td>5750</td>
<td>5750</td>
<td>5750</td>
<td>5750</td>
<td>5690</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.3</td>
<td>4.2</td>
<td>4.2</td>
<td>4.4</td>
<td>4.4</td>
<td>5.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5720</td>
<td>5740</td>
<td>5750</td>
<td>5750</td>
<td>5750</td>
<td>5745</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.7</td>
<td>4.3</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5615</td>
<td>5680</td>
<td>5735</td>
<td>5745</td>
<td>5725</td>
<td>5725</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.4</td>
<td>5.3</td>
<td>5.3</td>
<td>4.4</td>
<td>4.6</td>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5725</td>
<td>5740</td>
<td>5745</td>
<td>5750</td>
<td>5750</td>
<td>5745</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.6</td>
<td>4.3</td>
<td>4.3</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5250</td>
<td>5450</td>
<td>5625</td>
<td>5750</td>
<td>5760</td>
<td>5670</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.5</td>
<td>9.2</td>
<td>6.2</td>
<td>4.5</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The average below "standard" is 4.91% and the percentages for each spindle are summarised in Table IV.

### Table IV.

**Percentages Below Standard Speed.**

<table>
<thead>
<tr>
<th>Spindle No.</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>3.80</td>
<td>4.46</td>
<td>4.32</td>
<td>4.98</td>
<td>4.30</td>
<td>7.58</td>
</tr>
<tr>
<td>Fastest</td>
<td>3.7</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Slowest</td>
<td>3.9</td>
<td>5.2</td>
<td>4.7</td>
<td>6.4</td>
<td>4.6</td>
<td>12.5</td>
</tr>
<tr>
<td>Variation</td>
<td>0.2</td>
<td>1.0</td>
<td>0.5</td>
<td>2.2</td>
<td>0.4</td>
<td>8.0</td>
</tr>
<tr>
<td>Compared with 4.91%:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fastest</td>
<td>-1.2</td>
<td>-0.7</td>
<td>-0.7</td>
<td>-0.7</td>
<td>-0.7</td>
<td>-0.4</td>
</tr>
<tr>
<td>Slowest</td>
<td>-1.0</td>
<td>+0.3</td>
<td>-0.2</td>
<td>+1.5</td>
<td>-0.3</td>
<td>+7.6</td>
</tr>
</tbody>
</table>
For some reason not yet explained spindle 3 is a fast running spindle. The mirror as arranged is a rapid method of detecting faulty spindles at once by eye without determining revolutions.

The curves on Fig. 3 are arranged to show these results in graphic form. They must not be assumed to be accurate to one revolution per minute, although repeated tests give figures agreeing so nearly that they may certainly be taken as accurate within 0.25 of one per cent. When they are averaged, as in Table III., they may be taken to be accurate for all practical purposes. This is not to say that exactly similar figures would be obtained on every frame that is tested by this method. It is highly probable that there would be wide differences. Probably there are in existence spindles giving even worse results and, on the other hand, there are probably many giving results that are better. The results have been substantiated by twist tests on the yarn which leave no possible room for doubt that these variations do alter the twist of the yarn in almost exactly the proportion that they bear to one another (see Table VII.).

The next Table shows the results of another run during which the speed of the main drive was varied.

The Table has not been corrected for whorle diameter.

**Effect at other Speeds.**

<table>
<thead>
<tr>
<th>Speed of No. 8 Cap Spindle at Various &quot;Standard&quot; Speeds.</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P.M.</td>
</tr>
<tr>
<td>&quot; Standard &quot; Speed</td>
</tr>
<tr>
<td>30.2&quot; above floor</td>
</tr>
<tr>
<td>29.2&quot;</td>
</tr>
<tr>
<td>28.2&quot;</td>
</tr>
<tr>
<td>27.2&quot;</td>
</tr>
<tr>
<td>26.2&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Speed of No. 6 Cap Spindle at Various &quot;Standard&quot; Speeds.</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P.M.</td>
</tr>
<tr>
<td>&quot; Standard &quot; Speed</td>
</tr>
<tr>
<td>30.2&quot;</td>
</tr>
<tr>
<td>29.2&quot;</td>
</tr>
<tr>
<td>28.2&quot;</td>
</tr>
<tr>
<td>27.2&quot;</td>
</tr>
<tr>
<td>26.2&quot;</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Difference between 27.2" and 30.2", that is, the maximum variation of each spindle:

<table>
<thead>
<tr>
<th>No.</th>
<th>...</th>
<th>...</th>
<th>...</th>
<th>...</th>
<th>...</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>478</td>
<td>351</td>
</tr>
<tr>
<td>6</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>148</td>
<td>102</td>
</tr>
</tbody>
</table>

The same reduced to percentages of nominal speeds:

<table>
<thead>
<tr>
<th>No.</th>
<th>...</th>
<th>...</th>
<th>...</th>
<th>...</th>
<th>...</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>8.0</td>
<td>7.0</td>
</tr>
<tr>
<td>6</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>2.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Therefore the irregularity due to the bottom flange increases slightly with the speed.

Effect of Tape Thickness.

Pulley speeds are usually calculated from the outside diameters of the pulleys concerned. This is quite near enough when the belt thickness is small compared with pulley diameter, but when the belt is relatively thick the more precise form of calculation based on the centre line of the belt or tape is necessary.

In the present case no allowance need be made on the tin cylinder diameter, but the whorle diameter should be increased by the thickness of the tape (half-thickness on each side of the diameter).

Calculated on this basis the nominal speed of the spindles of the frame used in these experiments would be not 6,000 but 5,700 for a tin cylinder speed of 450, the thickness of the tapes being from 0.36" to 0.40".

From Table III it will be seen that somewhat higher speeds are obtained in many cases, the highest being 5,780 and the average about 5,750. The reasons for this slight discrepancy need not be entered into here. A similar "negative slip" or gain has been found in grinding wheel speed tests at the National Physical Laboratory, and is reported in Engineering, July 1st, 1921, page 11.

As a check on the theory, speeds were measured with two thin silk tapes with the following results:

<table>
<thead>
<tr>
<th>Tin Cylinder r.p.m.</th>
<th>...</th>
<th>...</th>
<th>...</th>
<th>...</th>
<th>450</th>
<th>450</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whorle diameter</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>.756&quot;</td>
<td>.756&quot;</td>
</tr>
<tr>
<td>Tape thickness</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>.003&quot;</td>
<td>.009&quot;</td>
</tr>
<tr>
<td>Calculated r.p.m.</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>5929</td>
<td>5882</td>
</tr>
<tr>
<td>Measured r.p.m.</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>5924</td>
<td>5888</td>
</tr>
</tbody>
</table>

Spindles driven by very thin tapes therefore run at almost exactly the calculated speed, that is, at the speed referred to as "standard" speed.
Guide Roller or Bowl.

The only complete cure found for speed variation due to varying tape alignment was the guide bowl mentioned on page 7.

Fig. 4 shows the type used in these experiments. It consists simply of a piece of brass tube on a short spindle supported by a bent iron bracket. While it served its purpose and is still running, it would probably not be sufficiently durable for mill use, and if lubricated might throw oil on the bobbins.

The design of such details is a matter for spinners and machine makers rather than for the Association, but two suggestions are made. Fig. 5 has a cast iron bracket with a 3½" tin pulley similar to a tension pulley, and carried in similar bearings. Fig. 6 is simpler and lighter, using a light steel pressing and a bowl made from the wood used in so-called "oil-less bushings." The latter material is not yet widely used and samples are being obtained for experiment.

The distance of the guide bowl from the whorle needs further practical trial. Shortness of the arm makes for cheapness and lightness, and for less twisting load on the lifter rail, but too sharp a turn in the tape may cause it to wear. Further experiments on the details are contemplated.

Alternative Forms of Whorle.

Fig. 7 shows various whorles tried. A. is the standard whorle delivered with the machine. This was used in all the foregoing experiments. B. is a modified form which gave no better results, but worse if anything. C. would not retain the tape at all at the steeper alignments. D. showed a slight improvement on A. E. with a loose bottom flange should apparently have cured any trouble due to friction on that flange, but showed no improvement. F., a larger whorle with a wide tape, showed considerable improvement on the standard, as shown by the following figures. The cylinder speed or diameter would have to be increased.
TABLE VI.

<table>
<thead>
<tr>
<th>Whorle 1.541&quot; diameter.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tape 1&quot; wide, guided to give bad alignment as on Fig. 3.</td>
<td></td>
</tr>
<tr>
<td>&quot;Standard&quot; Spindle Speed 2,920 r.p.m.</td>
<td></td>
</tr>
<tr>
<td>Height of whorle from floor</td>
<td>30.2&quot;</td>
</tr>
<tr>
<td>Speed for cylinder speed of 450 (mean of two runs)</td>
<td>2780</td>
</tr>
<tr>
<td>Per cent. below &quot;standard&quot; speed</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Variation in speed and therefore in twist = 2.9% compared with 8% for ⅜" whorle, Table IV.

Twist Measurements.

To test the effect of these speed variations on twist, some yarn was two-folded on a parallel bobbin at a slow traverse, the tape to the spindle used being guided as for No. 8, Fig. 3. Spindle speeds were measured at various heights as before, and from these the twist was calculated, allowance being made for take-up and winding on. The latter allowance was checked by measurement of the actual speed of the yarn round the cap. This calculated twist is given in the third column of Table VII., while in the fourth column are given measurements of twist taken on 60" lengths.

TABLE VII.

<table>
<thead>
<tr>
<th>Height of whorle from floor</th>
<th>Speed of spindle r.p.m.</th>
<th>Calculated turns per inch</th>
<th>Measured turns per inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.2</td>
<td>5125</td>
<td>12.35</td>
<td>12.3 to 12.6</td>
</tr>
<tr>
<td>29.2</td>
<td>5250</td>
<td>12.65</td>
<td>12.5 to 12.8</td>
</tr>
<tr>
<td>28.2</td>
<td>5450</td>
<td>13.15</td>
<td>13.0 to 13.2</td>
</tr>
<tr>
<td>27.2</td>
<td>5650</td>
<td>13.65</td>
<td>13.3 to 13.5</td>
</tr>
<tr>
<td>26.2</td>
<td>5750</td>
<td>13.75</td>
<td>13.6 to 13.9</td>
</tr>
</tbody>
</table>

The speeds are slightly different from those of Table III., probably due to changes in the frame. The correspondence between the actual twist and that calculated from speed measurements is remarkably close.

Power Loss.

As might be expected, the friction of the tapes on the whorle flanges absorbs a certain amount of power. This power has been measured for tapes aligned as Nos. 5 and 6 on Fig. 3, and works out at an average extra load of about one horse power for 250 spindles. With tapes aligned as Nos. 7 and 8 on Fig. 3, it would, of course, be much greater.

Friction on Washer.

It was considered that the loss in speed when the tape pulls downward might be due in part to the resulting friction on the bottom washer and lifter rail. This washer on spindle 8 was therefore replaced by a Hoffman ball thrust washer, but no improvement in speed could be detected.

Part III.

THE STROBOSCOPIC APPARATUS.—DETAILED DESCRIPTION.

Construction of Mirror Stroboscope.

A beam of light from an electric arc lantern with a condenser (see Figs. 1, 8 and 9) is concentrated on a small double-sided silver mirror,
FIG. 8.—MIRROR DRIVE AND ARC LAMP.
which revolves about one of its diameters at half the speed of the spindle under observation. Reflection from this mirror causes the beam to sweep through a circle, illuminating any object in its path intermittently—e.g., when the speed of the mirror is 3,000 r.p.m., giving 6,000 flashes per minute or 100 per second, each object in the path of the beam will be lit up for say 1/50 of 1/100 of a second, and will be in darkness the remaining 49/50 of the 1/100.

If the object be a spindle running at 6,000 r.p.m. it will turn exactly one revolution between flashes, each flash will light it up while it makes 1/50 of a revolution and each time it is lit up it will be in the same position. A rapid succession of identical images is therefore presented to the eye, blending into one image of an apparently stationary spindle. This image is usually somewhat blurred, but with careful adjustment an illumination of 1/150 in place of 1/50 is easily attained, and the maker's name can be read on the bobbins while running at 6,000 r.p.m. This degree of precision is not usually necessary.

If the spindle is running a little faster than 6,000 r.p.m. while the mirror is giving 6,000 flashes per minute, the spindle will turn just over a revolution between flashes. Thus each image presented to the eye will be a trifle further round than the previous one, and will give the appearance of a spindle moving slowly in the direction in which the spindle is really making about 6,000 r.p.m. If, on the other hand, the spindle is running more slowly than the flash frequency, it will have the appearance of moving slowly backwards, the revolutions per minute made by the image in each case being the difference between the flashes per minute given by the mirror and the r.p.m. actually being made by the spindle.

Drive of Stroboscope.

The drive to the mirror (Fig. 8) consists of two spindle tubes, (A.) held by collars above the highest point reached by the lifter rail. On one of these spindles a specially turned bobbin is firmly fixed, and from this bobbin a short tape B. runs to the cone pulley C., carrying the mirror H., Fig. 9. Before running on to the cone pulley, the tape passes over the flanged pulley D., the vertical position of this pulley being controlled by a fine-thread screw E. and knurled nuts F. By moving the tape up and down the cone pulley the mirror speed can be varied 10 per cent.

On the mirror spindle, which runs in ball bearings, is a small heavy flywheel G. The short tape is run slack, just tight enough to overcome the air friction of the mirror and flywheel. Whenever the effect of tape joints would be to change the speed of the mirror momentarily, the inertia of the flywheel resists such a tendency, provided the tape is slack enough to slip.
Slip in either tape has no effect on the accuracy of the results, since no dependence is placed on the drive to do more than rotate the mirror at a speed bearing a fairly constant ratio to that of the tin cylinder. The exact value of this ratio is determined by an optical method as follows.

Marked Band for Speed Measurement.

Round the cylinder, at a point clear of tapes, and convenient for illumination by the mirror, is stretched a band of drawing paper with its circumference divided into 40, 39, 38, 37, 36, 35, 34 divisions. To render the adjacent bands more readily distinguishable the even ones have marks about $\frac{3}{4}$" long and $\frac{1}{4}$" wide, while the odd-numbered ones have circles $\frac{1}{4}$" diameter, as shown in Fig. 10.
In the frame used for these experiments, the tin cylinder is 10" diameter and the whorle on the spindle tube 3/4" diameter. The "standard" speed of the tube is therefore $10 + \frac{2}{3}$ or $13\frac{1}{3}$ times that of the tin cylinder.

If the frequency of flashes given by the mirror is equal to the speed of such a theoretical spindle, the tin cylinder will turn $\frac{1}{13\frac{1}{3}}$ of a revolution between flashes. This is numerically the same as $\frac{7}{60}$ of a revolution, so the band of 40 divisions will move forward an amount exactly equal to three of its own divisions every flash. This band will therefore appear to be stationary.

At the same flash frequency, the next band will have moved the same fraction of a circle between flashes, but here the pitch of the marks is slightly greater and the distance moved will be rather less than the distance between three marks. The band of marks will therefore appear to move slowly backwards.

If the flash frequency be decreased by shifting the tape on the cone pulley until the 39 band appears stationary, the tin cylinder will then be making $\frac{3}{60}$ or $\frac{1}{20}$ of a revolution between flashes. Table VIII. shows the flashes per revolution of the tin cylinder when various bands appear stationary, also the corresponding number of flashes per minute for cylinder speeds of 300 and 450 r.p.m.

<table>
<thead>
<tr>
<th>No. of divisions in band apparently stationary</th>
<th>40</th>
<th>39</th>
<th>38</th>
<th>37</th>
<th>36</th>
<th>35</th>
<th>34</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flashes per rev. of cylinder</td>
<td>13\frac{1}{2}</td>
<td>13</td>
<td>12\frac{1}{2}</td>
<td>12\frac{1}{2}</td>
<td>12</td>
<td>11\frac{1}{2}</td>
<td>11\frac{1}{2}</td>
</tr>
<tr>
<td>Per cent. below &quot;standard&quot; speed</td>
<td>0</td>
<td>2\frac{1}{2}</td>
<td>5</td>
<td>7\frac{1}{2}</td>
<td>10</td>
<td>12\frac{1}{2}</td>
<td>15</td>
</tr>
<tr>
<td>Flashes per min. with cyl. at 450 r.p.m.</td>
<td>6000</td>
<td>5850</td>
<td>5700</td>
<td>5550</td>
<td>5400</td>
<td>5250</td>
<td>5100</td>
</tr>
<tr>
<td>Flashes per min. with cyl. at 300 r.p.m.</td>
<td>4000</td>
<td>3900</td>
<td>3800</td>
<td>3700</td>
<td>3600</td>
<td>3500</td>
<td>3400</td>
</tr>
</tbody>
</table>

**Method of Observation of Spindle Speeds.**

The position of the mirror is adjusted so that the spindles and the band on the tin cylinder are illuminated by its flashes. Its speed is adjusted so that the spindle being observed appears to be almost stationary.

Turning now to the marked bands on the tin cylinder, the one appearing most nearly stationary, i.e., the one most nearly corresponding to the speed of the spindle, is made to appear quite stationary by again adjusting the speed of the mirror. One observer keeps it so while another counts the revolutions backwards or forwards made by the image of the spindle under observation.
For example, suppose the tin cylinder is running at approximately 450 r.p.m. and that the band brought to apparent rest is that with 38 divisions, i.e., that corresponding to a drop of 5 per cent. or 300 r.p.m. from "standard" speed, and that the image of the spindle makes 23 revolutions in a half minute in the direction in which the spindle is really running. Then the speed of the spindle for a tin cylinder speed of 450 r.p.m. will be:

\[6000 - 300 + 46 = 5746 \text{ r.p.m.}\]

It should be noted that this is not necessarily the real speed of the spindle, but the speed at which it will run when the tin cylinder makes 450 r.p.m. (see below "Accuracy of Measurements.")

Further, suppose the cylinder is again running at 450 r.p.m. approximately, that the 36 band is apparently stationary, and that the spindle image makes 22 revolutions per minute backwards, i.e., in the opposite direction to that in which the spindle is really running. The speed of the spindle for a tin cylinder speed of 450 r.p.m. will be:

\[6000 - 600 - 22 = 5378 \text{ r.p.m.}\]

**Accuracy of Measurements.**

These measurements are liable to error from three sources only, and it will be shown below that the total error from these sources is unlikely to exceed \(\frac{1}{4}\)%. The reason for an accuracy so unusual in speed measurements is that what is being measured is not really speed but rather velocity ratio, the speed of each spindle for a given cylinder speed, or the revolutions made by each spindle per revolution of the tin cylinder. Further, this ratio is measured by what is really the optical equivalent of a gear drive.

Speed variation from causes outside the frame itself are not considered in the present investigation. Whatever effect such variations may have on air drag of the "balloon," etc., there is no direct effect on twist. Twist depends mainly on the relation of spindle speed to front roller speed. The front rollers are driven positively from the cylinder shaft by chain and spur gearing, so any variation in the relation of spindle speed to front roller speed must be in the tape drive, the subject of the present investigation. Further, it is the ratio of the tape drive and not the actual spindle speed that affects twist.

The sources of error are:

1. The image of the markings on the cylinder may not be kept exactly stationary.
2. The apparent revolutions of the spindle image may be miscounted.
3. The speed of the tin cylinder may vary during the measurements.
Regarding the first, the plan adopted was to keep the eye fixed on one particular point in the image, and to keep adjusting the mirror tape so that the point did not move more than about an eighth of a revolution from its starting point. When the travel exceeded this amount the measurement was started afresh. An eighth of a revolution in half a minute on a cylinder running at 450 r.p.m. is about one-sixteenth of one per cent.

A mis-count of even two revolutions of the spindle image in a half minute would affect the result by 4 in 5,600 (the approximate speed of the spindle) and is again about one sixteenth of one per cent.

The speed of the tin cylinder during the experiments was measured by a centrifugal tachometer of no special accuracy, and probably varied two or three per cent. from its nominal value. Such a change might affect the measurement under consideration in two ways. In the first place, the velocity ratio itself owing to slip might change with change in speed. A special set of measurements to determine this are reported in Table V., p. 14, where it will be seen that the ratio does change, but only one or two per cent. for a thirty per cent. change in speed. The effect is negligible for a two or three per cent. change in speed. In the second place, if the ratio is practically unchanged, the actual number of revolutions difference between nominal and real speeds will not be independent of speed but proportional to it. The counted revolutions of the spindle image is a fraction of this difference and therefore proportional to speed, but it has been shown above that even a large error in the counted revolutions has little effect on the final result.

An interesting check was frequently made on these measurements. When a spindle speed came about half way between two of the percentages marked on the band, it was measured from both in succession, the apparent motion of the spindle being, of course, in opposite directions in the two cases and the counted revolutions being deducted in the case of the lower percentage and added in the case of the higher one. In every case the two results were within a few revolutions of each other.

Alternative Methods Considered.

At least three ready-made stroboscopes were considered. All were expensive, and none fully suited the purpose. They were:—

1. A revolving perforated disc or shutter driven by a synchronous motor controlled by a tuning fork (Cambridge Scientific Instrument Co.)

2. A vibrating shutter attached to an electrically maintained equivalent of a tuning fork (Crompton-Robertson).

3. A neon lamp operated by induction coil and contact breaker, the latter geared to the apparatus being examined (Elverson).

The first came to our notice as the result of enquiries before commencing the series of experiments at present being described, the second about the middle of them, and the last when they were virtually completed.
Shutter Stroboscopes.

The first two suffer from the same defect, from the point of view of the present experiments—that they will only give one or more definite flash frequencies, corresponding to the frequencies of the tuning forks used. For observation of the curve of the yarn, licking, etc. (the subject of a future report) the flash frequency must be capable of fine adjustment to correspond with the rate of revolution of the yarn balloon. For speed investigations there is the further disadvantage that spindle and tin cylinder speeds must be simultaneously compared with the standard, as otherwise it would be impossible to distinguish variations due to the tape drive—the matter under consideration—from those due to the main driving motor.

The system at present in use, by measuring directly the velocity ratio of the drive, obviates the need for two simultaneous sets of measurements.

Further, neither of these instruments makes full use of the light of the arc lamp. An average condenser does not concentrate to a "point" much smaller than 1\(\frac{1}{8}\)" diameter, and closer concentration could only be obtained by more lenses and therefore more transmission loss. The Crompton instrument has a slit about 1\(\frac{1}{16}\)" wide, and uses several lenses. A revolving disc with a 1\(\frac{1}{2}\)" aperture corresponding to the mirror would require for our purpose to be at least 25" diameter, and would have to run at about 6,000 r.p.m.—its air resistance being rather a heavy load for a synchronous motor controlled by a tuning fork.

Unlike the shutter types of apparatus (1 and 2 above) the 1\(\frac{1}{8}\)" diameter polished silver mirror of the instrument made by the Association catches a large proportion of the light of the lamp, when using an ordinary condenser.

Elverson Oscilloscope.

Shortly after the apparatus had reached its present form, notices of the Elverson Oscilloscope appeared in the press, and a demonstration was given at Manchester which we visited. The apparatus is designed for investigations on valve and other motions and structural vibrations in petrol engines. It seems very well suited for that purpose. In our case it would need considerable modification on the lines of the present apparatus, and some of the features most prominent in the patent specification are of no value to us.

If given the features of regulation and means of measurement possessed by the apparatus we devised, it would have the advantages of greater portability, easier application to successive spindles and independence of electricity supply, and on these grounds is worth consideration. The instrument is arousing great interest and is doubtless fetching the high price being asked (100 guineas per annum rental).
Vision Stroboscope.

Reference should perhaps also be made to the original form of stroboscope, by which the object is viewed through a slot or slots in a rotating disc.

Assuming a slot 1/16" wide and an obscured period of 50 times the open period, a disc 6" in diameter would have a circumference of 18" (approx.) with 6 slots.

This would have to revolve at 1,000 r.p.m. close to the eye.

If the finer definition corresponding to the finer mirror adjustments be required, the ratio of obscured to open period, and the speed would have to be increased.

Furthermore, the apparatus and its drive would have to be moved opposite each spindle, or the observer be limited to observations from a distance.

And again, the apparatus, if close up, would impede access for piecing or any other purpose.

Finally, the speed of the mirror stroboscope is in principle almost unlimited. A steel mirror with four or more faces could be used, and the only limit would be the bursting strength of the steel, for the illumination and definition are the same at a high speed as at a low.

Development of Mirror Stroboscope.

The rotating mirror was at first driven by a small variable-speed electric motor, controlled by two sliding rheostats.

This arrangement was sufficiently good to show that the object desired at the time (observation of the yarn path) could be attained by stroboscopic lighting of this character and gave the staff and a few members of the Research Control Committee the opportunity of seeing, probably for the first time since cap frames existed, the real behaviour of the yarn in ballooning, licking, etc. It also showed that there were large and unexpected variations in spindle speed.

The defect of the arrangement was that constant hand adjustment of the control was necessary in order to compensate for variations in speed of the motor driving the frame and in the speed of the mirror motor. The former, when delivered, had an abnormally large variation of speed with change of load, but the makers re-wound the machine and since then its behaviour has been quite satisfactory. The mirror motor also varied slightly in speed, probably due to varying brush friction. The cord drive from motor to mirror spindle also gave rise to variations. A flywheel on the mirror shaft was tried without much success. Even when not large enough to level out the above-mentioned irregularities it interfered seriously with the hand control, making the mirror very sluggish in answering a shift of the rheostat slide.
Various forms of drive by gear from the cylinder with or without flexible shaft were considered, but none seemed worth constructing. Tape drive did not seem promising, but a temporary one rigged up with the existing mirror, spindle, base-board, etc., and a pulley turned the same size as the spindle whorles, gave surprisingly good results.

The speed of the mirror shaft was, of course, almost the same as that of the spindles, and the latter appeared practically stationary, except where flange friction was excessive. By a coincidence the teeth of the twist gear wheel also appeared to be nearly stationary, and a calculation from them back to the tin cylinder gave the first measurement of the difference between commonly calculated and actual speeds—about 6 per cent.

From this temporary arrangement it was only a short step to the design of the variable-ratio tape drive described above. The selection of twist change wheels as a measure of the flash frequency (no spinning was being done), developed into the placing of marked bands on the tin cylinder.

With the apparatus in this stage the work detailed in this publication was carried out.

Members may wish to have a similar apparatus of their own, and it is hoped further to simplify the design and make it an even more rapid and easy means of examining a frame for uniformity of speed, absence of vibration, etc., and at the same time of instructing employees as to what actually occurs in spinning.

Sale of Stroboscopes to Members.

Even in its present form, however, it is quite practical, and could be made for £30 down to £15 or even less, according to the numbers required.
British Research Association
for the
Woollen and Worsted Industries

Observation of Licking
and Some Methods
of Measuring Drag
in Cap Spinning.

Further results from the apparatus described in Publication No. 15
with a description of apparatus for measuring drag.

It is requested that publications be kept in the personal control of a Director
or head of the firm, and not lent to or discussed with other than those
responsible managers, etc., necessarily informed for the conduct of the business.

February, 1923.

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CAP SPINNING.

THE RELATION OF TENSION TO THE LICKING OF YARN ROUND THE CAP.

Further Observations based on the Apparatus described in Publication No. 15, July, 1922.

Introduction.

The results which were described in Publication No. 15 were entirely different from those which the stroboscopic apparatus was designed to discover. Its chief object was to make clear the reason for the licking of yarn round the cap under certain circumstances. The illumination of the spindle by intermittent or flashing light not only enabled the observer to see that different spindles were not running at the same speeds, but at the very outset it also showed how widely different was the form of a balloon when the yarn was licking, from the form of the same balloon on the same spindle when the yarn was being spun on to a smaller bobbin.

Licking and Drag.

In practice the amount of drag in any given frame is estimated by the excellence or otherwise of the spin, and it is entirely in keeping with everything that has previously been observed by practical men and by investigators, that the yarn should be found to adhere closely to the sides of the cap when the drag is smaller, when that smaller drag is the result of the bobbin being large in relation to the size of the cap. It is not clear, however, whether previous observers also knew that a lower drag, if produced by lower spindle speed, caused no tendency to lick. Perhaps it will make the subject clearer to state the case in terms of actual sizes. If yarn is being spun on a bobbin one inch in diameter, within a cap measuring 1.9 inches, it is usual for the yarn to fly away from the cap, making a symmetrical and almost uniform curve from the edge of the cap to the pot eye. But if the size of the bobbin is increased to 1.75 inches, the yarn will not fly clear of the cap at all, but will appear to adhere closely to the sides of the cap for almost two inches above the edge. That is to say, in a parallel bobbin, licking depends entirely on the relative diameters of cap and bobbin, and neither rise and fall nor position of lifter has anything to do with the case. In a spool-built bobbin, where the diameter on to which the yarn is winding is continually altering, the shape of the balloon is altering also.
Shape of Balloon.

The stroboscope had not been in operation many minutes before the real cause of the difference was made plain. It shewed that when no licking was taking place the yarn was rotating round the cap almost exactly as a skipping rope revolves through the air. There was little of the nature of a spiral about it. On the other hand, as soon as the yarn began to lick, it was easy to see that the middle portion of the balloon was retarded until it occupied a position about three quarters of a revolution behind the point at which the yarn was passing over the cap edge. In other words, when the yarn is licking it is much more in the form of a spiral, passing over the cap edge at a certain angle (which approaches 45°) to the centre line of the spindle. Attempts were made to photograph the yarn when the stroboscopic illumination made it appear to be almost stationary, but these attempts proved unsuccessful. Paper templates were therefore prepared and compared with the apparent position of the thread whilst it was running on to the bobbin, and pieces of wire were bent to correspond. These wire models were placed between the bottom edge of the cap and the pot eye, and compared with the yarn running on adjacent spindles and adjusted until they exactly reproduced the position of the yarn when licking and when flying clear. The wires were then photographed in four positions, the photographs being reproduced in Figures 1 to 4. The yarn which forms the balloon when it is licking actually appears to touch the cap for quite a considerable portion of its length, but it is also easy to see that this is entirely due to the fact that the yarn is then in a spiral position and that it is following the most direct course from the cap edge to that point of the balloon where it is furthest from the centre of the spindle.

All experiments so far made with different sizes and shapes of caps and of bobbins and run at all sorts of different speeds, illustrate the same fact very clearly. When the yarn strikes the cap edge almost tangentially (i.e., when the bobbin nearly fills the cap), it seems certain that the balloon will consist of a greater length of yarn, and that this yarn will be formed into something of the nature of a spiral. Which of these things is “Cause” and which is “Effect” is not yet really made absolutely plain. In fact, at the present moment we are inclined to think that the thread continues from the cap edge upward in a direction which is more or less a continuation of the line which it makes in passing from the outside of the bobbin to the cap edge. At present this question has been put on one side because it was considered much more important to discover, if possible, the relation of licking to the drag under which the yarn was spinning.

Measurement of Drag.

It always seemed to be anomalous that the yarn should lick when the drag was small, but this had always been known to be the case,
and therefore as soon as the stroboscope had shown what the nature of licking really was, it seemed the more desirable that the exact amount of drag which caused the yarn to lick or to run free, should be ascertained exactly. To do this was not an easy matter. It needed apparatus of a kind that had never before been used, and many suggestions were made as to the best method of ascertaining the amount of drag which the yarn has to stand as it is being put on to the bobbin. Two entirely different methods have been tried, and will be described. In a third, which has not yet been completed, it is proposed to fasten the bobbin to the tube by some means, such as a hair spring, and to use the stroboscopic lighting to observe how far the bobbin lagged behind the tube when yarn was being spun on to it. It is obvious that this system will not only involve the construction of very delicate apparatus, but that it will be exceedingly difficult to use in practice. The two other methods were therefore adopted first.

Drag at Bobbin.

That called the “Unwinding Method” was carried out by first spinning a single layer of yarn on to a bobbin of known diameter. The length of each wrap can, of course, be accurately calculated, and each wrap was marked while still under tension in the manner shown in Figure 5. Forty wraps round the bobbin were unwound, and on the yarn so unwrapped was suspended a light weight hanging beside a long vertical scale divided into inches and tenths as shown in Figure 6. The bobbin on to which the yarn was spun was made of aluminium, the diameter being 0.986”. A micrometer showed that the yarn diameter was 0.004”, and so the pitch line would be .990”. This multiplied by $\pi$ (3.1416) × 40 made the length of 40 wraps 124.4” to which length the yarn ought to extend under the drag at which it was spun. As a matter of fact, with a light aluminium pan attached the end only hung to about 123”, and the pan which formed the weight had to be loaded to about 7 grams before the yarn spun at 6000 revolutions was again extended to the calculated length.

Effect of Speed on Drag.

On exactly similar lines many experiments were tried, and long ranges of tests were taken at all speeds from 3500 to 8000 revolutions per minute. With four aluminium bobbins, which were practically 1” in diameter and with a 1.9” cap, the figures obtained were wonderfully regular and showed a steady increase in drag with increasing speed. This increase is not exactly in proportion to the square of the speed, but to the 1.7th power. These figures are interesting because the air resistance to the cross wires of an aeroplane increases in almost this ratio with increasing speed. The figures were therefore accepted as being eminently satisfactory.
Effect of Bobbin Diameter

No licking was taking place in the spinning of the yarn on to these 1" bobbins with 1.9" caps. Four aluminium bobbins which would only just go inside the cap were therefore made and measured. Their diameter was 1.579". When the single layer of yarn had been spun on to them, the necessary wraps were unwound and measured against the vertical scale before mentioned. Naturally, it was expected that there would be a very large reduction in the amount of drag. A long series of tests at different speeds rose and fell in correct relation to one another, and to the formula already established. But the actual drag differed only very slightly from the figures which represented the drag on a bobbin 33% smaller.

Bottom Drag contrary to accepted ideas.

In fact, when the mean drag for 6000 revolutions had been calculated, it actually appeared as if there was a heavier drag on a 1.579" bobbin than there was with a 1" bobbin in the same cap. This was such a startling discovery that it was concluded that some serious mistake had been made. But further tests which bore correct relation to one another at varying speeds using a 1" bobbin in a 1.65" cap again upset theory; for when they were compared with tests from a 0.86" bobbin in the same cap, the smaller bobbin again showed the least drag. The results, therefore, with these particular sizes of caps and bobbins appeared to be in flat contradiction to every theory which was known to work satisfactorily in all spinning mills in this country. Experiments will clearly have to be carried out over a much wider range.

Drag above Pot Eye.

Because of the inconsistency which seemed to exist in results obtained by the "Unwinding Method," it was decided to test the drag between the wire board and the front rollers, in very much the same manner as that in use by practical men when they are feeling the running threads with their fingers. A very light bell crank of steel wire was so arranged that one arm pressed a glass tube against the yarn as it run through the rollers to the pot eye. The other arm of the crank extended outside the wire board and was connected by a thread with a pan hanging near the floor. The apparatus has recently been transferred to the ring frame, and is shown there in Figures 7 and 8. It was very easy to see that weights in the pan deflected the running thread from a straight line between the roller and the pot eye, and it was equally obvious that at high speeds greater weights were needed to deflect the thread to the same extent. The difficulty was to ascertain how much deflection represented different amounts of drag on the thread. The spindle was therefore removed, and a piece of yarn run through the rollers and through the pot eye was allowed to hang vertically downwards with a weight of 5 grams on its end. Above
the pan on the thread which was attached to the long arm of the bell crank, a pen or pointer was fixed and it was easy to observe how much it was raised by the 5 grams tension on the yarn. By suspending different weights on the yarn, figures were obtained showing exactly what pull or drag in spinning will raise the pen to any definite height. When this process was complete the weights were removed, the spindle and cap put back in their places, and spinning or twisting was begun. Naturally, the drag was not always the same. Thicker and thinner places in the yarn increase or decrease the amount of centrifugal force and air resistance in the balloon, and even with a well-spun yarn the pen was always rising and falling. The pen was then arranged to move against a sheet of paper which travelled with the lifter motion and thereby produced a diagram which it is quite easy to translate into terms of average pull on the spinning yarn. For example, with a 1" bobbin and 1.9" cap at 4000 revolutions per minute the line will oscillate between the bottom line which represents 5 grams and the next line above which indicates a drag of 6 grams (Figure 9). It would descend at times below the zero line if that were possible, and allowance is made for this in reading the average of that particular diagram as 5.25 grams. Similarly at 6000 r.p.m. the drag varied between 10 and 15.5 and gave an average of 12.5 (Figure 10).

Comparison of Drag Measurements.

Testing by this method was much less laborious and less monotonous than that which was necessary for the "Unwinding Method," and it was not long before many series of figures were obtained. It was found first that the figures agree at all speeds with the theory of "Air resistance to wires in Aeroplanes," and secondly, that in this particular combination of 1.9" cap and 1" bobbin, the result only differed by about 15% from the figures obtained by the other method. This was the beginning of a long series of experiments. The results are much more easy to understand than those obtained by the other method, because they do not in a single instance contradict the opinions held as to the increase and decrease of drag by those who know most about the practical application of this question in the trade. That is to say, every increase in the size of a bobbin reduces the drag, and every decrease in the size of the cap does so as well, although at present we have not been able to specify an exact formula for the relation between the drag and the relative sizes of cap and bobbin. This is the more remarkable when it is considered that almost every test that has been made with relation to speed has come within reasonable distance of a curve which clearly fulfils certain conditions. It is not therefore stating the case too strongly to say that testing for the relation between drag and speed has been successful by both methods, but testing for the relation of drag to cap and bobbin diameter yields unexpected results in one case, and in the other results which are very difficult to express by a formula.
Difference between "Top" and "Bottom" Drag.

It is quite certain that the results obtained by the two methods are not identical, that facts which are known to be true of the flyer frame have some equivalent in cap spinning. That is to say, that the "bottom" drag on the yarn as it goes on to the bobbin may be something quite different from the "top" drag on the same yarn above the pot eye.

Further Experiments.

Further experiments are in progress, and a bobbin of the type described on page 5 will be tried. Experiments are also being extended to the ring frame, and possibly to the flyer frame, in the hope that this may throw some light on the discrepancy. It is the present intention to publish all these results at the same time, after they have been carefully compared with each other and conclusions drawn on a wider basis than is possible at present.

The precise workmanship necessary in making the apparatus—stroboscope, bobbins, etc.—described, has been carried out by Mr. J. Amos, Engineering Assistant.
Fig. 1. The two middle spindles have wire models of the yarn in typical balloons for empty and full bobbins. The shapes of these models were arrived at by comparison with the spinning yarn on the two outer bobbins when illuminated by the revolving mirror.
Figs. 2, 3 and 4. Same wire models as shown in Fig. 1 photographed in positions approximately 90° apart. It will be noticed that when spinning on an empty bobbin the yarn flies clear, but when the bobbin is full the yarn wraps itself round the cap. In a spool-built bobbin the photographs represent the state of the balloon near the base and top of the nose respectively.
A Note on Cap and Bobbin Dimensions and the Reduction of Doffings

Also

A Description of An Improved Form of Stroboscope

By HOWARD PRIESTMAN and A. W. STEVENSON.

It is requested that publications be kept in the personal control of a Director or head of the firm, and not lent to or discussed with other than those responsible managers, etc., necessarily informed for the conduct of the business.

May, 1924

BRITISH RESEARCH ASSOCIATION
for the WOOLLEN AND WORSTED INDUSTRIES,
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A Note on
Cap and Bobbin Dimensions
and the Reduction of Doffings

Following the methods described in Publication No. 18, an extensive series of measurements of drag or tension in cap spinning have been made. Though the figures themselves require further checking, and are not yet ready for publication, one of the inferences from the tests so impressed the members of the spinning sub-committee that suggestion was made of an early application to practice.

This inference is that the use of caps and bobbins larger than those ordinarily in use would not increase the drag nearly as much as is commonly supposed, and that in this way there are possibilities of considerably increasing the amount of yarn put on each bobbin.

One of the members of the sub-committee generously offered to put a frame at the disposal of the Association for a large scale test, offering also to supply caps and bobbins as required, or even a new frame, if this should prove to be desirable for the test.

An opportunity also occurred of showing these results to one or two other members who are considering the installation of new frames, and some of them are about to conduct tests for themselves. Under the circumstances it is felt desirable that the whole body of members should be informed, although large scale tests are not yet started.

Preliminary to these large scale tests, cap, bobbin, and roving, as in use on one of the member's frames, were obtained. The cap was 1.9" diameter and the bobbin 0.95" diameter; the yarn being spun 50's.

From the tabulated results of the fundamental experiments it was concluded that a 1.6" bobbin in a 3" cap would give a very similar drag. As the shoulder of a parallel cap would have been very much in the way at short balloon lengths, spool build and taper cap were decided on.

In some experiments on cap shape, which will be reported more fully later, little difference has been found between parallel and bell caps, but conical caps have been found distinctly better than either.

Fig. 1 shows the cap and bobbin in use in the member's mill, and Fig. 2 the experimental cap and bobbin made in the Association workshop. The shaded circles underneath show the cross-section and area of the space available for yarn on each bobbin. That on the experimental bobbin is about 2 1/2 times that on the bobbin in use.
The first experiments were made on a frosty day, which gave a very dry atmosphere in our spinning room. It was actually found impossible to spin on the old cap and bobbin, but quite easy on the new ones. On this and subsequent days the large cap and bobbin gave an excellent spin, no breakdowns being attributable to them.

As the apparatus, illustrated in Figs. 7 and 8, Publication No. 18, is somewhat troublesome when used for spinning, drag measurements are usually made with the nearest equivalent two-fold yarn. In this case 60's cotton was used.

Running at 7,200 r.p.m., the top drag with the old cap and bobbin measured 9.0 grams, and with the new 9.5 grams, an insignificant difference when it is remembered that the breaking strength of single 50's worsted is about 50 grams.

It ought to be particularly noticed that the drag diagrams, such as Figs. 9 and 10, Publication No. 18, from which these figures were obtained, differed very materially in their nature. Although they show half a gram difference in favour of the smaller cap, the diagrams themselves indicate that the drag on the larger cap is far less jerky and therefore quite likely to give a better spin, because the drag never rises to the heights recorded on the diagram of the smaller parallel cap. These points of excessive drag are attributed to the strains which make for cutting on the cap edge; in other words, they have more to do with bottom drag than with top drag.

Tests were also made on the smallest bobbin on to which this cotton could be two-folded without cutting at the cap edge. With the 1.9" cap, for which a 0.95" bobbin was in regular use, the first smaller size tried, namely, 0.86" diameter, refused to work. With the 3" cap, for which a bobbin diameter of 1.6" is proposed, a 1.25" bobbin worked without breakdown, this only occurring when a 1.12" bobbin was tried. This means that, while the ordinary bobbin and cap in use had only a 10% margin over the breaking-point by this way of testing, the bobbin proposed for the large cap has a margin of 40%. This larger margin is closely connected with the more regular drag mentioned above.

A criticism was made that owing to the greater balloon diameter the resulting yarn would be excessively "beardy" and deficient in both strength and stretch.

Two bobbins were spun with each cap between tins at 3 3/4" pitch, though a larger pitch would be recommended for the larger cap. The speed was the same in both cases, namely, 7,200 r.p.m.

The yarns were then two-folded and compared first for appearance. That spun on the large cap was certainly more "beardy," though not excessively so, in spite of the fact that the pitch was only 3 3/4" and the yarn was battering on the tins.
Strength and stretch tests were then made on a "Baer" single-thread tester. The mean of twenty tests of each yarn gave an advantage of about 3% in both strength and stretch in favour of the yarn spun with the large cap. About 130 tests of each on a Moscrop single-thread tester gave a similar result.

Full size blue-prints of Fig. 2 can be obtained from the Association offices. The bobbin would, of course, require a stouter flange and a metal top for mill use, and the cap may have to be modified in detail for economical quantity production. The Association staff would be glad to confer with members thinking of trying larger caps and bobbins.

Conclusions

1/50’s worsted may be spun on 1.6" bobbins with a 3" taper cap in some ways more satisfactorily than with 0.95" bobbin and 1.9" parallel cap.

The larger bobbins will hold more than twice as much yarn as the ordinary ones, reducing expense in both doffing and two-folding.

Although the pitch was only 3½" and the yarn was battering on the tins, it was but little more "beardy" than the ordinary yarn.

The yarn is as strong as the ordinary yarn.
Fig. 1.  

Fig. 2.
FIG. 3
A Description of
An Improved Form of Stroboscope

Following the description of the Research Association's stroboscope in Publication No. 15, and subsequent notices in the technical press, a number of requests for instruments were made by members and others.

As the form used at Torridon, and described in the above-mentioned publication, would have been cumbersome for mill use, a more compact and portable design was got out. The essential part of the instrument, the revolving mirror and cone pulley drive, still remains the same as shown in Fig. 9, Publication 18; but instead of being clamped to the spinning frame, and illuminated by an arc lamp on a separate stand, as shown in Fig. 8, Publication 18, the arc lamp, condenser, and revolving mirror form a self-contained unit, as shown in Fig. 3 of this publication.

The over-all width in the narrowest direction is 12\(\frac{1}{2}\)", enabling the instrument to be taken down any gangway between spinning frames. The arc lamp is placed in the bottom of the casing; with switch, fuse, and resistance just above. The light, after passing through a condenser, is reflected vertically and then again horizontally on to the revolving mirror. The second stationary mirror is adjustable to allow the light to be thrown either upwards or downwards after leaving the revolving mirror, and the revolving mirror can be adjusted in height to suit the spinning frame. Current may be taken from one of the lighting lamp-holders, as shown, or a special cable can be run if the lighting circuits are not heavy enough to carry the necessary current of about 8 ampères. Where no electricity is available, the instrument can be fitted for dissolved acetylene or limelight. The whole instrument weighs about 52 lbs. and can be easily carried by one man. Castors could be fitted if desired, but it is thought that they might lead to rougher handling than if the instrument is lifted from place to place.

The price has been fixed at £30, with a substantial discount to members.

The annexed photograph shows the instrument applied to a frame in a mill.
The British Research Association
for the
Woollen and Worsted Industries

Drag or Tension on the Yarn in Cap Spinning

By
HOWARD PRIESTMAN
and
A. W. STEVENSON.

It is requested that publications be kept in the personal control of a Director or head of the firm, and not lent to or discussed with other than those responsible managers, etc., necessarily informed for the conduct of the business.

November, 1924

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Drag or Tension on the Yarn in Cap Spinning.

Summary.

This publication gives the results of a large number of measurements of yarn tension (or, as it is usually termed in the trade, drag) in cap spinning, using the methods described in Publication No. 18. Speeds, cap and bobbin diameters, and balloon lengths have been varied over wide ranges.

For practical purposes it may be said that drag is proportional to the square of the speed and to the square of the balloon length.

Its relation to cap and bobbin diameters cannot be readily summarised, and reference should be made to the Tables, which will repay careful study.

Measurements have also been made and tabulated of the minimum size of bobbin for a given cap and of the effect of balloon length on this size.

Introduction.

The results which were described in Publication No. 18 made it clear that there were forces in work in all cap spinning which, even if they were suspected by some investigators, were nevertheless likely to prove contrary to most accepted theories. This was particularly the case in regard to the statement that the drag above the pot eye and the drag where the yarn went on to the bobbin differed as much in cap spinning as they differed in a flyer frame. Subsequent investigations have therefore been directed to ascertain:

1. How the drag above the pot eye is affected by:
   (a) Speed.
   (b) The relation of cap to bobbin diameter.
   (c) Balloon length.

2. Bottom drag, as it is affected by:
   (a) Speed.
   (b) The relation of cap to bobbin diameter.

3. The ratio of cap to bobbin diameter for:
   (a) A point at which it is possible to start spinning.
   (b) A point at which it is possible to run.
Observations.

"Top" drag was measured by the apparatus illustrated in Figs. 7 and 8, Publication No. 18, about five hundred diagrams being made and analysed.

A long series of measurements of bottom drag were made by the unwinding method described in Publication No. 18, the measurements showing great consistency among themselves. But when they were tabulated alongside the corresponding figures for top drag and discussed with others, members of the staff, it was evident that the method was unreliable although the results were consistent among themselves; the figures arrived at for drag by this unwinding method were all much too low.

The apparatus mentioned in Publication No. 18, p. 5, lines 9 to 14, which had been abandoned as unworkable, was again adopted and improved with the collaboration of Messrs. Hoffmann (ball bearing makers) and the figures given in this paper were obtained with it. A full description is given at the end of this publication.

In spite of the large number of observations made, it is clear to the investigators that they have only touched the fringe of the subject, which can be pursued in many other directions than those which have hitherto been followed.

Speed.

Each figure set out in Table I represents the result of a series of experiments made at a range of speeds usually varying from 3,000 to 8,000 revolutions of the spindle per minute.

The figures were plotted and a smooth curve was drawn through them. The point at which this curve cuts the vertical 6,000 line gives the figure called "mean drag referred to 6,000."

Such a curve is shown in Fig. 1. It will be seen that the drag actually measured at 6,000 was 15 grams, but the curve drawn through all the points indicates 14.0 grams as a more likely figure for 6,000.

Actually the curves were not drawn with evenly divided scales such as those shown in Fig. 1, but on paper with logarithmically divided scales, as shown in Fig. 2. Sets of figures which, if plotted on ordinary paper would give curves of parabolic form like that of Fig. 1, when plotted on logarithmically divided paper give straight lines. It is obviously easier to draw an average straight line among a number of points than an average curve.
Irregularities.

All those acquainted with the inequalities invariably found in worsted yarns, will not be surprised to hear that considerable discrepancies occurred from time to time in the figures. As was pointed out in Publication No. 18, the first ratio obtained with increase in speed was nearly always in the neighbourhood of the 1.7th power. Later figures taken with the bell crank above the pot eye gave a figure more near to an average of 1.8 (over a very wide range of cap and bobbin sizes) but more recent figures, particularly those which were taken to determine the influence of balloon length on top drag, give a still higher figure. The position in regard to this relationship of drag to speed cannot therefore be said to be as satisfactory as it appeared when Publication No. 18 was issued, but although the measurements obtained are not so consistent as was and is desired, yet the figures seem sufficiently concordant to be of very practical interest.

Cap and Bobbin Diameters.

As has already been stated, a very large number of figures were got together, but it was not discovered until quite a late stage in the proceedings that the diameters of caps and bobbins used in the trade bear no definite relation to one another. It was therefore decided to begin a series of experiments in which four distinct sizes of cap should have an easily-recognised relation to one another and to the size of the bobbins on to which the yarn was spun. For instance, a 3 inch cap spinning on to a 1½ inch bobbin has an obvious relation to a 2 inch cap spinning on to a 1 inch bobbin, a 1½ inch cap spinning on to a ¾ inch bobbin and a 1 inch cap spinning on to a ¾ inch bobbin. Table I is based on this idea, and although the margin of error which must necessarily occur in all spinning calculations has not been eliminated, there seems to be quite sufficient agreement between the figures to allow of certain conclusions being made.

Large Caps.

It is probable that the practical mind will fasten on the figures given for the largest size of cap, for it is quite obvious that the increase of drag is not nearly so great as is commonly supposed, or in other words, it may be clearly stated that large caps spinning on to large bobbins do not increase the drag as much as is commonly supposed. Table I shows figures which are, of course, in direct relation to one another, that is to say, in every case only one factor is altered. All the tests are arranged at the same balloon length, or in other words, so that the edge of the cap is at the same distance from the pot eye. The figures published in Table IV. (p. 11), which have relation to the extra drag arising from increased balloon length, make it clear that
the drag can be altered very widely by alteration in the height of the spindle and that it is therefore possible with properly-constructed caps to spin on to bobbins of such diameter that their contents will be three or four times as great as many which are now in common use. Such increase in size will naturally result in many economies in a spinning mill, although it will mean a revolutionary alteration in the size of caps and bobbins. [The question of the use of larger caps and bobbins has been discussed in Publication No. 37]. A few caps of the design illustrated in Fig. 2, Publication No. 37, are available for loan to members.

**Forces in the Balloon.**

After establishing the fact that the drag on the thread that is being spun increases in some relation to the speed of rotation, and to relative cap and bobbin sizes, it was of interest to discover what other factors affect the complicated combination of forces which together play their part in supplying the tension which winds the yarn tightly on the spool. One result was the collection of a series of figures representing the drag at different speeds with the balloon length varying from 6.8 inches to 16 inches.

**Effect of Balloon Length.**

The figures which have to do with the increase in speed show variations from what was expected, but after the mean for 6,000 has been ascertained a comparison of this mean at all balloon lengths from 6.8 inches to 16 inches shows a rise at a ratio which is near to the square of the length (2.24). It is common knowledge that increased balloon length means increased drag, and the figures obtained are interesting as confirming existing practice, with the additional advantage that the increase may be calculated without any difficulty.

Throughout these experiments it was obvious that there was some force at work which causes cutting on the cap edge after the size of the cap has been increased too much or the size of a bobbin too greatly reduced. A very long series of experiments proved pretty conclusively that an extension of balloon length acts in almost exactly the opposite way, causing the yarn to cut less at the bottom.

**Minimum Bobbin Size.**

There is a very definite minimum size of bobbin beyond which, no matter how much the speed is reduced, it is impossible to spin. For instance, with a 1.65 inch cap and a 0.75 inch bobbin running at 8,000 revs. per minute, a yarn might very well spin with a measured drag of 17 grams. With the size of the bobbin decreased by one-tenth of an inch the same yarn would not spin at 4,000 revs. per minute. The original 0.75 inch bobbin running at 4,000 revs. per minute would
give a drag of 6 grams, and it might reasonably have been expected that the decrease of one-tenth of an inch in the size of the bobbin (to 0.65 inch) would only have increased the drag to about 7 grams. Instead of this, a yarn which will carry a weight of 150 grams breaks, or rather cuts, before the balloon has had time to form.

There is also a very obvious difference between the possibility of a yarn running when it has once formed a balloon and the failure of the same yarn to start spinning at all. Thus the possibility of spinning or otherwise seems to have little to do with drag, at any rate with drag as measured above the pot eye.

Under certain circumstances the lengthening of the balloon in a way which considerably increases the top drag seems even to diminish the likelihood of the yarn's breaking down by cutting at the moment when the spindle begins to rotate.

For example, a 2/40's would begin to cut at the cap edge in the case of a 0.72 inch bobbin and a 1.65 cap when the balloon is only 7 inches long, but if the balloon be increased to 9 inches it will spin at a high speed on the same 1.65 cap, and when the balloon reached the extreme length of 16 inches the same yarn will actually wind on to a 0.72 inch bobbin in a 1.9 inch cap at any speed that is desired. When once the yarn has begun to balloon it seldom breaks down unless it is spun on to a portion of the barrel which is considerably less in diameter than that on which the spinning began. For instance, the yarn which broke with a 0.72 inch bobbin and a 1.65 cap will run quite freely on a pirn 0.60 inches in diameter, because in that case it was possible to begin running the yarn on to a portion of the pirn which was 0.9 inches in diameter, and in the 16 inch balloon length, with the same cap, similar facts were clearly seen. In that case yarn would begin winding on to a 0.75 inch bobbin in a 1.9 inch cap and break when the cap was 2 inches in diameter, but when spinning began on a larger portion of the pirn the yarn would run quite well when the barrel was reduced to 0.66.

Effect of Yarn Size, Spinning and Twisting.

All the figures in this paper refer to two-folding 40's yarn.

A number of comparative experiments were made on spinning and twisting, from which it was concluded that there was practically no difference in top drag between spinning 20's and two-folding 40's.*

A few experiments were made to determine the effect of the size of yarn on drag, and on minimum bobbin size, but the results are too few to justify publication.

* This does not mean that there is no difference in likelihood of breakdown when spinning 20's and two-folding 40's. It only means that the tension which might cause breakdown is practically the same. That the two-fold is much less likely to break is the reason for its use when making those measurements of tension.
Tables.

Table I, which has already been referred to, shows top and bottom drag for a number of cap and bobbin sizes. As already explained, each figure in this table is based on measurements of drag over a wide range of speeds, and is the mean figure for 6,000 r.p.m. deduced from the measurements at all speeds.

Comparing the top drag for a 0.75 inch bobbin in a 1.5 inch cap with that for a 1.5 inch bobbin in a 3.0 inch cap, it will be seen that there is an increase in drag of 50% (from about 3/4 oz. to 1 1/2 oz.) On the other hand the amount of yarn going on to each bobbin will be about four times as great.

Table II gives the figures for top drag at various speeds from which the mean figures in Table I were calculated. The measurements were made by means of a bell crank above the pot eye as described on page 6 of Publication No. 18. The last three lines of Table III are interesting, showing that there is little difference in the top drag when a conical or bell cap is substituted for a parallel one. Further experiments on this are nearly ready for publication.

Table III gives the figures for bottom drag at various speeds from which the mean figures in Table I were calculated. The measurements were made as described on page 12 of this publication.

Table IV shows the effect of balloon length, measured from pot eye to cap edge, on drag at various speeds, and in the last column the mean drag referred to 6,000 r.p.m. for each length. The drag is proportional to something just over the square of the balloon length.

Table V shows the smallest size of bobbin on which two-folding of 40's can be started at various balloon lengths. Observations such as these are, of course, much affected by the irregularity of the yarn in use, but the figures given are the mean on a number of observations plotted on squared paper, and averaged by smooth curves, and show the general trend of minimum bobbin diameter in relation to cap diameter and balloon length rather than the absolute minimum diameter.

Table VI shows the smallest size of bobbin on which two-folding 40's can be continued when it has been started on a larger portion of the bobbin.

Conclusions.

For practical purposes drag may be said to be proportional to the square of the spindle speed.

It may also be said to be proportional to the square of the balloon length (i.e., the height from the cap edge to the pot eye).

Its relationship to cap and bobbin diameter is given in the Tables
and does not as yet lend itself to concise expression. It depends more on the ratio of bobbin diameter to cap diameter than on the actual diameter of the cap or the bobbin.

When using large caps drag increases less than is commonly supposed (see Publication No. 37).

Its relationship to count is not yet determined.

The MINIMUM BOBBIN DIAMETER (below which spinning is impossible) is almost unaffected by speed, depending rather on diameter and shape of cap, balloon length and count.

Slide Rule Calculation.

It may be of interest to remark that the bottom and top scales of a standard slide rule bear the same relation to one another as spindle speed and drag and balloon length and drag.

In the following examples the usual letters are given to the scales—A, B, C, D, starting from the top of the rule.

(1) The speed of a spin is increased from 6,000 to 6,600. What is the increase in drag?

Set 6 on C scale to 66 on D scale and against 1 on B scale read 1.21 on A scale. This means that the drag has increased from 1 to 1.21 or 21%.

(2) The balloon length is increased from 8 to 9½". What is the increase in drag?

Set 8 on C scale to 9.5 on D scale and against 1 on B scale read 1.41 on A scale. The drag has increased 41%.

(3) The balloon length is decreased from 8 to 7½". What is the decrease in drag?

Set 8 on C scale to 7.25 on D scale and against 1 on B scale read 0.82 on A scale, a decrease of 18%.

Further Objects.

The investigators have, among other things, the following two objects.

(1) To give spinners a means by which, given count, spindle speed, balloon length, cap and bobbin diameters, they can in a few seconds calculate the probable drag in grams or ounces.

(2) To give them a handy instrument for the measurement of drag. Such an instrument would bear the same relation to those used for this paper as the mill stroboscope does to the early research instrument.
### Table I.

**Mean Top and Bottom Drag in Grams** for Various Cap and Bobbin Sizes.

Two-folding 40's. Balloon length 8.2 inches.

(mean Drag referred to 6,000 r.p.m. †)

<table>
<thead>
<tr>
<th>Cap Diam. (inches)</th>
<th>Bobbin Diam. (inches)</th>
<th>Top Drag</th>
<th>Bottom Drag</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.52</td>
<td>0.75</td>
<td>1.00</td>
</tr>
<tr>
<td>0.52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>9.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.25</td>
<td>12.7</td>
<td>8.5</td>
<td>7.0</td>
</tr>
<tr>
<td>1.50</td>
<td>10.5</td>
<td>9.1</td>
<td></td>
</tr>
<tr>
<td>1.75</td>
<td>10.2</td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>2.00</td>
<td>11.9</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>2.50</td>
<td>12.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.00</td>
<td>15.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*28.3 grams = 1 oz.* † see page 4.

### Table II.

**Top Drag in Grams for Various Speeds, Bobbin and Cap Sizes.**

Two-folding 40's. Balloon Length 8.2 inches.

<table>
<thead>
<tr>
<th>Bobbin Diam.</th>
<th>Cap Diam.</th>
<th>Speed in R.P.M.</th>
<th>Mean Referred to 6000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4000 5000 6000 7000 8000 9000</td>
<td>6000</td>
</tr>
<tr>
<td>0.52</td>
<td>0.75</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>0.52</td>
<td>1.00</td>
<td>6.5</td>
<td>9.5</td>
</tr>
<tr>
<td>0.52</td>
<td>1.25</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>0.75</td>
<td>1.00</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>0.75</td>
<td>1.25</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>0.75</td>
<td>1.50</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>1.00</td>
<td>1.25</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>1.00</td>
<td>1.50</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>1.00</td>
<td>1.75</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>1.00</td>
<td>2.00</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>1.50</td>
<td>1.75</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>1.50</td>
<td>2.00</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>1.50</td>
<td>2.50</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>1.50</td>
<td>3.00</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>0.86</td>
<td>1.50</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Parallel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.86</td>
<td>1.50</td>
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</tr>
<tr>
<td>Conical</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>0.86</td>
<td>1.50</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Bell</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE III.

**Bottom Drag in Grams for Various Speeds, Cap and Bobbin Sizes.**

Two-folding 40's. Balloon length 8.2 inches.

<table>
<thead>
<tr>
<th>Bobbin Diam.</th>
<th>Cap Diam.</th>
<th>4000</th>
<th>5000</th>
<th>6000</th>
<th>7000</th>
<th>8000</th>
<th>9000</th>
<th>Mean Referred to 6000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>1.75</td>
<td>5.6</td>
<td>8</td>
<td>12</td>
<td>19</td>
<td>24</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>1.00</td>
<td>2.00</td>
<td>6.5</td>
<td>8.5</td>
<td>13</td>
<td>19</td>
<td>24</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>1.00</td>
<td>2.50</td>
<td>8</td>
<td>8.5</td>
<td>13</td>
<td>19</td>
<td>24</td>
<td></td>
<td>19</td>
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<tr>
<td>1.37</td>
<td>1.75</td>
<td>5.5</td>
<td>8</td>
<td>12.5</td>
<td>16</td>
<td>20</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>1.37</td>
<td>2.00</td>
<td>5.5</td>
<td>8.5</td>
<td>12.5</td>
<td>16</td>
<td>20</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>1.37</td>
<td>2.50</td>
<td>8</td>
<td>12</td>
<td>17</td>
<td>19.5</td>
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<td></td>
<td>16</td>
</tr>
<tr>
<td>1.50</td>
<td>1.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>1.50</td>
<td>2.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>1.50</td>
<td>2.50</td>
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<td></td>
<td></td>
<td></td>
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<td>17</td>
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<td>3.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22</td>
</tr>
</tbody>
</table>

### TABLE IV.

**Top Drag in Grams at Various Balloon Lengths and Speeds.**

Two-folding 40's.

Bobbin 0.75 inches diam. Cap 1.25 inches diam.

<table>
<thead>
<tr>
<th>Length of Balloon</th>
<th>Speed in R.P.M.</th>
<th>Mean Referred to 6000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4000</td>
<td>5000</td>
</tr>
<tr>
<td>6.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.5</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>9.0</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>9.5</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>10.0</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>10.5</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>11.0</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>11.5</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>12.0</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>16.0</td>
<td>9</td>
<td>16</td>
</tr>
</tbody>
</table>
TABLE V.
MINIMUM STARTING SIZES OF BOBBINS
FOR VARIOUS CAPS AND BALLOON LENGTHS.
Two-folding 40's.

<table>
<thead>
<tr>
<th>Balloon Length</th>
<th>Cap Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>7&quot;</td>
<td>.67</td>
</tr>
<tr>
<td>9&quot;</td>
<td>.63</td>
</tr>
<tr>
<td>11&quot;</td>
<td>.60</td>
</tr>
<tr>
<td>13&quot;</td>
<td>.55</td>
</tr>
<tr>
<td>16&quot;</td>
<td>.53</td>
</tr>
</tbody>
</table>

TABLE VI.
MINIMUM RUNNING SIZES OF BOBBINS
FOR VARIOUS CAPS AND BALLOON LENGTHS.
Two-folding 40's.

<table>
<thead>
<tr>
<th>Balloon Length</th>
<th>Cap Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>7&quot;</td>
<td>.55</td>
</tr>
<tr>
<td>9&quot;</td>
<td>.52</td>
</tr>
<tr>
<td>16&quot;</td>
<td>.52</td>
</tr>
</tbody>
</table>

APPENDIX.

Measurement of Bottom Drag.

Fig. 3 shows a standard cap spinning tube A and bobbin B, the bobbin being driven by the dogs C on the whorle D, the whorle being permanently attached to the brass tube.

Fig. 4 shows a special tube and bobbin designed for measuring drag or tension in the yarn as it is wound on to the bobbin. As before, A is the brass tube and D the whorle for the driving tape, E is a flywheel added to reduce the momentary speed fluctuations which occur in all tape driving each time the joint passes the whorle. The bobbin B is a light steel shell held clear of tube A by ball bearings, and carried round, in one form, by a fine rubber cord F. This rubber cord stretches more or less according to the drag on the yarn as it is being wound on to the bobbin. Round the bottom flange of the steel bobbin is a divided scale on which can be seen with stroboscopic lighting the amount by which the pull of the yarn makes the bobbin lag behind the brass tube, whorle and flywheel.

Had the use of the rubber cord been continued, calibration might have been made by fixing the tube and bobbin with axis horizontal,
unwinding a portion of the yarn and attaching to it known weights. The amount by which these weights caused the bobbin to turn against the pull of the rubber could have been noted. This calibration would only have been approximately correct, as it would have neglected the effect of centrifugal force and air resistance on the rubber cord when running.

It was evident from the appearance of the cord when running and lit by the stroboscope that these forces were not negligible, and a method was therefore devised for calibrating the instrument under actual working conditions. The apparatus is shown in diagram in Fig. 7.

A silk cord GH was passed round the bobbin B and an aluminium grooved pulley J, the grooved pulley being supported on pivot bearings. To it was fixed an aluminium wire K, on which a brass weight L could be set at any desired radius from the centre of the pulley. B is, of course, running, and J is stationary, except for a slight floating movement, and it is immaterial whether the cord slips on B or J, or partly on each. The drag on B is the difference between the pull in G and that in H, and it is also this difference which is available for supporting wire K and weight L in a horizontal position.

One way of operating would be to adjust the position of weight L, until wire K floated horizontally between stops M. The method of operation found most convenient was to set weight L in a definite position and to vary the total tension in GH until K floated. The amount by which the bobbin was made to lag was at the same time observed by stroboscopic lighting. By taking a succession of positions for weight L, a curve was drawn showing the drag corresponding to any movement of the bobbin B against the tension of the rubber cord.

Considerable difficulty was experienced in getting a rubber cord sufficiently fine and sensitive. Fine wire springs were tried without much success. The form of control at present being used is a length of heavy silk cord. When there is no drag centrifugal force causes it to fly out in a narrow loop as shown in Fig. 5, but drag on the bobbin causes the loop to widen as shown in Fig. 6, the amount of widening depending on the drag. Besides greater sensitiveness this form of control has the advantage that the controlling force increases as the square of the speed. Drag in the balloon increases approximately in the same ratio. This means that for a given length of balloon, cap diameter and bobbin diameter, the reading on the scale is almost the same at all speeds, any variation in the reading being a measure of the variation from the "square" law in the relationship of drag to speed.
The thanks of the Association are due to Messrs. The Hoffman Manufacturing Co. Ltd., of Chelmsford, who made (to our outline design) and presented the apparatus shown in Fig. 4.

**Fig. 1.**
The crosses indicate the results of experiments, the curves strike an average.

These figures refer to bottom of page 4.
British Research Association
for the
Woollen and Worsted Industries

Higher Drafts
in
Bradford Spinning

By
HOWARD PRIESTMAN and A. W. STEVENSON

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July, 1926.

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British Research Association
for the
Woollen and Worsted Industries

Higher Drafts in Bradford Spinning

By
HOWARD PRIESTMAN and A. W. STEVENSON

July, 1926.
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III. EXPERIMENTAL  ...          ...          ...          ...          ...          4
IV. CONCLUSIONS    ...          ...          ...          ...          ...          12

I.
SUMMARY.

The principal experimental facts are as follows. It is quite possible
to draw a slubbing or roving twice in the same direction. A frame
was fitted up to do this in one operation and spinning was effected at
drafts even up to 70, though about 36 seems most satisfactory.

Almost the whole of the difficulties encountered have been con-
cerned with the secondary effects of drafting, such as carrier lapping.
Means of correcting and controlling this have been devised. Considerable
quantities of yarn have been spun, and samples of cloth have been
woven, but the process is not yet perfectly satisfactory. There are
factors, probably including humidification and fibre lubrication, which
are not yet understood. If these factors can be overcome, the process
has an obvious commercial future.

This communication is therefore to be regarded as a record of
work carried out and of provisional conclusions reached, not as express-
ing finality. The work is continuing.

It has been thought desirable to publish what has already been
done, for two reasons, viz., that the Association should not risk loss
of priority, particularly since the subject is already attracting much
attention in the cotton trade, and secondly that the experiments are
so far advanced that greater freedom of discussion with and advice
from members is desirable. Some members might also wish to do exper-
iments in their own mills.

A brief outline of the stages of development will be found on the
folding plate at the end of this report.
II.

INTRODUCTION.

Almost exactly 200 years ago, a man called Wyatt took out a patent for machine spinning. The specification shows that the inventor had grasped the two great principles of spinning, the first and foremost being the extension of the material between two or more pairs of fixed rollers. Before the century was out Arkwright and other inventors had developed this idea into a spinning frame which hardly differed at all from the machinery in use to-day. Although the same apparatus is used both for cotton and for wool, it has long been obvious that there is a strange want of knowledge of the principles underlying drafting, for the simple reason that a sliver of cotton having a fibre length of 1½ inches can be extended twenty times in one operation, whereas a sliver of wool composed of six inch fibres can only be extended to six times its length. Yet in dealing with wool it is an accepted rule that the longer the fibre the greater the permissible draft. The hope that the difference between the two might be eliminated, which was expressed by Priestman twenty years ago, has never been absent from our minds and was the original cause of this investigation, for it is a pretty well established fact that the machinery employed in the worsted trade has undergone no great change in the principles it embodies for more than 100 years. The cost of the production of a worsted yarn depends very largely on the amount of extension which is possible in any given machine and it must therefore be obvious to everybody that if the draft which is possible in any process can be materially extended (as it has been in the cotton trade), the conversion cost will be reduced to a proportionate extent. It is believed by many eminently practical worsted spinners that when the material reaches the slubbing box, the sliver is as level or leveller than at any other point in the course of manufacture and therefore if it were possible to increase the draft from 6 to 36 the two processes of reducing and roving would be altogether eliminated and yarn produced in a single spinning frame direct from a bobbin 10 inches by 5 inches.

In every one of the processes which compose a set of Bradford drawing the yarn is extended between two rollers as described by Wyatt in 1730. This is shown in Fig. 1 in which A B are a pair of back rollers with a surface traverse of one inch per second, C D being another pair with a surface traverse of 6 inches per second, the distance from the line A B to the line C D being slightly greater than the length of the wool they are working. If the wool fibres were all of one length, these two pairs of rollers would in all probability turn out a perfect yarn, but because there are short fibres as well as long ones present, it has been found necessary to place two pairs of small rollers, which are called carriers, between A B and C D in such a position that they control the
movement of the short fibres which would otherwise run through the
front rollers in lumps. For many years it has been well known that when
wool was less than six inches long, slivers could not be extended by more
than six times their length at one operation. It was in the hope that
some modification of these rollers might result in a greatly increased draft
that the present investigations were undertaken and they were based
on a profound doubt of the truth of the statement that drafting twice
in the same direction is an impossibility.

Reversal in Drafting.

In the past, as soon as material had been extended to say six times
its original length, it has been wound on to a bobbin before putting it
through another operation, the very fact of unwinding from this
bobbin making it necessary that the second drafting should take place
in a direction which is the reverse of the first.

Apparently the necessity for this unwinding has induced people to
believe that no other method is possible and on this opinion they have
based the theory that wool cannot be drafted twice in the same direction
with any success. Priestman in 1906 pointed out that the 3 roller systems
as used in cotton did actually give two successive drafts and formed an
exception to the practice of reversal for each draft. The first experiment
of this series was therefore to unwind roving from one bobbin to another
and to spin it in the ordinary way. By this method two consecutive
drafts were made in the same direction yet this made practically no
difference to the levelness of the yarn.

Successive Drafting.

It was a very short step from the above experiment to that suggested
by Priestman based on the fundamental difference between cotton
spinning and the spinning of worsted yarn. In the former the back and
front rollers are separated by nearly double the length of the fibre and
the intermediate pair of rollers hold the fibres so tightly that they
practically form an intermediate grip dividing the draft into two parts;
the first draft being about 2 and the second 8. Though the three or four
lines of rollers in a cotton frame are superficially similar to those on a
worsted frame, there is a radical difference. In worsted spinning as
usually practised it may be said that the intermediate rollers or carriers
do not grip the fibres at all, they only steady the movement of the short
fibres, the control of which makes worsted spinning so much more
complicated than cotton spinning.

The problem before the writers was therefore to endeavour to apply
the principle of successive drafts, or a heavily loaded middle roller, to
worsted, and at the same time to maintain control of the fibres.
The details of how and how far this has been accomplished follow in the remainder of the paper, but a short description of the figures is given here.

Figure 1, already referred to, is a diagram of the ordinary Bradford cap spinning frame.

Figures 2, 3 and 4 show stages in development of rollers giving two successive drafts.

Figure 5 shows one of the later arrangements. Here A B are the back rollers and the first draft takes place between A B and C D, while the second draft is between C D and E F. Thus the intermediate rollers C D serve both as front rollers of the first draft and back rollers of the second draft.

Figure 6 shows an arrangement in which a false twist tube is used.

III.

EXPERIMENTAL.

Material.

The majority of the following experiments were made with commercial botany rovings, about 64's quality, obtained from various members.

Reversing a Roving.

The first experiment of this series was to take an ordinary roving, about 3 drams per 40 yards, and rewind it from one bobbin to another and spin it in the ordinary way. This made two drafts in the same direction and the spinning was not noticeably worse. When yarn prepared from the same roving in this and the ordinary way was tested in the Moscrop machine there was little difference between the samples, that drafted twice in the same direction being slightly weaker but more uniform in strength.

Successive Draft.

We then arranged a frame with two succeeding groups of rollers tandem fashion (Fig. 2) geared so that the first group drafted six and the second group drafted about the same. By an accident we set the gearing wrong and the first yarn which we weighed which was spun from an eighteen-dram roving (equivalent in weight to 1's yarn) was 1/70's, i.e. a draft of 70 in a single process. This in itself was ample proof that existing ideas regarding drafting might be put on one side as incorrect. When the draft was reduced to 40 to 1, the yarn spun quite well that day, but on the succeeding day, with everything apparently the same, the carriers lapped badly.
Carrier Lapping.

This lapping of the carriers, which has been our greatest trouble, seemed to us to be connected with the flatness and breadth of the roving (due to lack of twist) when passing through the front set of drafting rollers.

The trouble has at times extended to the front rollers, top and bottom, and very occasionally to the bottom middle roller.

The lapping, troublesome in itself by causing breakdown, has also seemed to us to be connected with the uniformity of the yarn in two ways:—primarily by abstracting fibres from the roving and thus making the yarn smaller in places (and sometimes larger in others by returning abstracted fibres in a bunch) and secondarily because its presence is almost certainly an indication that drafting is not going on in a proper manner.

Laps seem to begin with one stray fibre, which usually passes round the roller two or three times before attracting others. Once it begins doing so, the accumulation usually grows more and more rapidly until it absorbs the whole of the roving thus breaking down the “end.” Much less frequently the lap breaks down at an early stage and passes into the yarn as a “slub.”

There have been two main lines of attack—endeavouring to eliminate the tendency of fibres to stray and wiping fibres off after they have strayed but before they have had time to accumulate neighbours.

We are unable even yet to say whether the straying is due to mechanical or electrical causes or to both, or how far it is electrically or mechanically dependent on the nature and amount of lubricant on the fibres.

One of the first modifications, based on the idea that the cause might be electrical, was to substitute an electrically conducting carrier roller—aluminium—for the usual varnished wood roller. This merely made the lapping worse.

On the assumption that ordinary Bradford drafting depends for its efficiency on both twist in the roving and carrier rollers, an early experiment was to apply false twist to the broad flat sliver. It seemed to give little improvement, though tried in various positions at this stage of development, yet when tried much later and in combination with other modifications it gave excellent results (see p. 10).

The next experiment was of the second class—removal of the stray fibres. Parchment was fastened to the top front roller, leaving long loose wings which wiped the fibres from the carriers when they were inclined to lap. (Fig. 3). This was satisfactory in many ways but it made piecing almost impossible. When removing the lap from the top roller
for piecing in the usual way it was very difficult to avoid tearing off a parchment wing as well. Such flaps are however used in mule spinning (see p. 9).

By this time we were convinced that it was more imperative to have the carriers nearer the nip of the front rollers when dealing with twistless slivers than when spinning in the ordinary Bradford way. With this in view the parchment covered rollers were made considerably smaller in diameter than those we had been using, being in fact the iron rollers usually used as back rollers but covered, some in single and some in double leather for use as front rollers. The diameter was about $2\frac{3}{4}$".

Though lapping was less frequent on the bottom carriers than on the top ones, it was nevertheless troublesome. It was practically stopped by placing a rod covered with lamp wick (part of the ordinary frame equipment) under and between the bottom carriers as shewn in Fig. 3.

The parchment flap has another function besides wiping the front top carrier. By its flick each time it is released from the nip it tends to shake off any fibres which may adhere to itself. Thinking the parchment covering would act in the same way if applied to the carriers themselves we sandpapered the shellac varnish off them preparatory to fixing the parchment. We tried one of them in this condition and were surprised to find a very great improvement, so great that we thought at the time we had cured carrier lapping completely.

Such lapping as remained we thought to be curable by controlling the atmosphere, particularly as it was always worst in the afternoon when the atmosphere in the room was warmer and drier. Unfortunately later experiments failed to confirm this, and considerable further modifications were necessary before lapping became a negligible trouble (see pp. 9–11).

**Large Single Drafts.**

In all the previous experiments the back draft was about six and the front draft about the same, making a total draft of nearly 40.

For comparative purposes some experiments were made on large single drafts. We attempted a single draft of 33 but the sliver was absolutely plucked to pieces and gave no continuous output at the front rollers. When the draft was lowered to 27 the output of fibres from the front rollers never completely ceased but was so frightfully irregular that it would not form a yarn. When the draft was reduced to 19 we were able to spin a yarn which might be described as reasonable. An aluminium front top carrier was used, the yarn being much better than when a wooden one was used. This was exactly opposite to the
effect of an aluminium carrier in the second stage of successive drafting (p. 5). As the matter has not been further investigated no explanation is offered of the apparent contradiction.

Three Successive Drafts.

In order to see whether three drafts in the same direction were possible we re-wound one reducing bobbin on to another, thereby reversing the direction of the fibres so that on spinning there were three drafts in the same direction. This showed no important variation but it led to another series of tests with drafts in the same direction and in reversing directions as indicated in the table below. This table shews five different ways in which two drafts were applied to an 18-dram roving.

TABLE I.

<table>
<thead>
<tr>
<th>Direction of first draft compared with previous process</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twist or otherwise in roving between drafts ... ...</td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
<td>Reverse</td>
<td>Reverse</td>
</tr>
<tr>
<td>Direction of second draft compared with first ... ...</td>
<td>None</td>
<td>Twist</td>
<td>Twist</td>
<td>None</td>
<td>Twist</td>
</tr>
<tr>
<td>Number of drafts in same direction ... ... ...</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Strength in ozs. (mean of Ten Tests) ... ... ...</td>
<td>5.2</td>
<td>4.1</td>
<td>4.9</td>
<td>5.6</td>
<td>5.4</td>
</tr>
</tbody>
</table>

For Columns A, B and C the roving was re-wound on to a fresh bobbin as explained above, thus the first new draft was in the same direction as that which had been applied in the previous process.

For Columns D and E the roving was used in the ordinary way, the first new draft coming in the reverse direction to that in the previous process.

For Columns A and D the roving passed down the two sets of drafting shewn in Fig. 3, giving a second new draft in the same direction as the first. Thus in Column A the two new drafts and that of the previous process were all in the same direction (three in all); in Column D the two new drafts are in the same direction as each other but are preceded by a reversal.

For Columns B, C and E the roving after its first new draft was wound on to a bobbin with a small amount of twist. For Column B it was re-wound to preserve similarity in drafting direction, again
making three drafts in the same direction. For Columns C and E there was no re-winding, the second new draft being thus a reversal of the first.

Column E is similar to ordinary mill practice, except that there is no doubling.

Column D is the method proposed in this report. Columns A, B and C are purely experimental.

These tests gave us no very definite lead, but possibly strengthened the idea that drafting in the same direction has not in itself been the difficulty which it was always supposed to be in the trade and that some subsidiary fault such as lapping due to absence of twist has probably been the cause of all previous failures.

**Hard Twisted Roving.**

It was suggested to us from experiments with mohair that a large draft might be given to very hard twisted roving. Drafting would begin with very serious plucking and by-and-by plucking would become less and less until drafting went quite uniformly.

The idea was that if this could be done with thick hard twisted Botany roving the sliver delivered to the back rollers of the second set would still contain an appreciable amount of twist. We failed to get uniform draft in the first set; plucking persisted.

**Ratio of Two Successive Drafts.**

Experiments were now made on the distribution of draft between the two sets. Drafts of from 2 to 8 in both front and back were combined in wide variety, and without any exception we found that the short back draft turned out a distinctly inferior yarn. The results of intermediate drafts were not equally conclusive; in fact they were so indefinite that we came to no conclusion except that the shorter back drafts invariably gave the worst yarn, and for that reason gave up using drafts of less than 4½ in the back set.

This is interesting because it is clear that the shortest drafts sent forward yarn with many more turns per inch than was the case when a draft of 5 was used.

Some of the best yarn made about this time was 36's, made from 18 dram slubbing (a draft of 36), the back draft being 5.4 and the front draft 6.7. It was actually better than yarn on a cheese supplied for another purpose from the stock of a first-class firm of weavers.

**Speed of Carrier Rollers.**

On the advice of one member of the Committee, we tried various carrier roller speeds, from slower than the back roller to over 100 per
cent. faster, but without tangible improvement. Further and more
detailed investigation along this line is proposed.

Small Front Rollers.

The spinning manager to one of our members, with whom we
discussed the problem, advised us to go still further in the direction of
smaller front rollers and to copy as closely as we could the front roller
arrangement of the worsted mule.

This necessitated considerable alteration of the rollers and roller
stands and the opportunity was taken to substitute one row of middle
rollers for the two rows with no-draft between as shewn in Figs. 2 and 3.
The reason for this latter arrangement was not so much desire as the
impossibility of arranging the existing roller stands in any other way.

At the same time the back rollers were made with a double nip to
grip the heavy roving firmly.

Fig. 4 shews the result of these alterations. From the time they
were made we have been able to spin satisfactorily, the smaller the
rollers and the nearer the front carriers to them, the better being the
yarn. The best results were obtained with ⅔" carriers of unvarnished
wood, 1½" front bottom roller, 1" parchment covered top front roller,
but with this combination piecing was even more difficult than with
the larger parchment-covered rollers previously mentioned.

The piecing difficulty led us to abandon the small parchment
covered roller for the time being and to substitute slightly larger leather-
covered rollers as shewn in Figs. 5 and 6. A number of types of leather
covering have been tried, including the soft chrome leathers. The
best results up to the present have been obtained with a thin varnished
leather over a cloth foundation as used in cotton spinning. Rubber
coverings are at present under trial.

We may quite possibly return to parchment covering following
more closely than before mule construction and piecing technique, or
using a forward-rubbing plush covered roller above the front rollers
similar to that now in use below and described in the next paragraph.

Rubbers and Clearing Rollers.

As was to be expected, the small bottom front roller was more
subject to lapping than the 3" one previously in use. Various arrange-
ments of clearers were tried. A plush covered roller revolving in the
same surface direction, as is used in cotton machinery and on worsted
mules, was unsatisfactory. The fixed clearer shewn in Fig. 4 was also
unsatisfactory, both having the feature of drawing towards them the
yarn on its way to the pot-eye. This action was at first thought to be
electrical, but is now considered to be a mechanical action, one end of a loose fibre being caught under the rubber while the other end is securely fixed in the yarn.

A forward-rubbing plush roller, as shewn in Figs. 5 and 6, has been very satisfactory from all points of view—clearing of stray fibres, facility for piecing and non-attraction of the yarn on its way to the pot-eye.

If a return to parchment top rollers is considered desirable, a similar plush roller may be applied to them, though the frame construction will be more complex.

Again following cotton practice, a roller rotating by contact was applied to the top carriers, again without success. A roller driven in the opposite surface direction and brushing both carriers was next tried, only to be abandoned because of its tendency, if adjusted the least bit too heavily, to reverse the rotation of the carriers themselves.

Finally flexible fixed wipers of plush or fleecy flannel (several materials are still under trial) were arranged as shewn in Fig. 5, and these were highly satisfactory, so much so that we have sometimes spun two successive doffings without lapping of any kind.

False Twist.*

Even though the spin as described above was good, when we directed a strong electric light on the fibres between the front carriers and the front roller we could see that although the carriers were not actually lapping, the fibres were always trying to go either up with the top carrier or down with the bottom one until they were brushed off by the rubber or by the front rollers and blended again, often in a bunch, in the yarn.

It was quite obvious that this must be stopped. We reverted to the false twist tube, placing it behind the front carrier in the second group, as shewn in Fig. 6. This reduced the straying of the fibres to a great extent, and the yarn produced was pronounced independently by two good judges to be good yarn. Some was woven into cloth and submitted to the Worsted Spinning Sub-Committee for inspection. The cloth was considered by them to be satisfactory and merchantable.

Further experiments on false twist are in progress, and the application of reciprocating rubbers as used in French Drawing and in Woollen Carding is under consideration. At the same time it is realised that reciprocating rubbers and false twist tubes are complications, and no opportunity will be missed of doing away with them in favour of simple roller arrangements.

* For explanation see Appendix.
Effect of Humidity.

A simple humidifier (a fan blowing through a tank of wet coke) has been fixed beside the cap frame to enable the effect of humidity on carrier lapping and other aspects of double-draft spinning to be observed. The results have been inconclusive. At one time a bulb difference of 5°F. at a temperature of 88°F. seemed to be necessary, but later some very successful spinning was done with a bulb difference of 9°F. at a similar temperature. There is a feeling in the minds of the investigators that a good or bad spinning atmosphere cannot be entirely described in terms of temperature and bulb difference.

Electrification.

Closely connected with the effect of humidity is the question of the electrification which may be playing some part in the tendency of a twistless sliver to lap on the carriers. The electrostatic attraction between a semi-conductor and a good conductor used in the operation of sensitive relays and loud speakers and there known as the Johnsen-Rahbeck effect, may find a parallel in wool while being drafted. Mr. R. V. Ripley, assistant in the engineering department, brought this effect to our notice, and made some experiments in the matter. These were too brief to be conclusive, but this aspect of electrification may be taken up again at a later date.

Another experiment on electrical lines was made. It was thought that if the fibres as they passed from the front carriers to the front roller nip could be surrounded by a conducting atmosphere any electricity generated would be discharged. This might improve the spin, and would certainly throw light on the question of whether the straying of the fibres is due to mechanical or electrical causes.

Perhaps the most effective way of obtaining this conducting atmosphere is by radium emanation, which has been tried on an experimental scale in woollen carding and paper making, but as far as we know without commercial success.

Products of combustion also form a conducting atmosphere. The application of these was tried without any success, but the experiment cannot be considered conclusive, as any good effect of the conducting atmosphere may have been countered by the high temperature of the gases. Though the experiment only lasted a few minutes, the rollers were covered with rust.

An electrical field was produced in the space between carriers and front rollers by two electrodes connected to a Wimshurst machine. Their presence seemed to make the spreading worse, but again the experiment was not conclusive.
Fibre Lubrication.

Some recent experiments with "French" rovings seem to indicate that they lend themselves better to the new drafting process than rovings prepared on the "Bradford" system. It is hardly thought that the absence of twist can be the beneficial factor as there is practically none left in a "Bradford" roving when it reaches the front set of drafting rollers. The cause is thought more probably to lie in the smaller amount and different nature of lubricant on the fibre. The matter is being further investigated, and the desirability of still using the product of ordinary Bradford drawing machinery, with some small change in the method of fibre lubrication, is being kept well in view.

IV.

CONCLUSIONS.

These experiments have shewn that drafting wool twice in the same direction is not the impossibility it is generally supposed to be. Even at the present stage of development of the process it is possible to spin perfectly merchantable yarn with a draft on the spinning frame of 36. The yarns produced up to the present are as good as many commercial yarns, though it is not claimed that they are equal to the best.

Spindles have run a whole day without an end down.

The chief obstacle has been the lapping of the carriers in the second stage of the draft, possibly related to the fibre lubrication and the small amount of twist left in the roving at this stage. A minor one has been similar lapping of the front rollers, particularly when reduced in size.

These obstacles have been partially countered by the application of rubbers or clearers to the rollers, and have been almost eliminated by the use of false twist.

Further research is in progress on false twist, roller and clearer arrangements and fibre lubrication.

Acknowledgments.

Acknowledgment is due by the writers to the various members of the Worsted Spinning Sub-Committee, their firms and staff for much helpful advice and criticism, also for the supply of suitable rovings, etc., for the experiments.
Acknowledgment is also due to the following member firms, not represented on the Committee, for assistance in various ways—advice, supply of material, permission to look over their mills, etc.—

Messrs. John Priestman & Co. Ltd.
Messrs. John Smith & Sons Ltd.
Messrs. W. & J. Whitehead Ltd.
Messrs. Wooley Ltd. (Bramley).
Messrs. Thos. Burnley & Sons Ltd.

Mention should also be made of work done by Mr. J. Amos and Mr. W. Townsley, assistants in the engineering department, in many alterations of the standard spinning frame.

APPENDIX.
FALSE TWIST.

Some explanation of false twist may be of interest to those unacquainted with the principle. It is usually applied to a sliver or roving by passing it through a rotating tube which tends to put in permanent twist, but is prevented from doing so by a roller nip just ahead (see Fig. 6). Such a tube gripping the material fairly tightly by a jaw is an essential feature of the only successful woollen spinning frame, while rotating funnels of gentler action are frequently used to smooth down the projecting fibres of slivers coming from cards, gill-boxes and combs.

In its present application it has probably two distinct effects, smoothing down and entwining the projecting fibres and improving the drafting by putting a little twist (comparable with usual roving twist) into the roving during the early portion of the second ratch.

An interesting experiment on the action of the tube shewn in Fig. 6 was made by sending down together a black and a white roving, so that the twist could be observed. The drafted material was taken by hand from the front rollers instead of being spun, so that any twist passing through the front rollers could also be observed. The top carrier roller was removed. The rollers were started first and subsequently the false twist tube. At once about one-and-a-half turns of right-hand twist appeared above the tube and a similar amount of left-hand twist below. But while the twist above remained there, that below slowly passed through the front rollers, the black being noticed as crossing, re-crossing and crossing again. No further change took place, the sliver between the middle rollers and the twist tube always having about one-and-a-half turns of temporary twist, and that between the tube and the front rollers being parallel. The material delivered by the front rollers was also quite parallel.
BRIEF EXPLANATION OF FIGURES.

Further details will be found on pages given in brackets.

Fig. 1. This shows the essential parts of an ordinary Bradford cap spinning frame. (p. 2).

Fig. 2. The front set of drafting here is of the usual cap frame type. The back set has been made up from rollers and roller stands borrowed from adjoining frames. As explained in the text, the carriers in front set lapped badly. (p. 4).

Fig. 3. The top front roller of the front set has been decreased in size and fitted with parchment flaps wiping the top front carrier. A fixed rubber has been applied to the bottom carriers. The top front roller of the back set has been covered, as is standard practice in all roller drafting. (p. 5).

Fig. 4. The front rollers have been decreased to mule size and the roller stands reconstructed to a more compact design. This has allowed the carriers to be brought close to front and middle rollers, and one middle roller to be used in place of two. The fixed rubber on the bottom front roller was unsatisfactory. The small parchment-covered top roller gave good spinning but very difficult piecing. (p. 9).

Fig. 5. The parchment wiper has been replaced by fixed flexible plush wipers. Similar wipers have been applied to the bottom carriers.

A plush-covered roller rubbing forwards has been applied to the bottom front roller. (p. 9).

Fig. 6. One line of carriers has been replaced by false twist tubes with very satisfactory results. (p. 10).
We were recently asked if we could measure the drag in ring roving under various conditions. The work has been completed, and it is thought that a description of the method used might be of general interest.

The instrument is the same in principle as that used for drag research in spinning at Torridon, and described in Publication No. 18, p. 6, and illustrated in Fig. 7 of that publication. The autographic attachment used there would have been difficult to operate under mill conditions, and as the object was to ascertain relative drag, a simpler modification was used.

The accompanying photograph shows the instrument in place on a roving frame. Like the earlier instrument, it "feels" the drag much as a spinner does with his finger. Fine wire arms A and B are fixed in a spindle C, the latter revolving in centres similar to those used for the balance wheel of a clock. Arm A is bent and carries a glass tube which bears against the roving in the same way as the spinner's finger. Arm B is screwed with a fine thread on which a weight D can be run out or in.

In order that the roving may be deflected exactly the same amount each time, a fixed pointer E is provided. In making a measurement the weight D is run out or in until A and E are exactly in line, or rather until A vibrates equally on each side of E. The distance of the weight from the centre of the spindle is then measured by a precision steel rule. The greater this distance, the greater the drag.

Had the drag been required accurately in grams, it would have been necessary to calibrate the instrument before removing it from the frame, dismantling the spindle and the top front roller. To enable the results to be given in approximate grams (accurate relative to each other) the instrument was calibrated after return to Torridon. A pulley was fixed in a similar position to the front roller and a piece of hard twisted roving run over this and through the instrument. To the lower end of this piece of roving, various weights in grams were attached, and the position of D necessary to bring A and E in line, noted. From these results the observations at the mill were converted to approximate grams.

For facilities to photograph the instrument in place on a ring roving frame, we are indebted to Messrs. John Priestman & Co., Ashfield Mills, Bradford.
Balloon Diameter in Cap Spinning

By
A. W. STEVENSON

January, 1928

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THE BRITISH RESEARCH ASSOCIATION
for the
WOOLLEN AND WORSTED INDUSTRIES

Balloon Diameter in Cap Spinning
By A. W. Stevenson

I. INTRODUCTION.
II. EXPERIMENTAL METHODS.
III. FACTORS AFFECTING BALLOON DIAMETER.
IV. TABLES.
V. A THEORY OF FORCES IN THE BALLOON.

ABSTRACT.
Measurements of balloon diameter were made primarily as a step towards building a theory of cap spinning, but are published for their practical utility in operating or selecting frames. The experimental work included the balancing of extra large bobbins.

Tables are given of balloon diameter when spinning and two-folding a wide range of counts at various speeds and with various cap diameters, balloon lengths and twists.

An approximate theory of the forces acting in cap spinning is developed and linked up with the tables.

I. INTRODUCTION.
The pitch of spindles desirable on a new frame for a given class of work or the amount of battering on the tins likely to occur on an existing frame are matters on which the experienced practical spinner has a pretty sound judgment. But should he wish to check or support his judgment from published figures we do not think he will find them anywhere in textile literature.

These measurements of balloon diameter are being published to fill this gap, but it is not for this reason that they were made. They are a step in the general line of cap spinning research which began with the observation of balloon shape and licking by the stroboscope and was continued in the long series of measurements of top and bottom drag. This line of research should eventually yield a complete theory of cap spinning and will clear up many of its puzzles and put its comparison
so most of the measurements published here are for a bobbin only a trifle smaller than the cap.

Count has a considerable effect but again not so large as might be expected. Change of count from 10's to 60's usually changes the balloon diameter in the ratio of 3 to 2. Fig. 6 shows the variation graphically. Twist has an effect the opposite of what might be expected, a faster delivery from the front roller giving a smaller balloon. A two-fold yarn makes a smaller balloon than a single yarn of the same equivalent count.

Early in the experiments it was thought that the height of the barometer had an appreciable effect. Theory shows that it must have some effect, but it is too small to measure with yarn of ordinary regularity.

IV. TABLES.

The contents of these tables may be summarised in terms of the variable quantities.

<table>
<thead>
<tr>
<th>COUNT.</th>
<th>All tables show counts of 10, 20, 40 and 60 except IV, which shows the two-folding of these counts.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPEED.</td>
<td>All tables show spindle speeds of 4,000, 6,000 and 8,000 r.p.m. (Nominal speeds without correction for slip, etc.).</td>
</tr>
<tr>
<td>CAP DIAMETER.</td>
<td>All tables show cap diameters of 1&quot;, 1.5&quot;, 2.0&quot;, 2.5&quot; and 3.0&quot;. The caps in each case were parallel.</td>
</tr>
<tr>
<td>BOBBIN DIAMETER.</td>
<td>For all tables except II the bobbin was just smaller than the inside of the cap, corresponding to a bobbin nearly full. For Table II the bobbin had in each case a diameter half that of the cap and was nearly empty.</td>
</tr>
<tr>
<td>BALLOON LENGTH.</td>
<td>Tables I to IV are for a balloon length of 8&quot;. Table V shows 7&quot; and VI shows 10&quot;.</td>
</tr>
<tr>
<td>TWIST.</td>
<td>The twist in all tables except III was as follows: Count ... ... 10 20 40 60 Turns per inch... 4.5 6 11 19 In Table III the twist was 50% harder.</td>
</tr>
<tr>
<td>TWO-FOLDING.</td>
<td>Table IV shows the two-folding of 10's, 20's, 40's and 60's. The turns per inch were the same as for spinning the single in each case.</td>
</tr>
</tbody>
</table>

The letter L in the tables indicates that the diameter of the balloon exceeded 5.8", the maximum diameter which could be measured. The letter B indicates that the material broke instead of spinning.
### Table I.

**Spinning. Normal twist. Bobbin nearly full. Balloon length 8\".**

<table>
<thead>
<tr>
<th>Cap diameter in inches</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Counts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-10's</td>
<td>3.4</td>
<td>4.2</td>
<td>4.9</td>
<td>5.7</td>
<td>L</td>
</tr>
<tr>
<td>1-20's</td>
<td>2.7</td>
<td>3.4</td>
<td>4.1</td>
<td>4.6</td>
<td>5.3</td>
</tr>
<tr>
<td>1-40's</td>
<td>2.2</td>
<td>2.9</td>
<td>3.4</td>
<td>3.9</td>
<td>4.4</td>
</tr>
<tr>
<td>1-60's</td>
<td>2.1</td>
<td>2.6</td>
<td>3.2</td>
<td>3.6</td>
<td>4.1</td>
</tr>
</tbody>
</table>

**Speed 4,000**

| **Counts**             |     |     |     |     |     |
| 1-10's                 | 3.5 | 4.3 | 5.0 | L   | L   |
| 1-20's                 | 2.8 | 3.6 | 4.3 | 4.8 | 5.5 |
| 1-40's                 | 2.4 | 3.1 | 3.6 | 4.1 | 4.6 |
| 1-60's                 | 2.2 | 2.8 | 3.3 | 3.8 | 4.3 |

**Speed 6,000**

| **Counts**             |     |     |     |     |     |
| 1-10's                 | 3.6 | 4.4 | 5.1 | L   | L   |
| 1-20's                 | 2.9 | 3.6 | 4.4 | 5.0 | 5.5 |
| 1-40's                 | 2.4 | 3.1 | 3.6 | 4.1 | 4.7 |
| 1-60's                 | 2.3 | 2.9 | 3.4 | B   | B   |

**Speed 8,000**

### Table II.

**Spinning. Normal twist. Bobbin nearly empty and half cap diameter. Balloon length 8\".**

<table>
<thead>
<tr>
<th>Cap diameter in inches</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
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</thead>
<tbody>
<tr>
<td><strong>Counts</strong></td>
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<tr>
<td>1-10's</td>
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<td>4.9</td>
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<td>1-20's</td>
<td>2.5</td>
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<tr>
<td>1-40's</td>
<td>2.1</td>
<td>2.4</td>
<td>2.9</td>
<td>3.3</td>
<td>3.7</td>
</tr>
<tr>
<td>1-60's</td>
<td>2.1</td>
<td>2.3</td>
<td>2.8</td>
<td>3.1</td>
<td>3.4</td>
</tr>
</tbody>
</table>

**Speed 4,000**

| **Counts**             |     |     |     |     |     |
| 1-10's                 | 3.2 | 3.5 | 4.2 | 4.7 | 5.1 |
| 1-20's                 | 2.7 | 3.0 | 3.6 | 4.0 | 4.4 |
| 1-40's                 | 2.3 | 2.6 | 3.0 | 3.4 | 3.8 |
| 1-60's                 | 2.1 | 2.4 | 2.9 | 3.2 | 3.5 |

**Speed 6,000**

| **Counts**             |     |     |     |     |     |
| 1-10's                 | 3.3 | 3.6 | 4.3 | 4.7 | 5.1 |
| 1-20's                 | 2.7 | 3.0 | B   | B   | B   |
| 1-40's                 | 2.3 | 2.6 | 3.1 | 3.6 | B   |
| 1-60's                 | 2.2 | 2.5 | 3.0 | 3.3 | 3.7 |
### TABLE III.

**Spinning.**
**Bobbin nearly full.**

<table>
<thead>
<tr>
<th>Cap diameter in inches</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
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<tbody>
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<td>1-60’s</td>
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<tr>
<td>1-60’s</td>
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</table>

**Twist 50% above normal.**
**Balloon length 8”.**

<table>
<thead>
<tr>
<th>Cap diameter in inches</th>
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<tr>
<td>Counts</td>
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<tr>
<td>1-60’s</td>
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**Speed 4,000**

<table>
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<table>
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<th>Speed 8,000</th>
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</thead>
<tbody>
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### TABLE IV.

**Two-folding.**
**Bobbin nearly full.**

<table>
<thead>
<tr>
<th>Cap diameter in inches</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
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<tr>
<td>2-60’s</td>
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</tr>
</tbody>
</table>

**Normal twist.**
**Balloon length 8”.**

<table>
<thead>
<tr>
<th>Cap diameter in inches</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
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<th>3.0</th>
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<td>2-60’s</td>
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**Speed 4,000**

<table>
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<td>3.0</td>
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<td>2.5</td>
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**Speed 6,000**

<table>
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**Speed 8,000**

<table>
<thead>
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<tr>
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<td>3.3</td>
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<td>2.7</td>
</tr>
<tr>
<td>2-60’s</td>
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</table>
FIG. 3.
### Table V.

**Spinning.**

<table>
<thead>
<tr>
<th>Cap diameter in inches</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
</tr>
</thead>
<tbody>
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<td></td>
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<tr>
<td>1-10's</td>
<td>3.2</td>
<td>4.1</td>
<td>4.8</td>
<td>5.5</td>
<td>L</td>
</tr>
<tr>
<td>1-20's</td>
<td>2.6</td>
<td>3.4</td>
<td>4.0</td>
<td>4.6</td>
<td>5.1</td>
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<tr>
<td>1-40's</td>
<td>2.1</td>
<td>2.8</td>
<td>3.2</td>
<td>3.9</td>
<td>4.2</td>
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<tr>
<td>1-60's</td>
<td>2.1</td>
<td>2.6</td>
<td>3.1</td>
<td>3.6</td>
<td>4.2</td>
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</tbody>
</table>

**Normal twist.**

<table>
<thead>
<tr>
<th>Balloon length 7&quot;</th>
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</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Speed 4,000**

### Table VI.

**Spinning.**

<table>
<thead>
<tr>
<th>Cap diameter in inches</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-10's</td>
<td>3.3</td>
<td>4.3</td>
<td>4.9</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>1-20's</td>
<td>2.7</td>
<td>3.5</td>
<td>4.2</td>
<td>4.8</td>
<td>5.3</td>
</tr>
<tr>
<td>1-40's</td>
<td>2.3</td>
<td>2.9</td>
<td>3.4</td>
<td>4.0</td>
<td>4.5</td>
</tr>
<tr>
<td>1-60's</td>
<td>2.2</td>
<td>2.8</td>
<td>3.3</td>
<td>3.8</td>
<td>4.2</td>
</tr>
</tbody>
</table>

**Normal twist.**

<table>
<thead>
<tr>
<th>Balloon length 10&quot;</th>
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</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Speed 6,000**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>
V. FORCES IN THE BALLOON.

When no data has been published on so readily measurable a dimension as the diameter of the balloon, it is not surprising that little attempt has been made to outline a theory of the forces acting in cap spinning other than is done in Priestman's Worsted Spinning, p. 73.

Ring spinning is little better off. Cotton spinning text books make calculations on the subject, but in some cases the writers ignore such elementary principles of mechanics as Newton's Laws of Motion and actually calculate the force necessary to keep a frictionless body in steady motion.

In cap spinning no one seems to have even expressed surprise at a fact which must be well known to practical spinners that increase of speed from 5,000 to 9,000 r.p.m. hardly affects the diameter of the balloon and that increase in balloon length has also little effect. When the front rollers are run more slowly to give a harder twist the balloon, instead of shrinking, becomes larger in diameter. Why does this half-loop of yarn settle for itself a definite diameter of path and swing round in it, skipping rope fashion, winding on just as much as is delivered by the front rollers, changing the diameter of its path but slightly when the speed is doubled and swinging in a smaller circle when more material per minute is fed into the loop?

The following discussion of the forces may be of interest, though it is only a rough approximation. The forces are so complex and interdependent that a precise mathematical discussion is very difficult indeed. Suppose a bobbin on a spindle has one end of a piece of yarn attached to it as shown in Fig. 7, while the other end is fed forward or drawn back through a guiding eye or twizzle. For the purpose of discussion we shall neglect the fact that twist would soon accumulate to such an extent as to break the yarn and for the time being we shall neglect the presence of the cap.

Suppose the bobbin and yarn to be spun round in a vacuum. The yarn, under the action of centrifugal force, will fly outwards in a radial plane as shown by A B D in Fig 7. Consider a very small portion of the yarn such as δl. This element of yarn will be pulled outwards by a force proportional to its mass (or weight), the square of its angular velocity (or r.p.m.) and to the radius at which it is rotating. If Fig. 7 be turned on its side it will be seen that the yarn is quite analogous to a chain hanging between two points A and D. Each link in the chain would be pulled down by gravity just as the element of yarn is pulled outwards by centrifugal force. The curve taken up by the chain is known mathematically as a catenary and the yarn will take up a somewhat similar form. But the important point for us at the moment is that the only forces on the yarn are in a radial direction and whatever its curve, it will lie entirely in a radial plane and will have no tendency
to wind on the bobbin. If more yarn is fed through the eye the balloon diameter will increase, say to A C D, and if yarn is drawn back it will decrease again to A B D but will always remain radial as shown in the plan view.

If now air be admitted to the chamber in which the loop is rotating the forces on it will no longer be entirely radial. Each element in addition to the centrifugal force already mentioned will have acting on it an aerodynamic force due to its motion, and as it is approximately cylindrical this force will be directly opposite to its direction of motion or tangential to the circle in which it is rotating. The magnitude of the force will be approximately proportional to the length and diameter of the element, to the square of its angular velocity and to the square of the radius at which it is rotating.

Suppose the loop while running in a vacuum has been a small one as at B in Fig. 8. Admission of air will at once cause the loop to swing back to some position such as E, like a chain in a strong lateral wind. If now more yarn is fed into the loop it might widen as shown by the dotted line and would probably do so if both centrifugal force and air resistance increased in the same way with increasing radius. But while the former increases as the radius, the latter increases as the square of the radius, i.e., much more rapidly than the former, and the loop will lean farther back, say to F. Further supply of material will allow the loop to lean still farther back as at H but a still further supply will produce no increase in balloon diameter because the loop is now tangential to the bobbin surface at A. Any tendency to increase the diameter of the balloon beyond H and lean farther back would simply wind material on to the bobbin along A M and change the balloon position from A H to M J.

This represents the normal spinning condition in which the bobbin winds on as much as is delivered by the front rollers and the diameter of the balloon remains constant, except that in winding on the bobbin from A to M the yarn would lay itself in a steeply spiral fashion and rapidly decrease the length of the balloon. It is prevented from doing so in practice by the cap edge which guides it on the bobbin in a relatively flat helix on a cylindrical or conical surface according to the setting of the Scaife motion. The friction of the yarn on the cap edge would require an investigation all to itself. When the diameter of the bobbin is nearly equal to that of the cap (as when the bobbin is nearly full) this friction has probably little effect on the forces in the yarn, but when the bobbin diameter is small it may be the leading factor in deciding whether or not spinning can take place.

The increase in balloon diameter with increased twist may be explained as follows. As the weight per unit length or the count is still the same, depending on the roving and the draft, the centrifugal
force on a small element such as that considered will be the same. But with a harder twist the diameter of the yarn will be less and the air resistance less. Referring to Fig. 9, the yarn, which had been at H as in Fig. 8, would, if it remained at the same diameter, lean less far back as at K. But it would no longer be tangential at A and therefore would not wind on, corresponding to G in Fig. 2. More yarn will therefore be absorbed in the balloon and its diameter increase to say L before winding on again takes place.

The variation of balloon diameter with count can be explained along similar lines. An increase of count with the same relative hardness of twist would produce an increase in weight and therefore of centrifugal force proportional to the square of the diameter of the yarn. The corresponding increase of air resistance would only be proportional to the diameter of the yarn. Thus centrifugal force increases more rapidly than air resistance with increasing count and therefore the diameter of the balloon increases.

In all the above discussion the speed in r.p.m. has been assumed to be constant, and it has been shown that the diameter of the balloon depends on the relationship of the centrifugal and aerodynamic forces acting on the yarn. Both these sets of forces will vary approximately with the square of the angular velocity and thus their relationship will be unchanged by a change in r.p.m. It thus seems quite reasonable that balloon diameter should be little affected by change in spindle speed. Such variation as really exists is probably due to the effect of the cap edge, not as yet investigated, and to the fact that while centrifugal force varies rigidly with the square of the speed, air resistance only does so approximately.

Along the above line of argument an increase of density of the air such as is indicated by a rise in the barometer should increase the air resistance without affecting the centrifugal force and therefore decrease the balloon diameter. Careful comparative tests over a wide range of weather have failed to reveal a measurable difference. This is the more interesting as some early experiments were interpreted as showing a distinct difference. When examining the effect of speed on balloon diameter three sets of results on different portions of the speed range, made on different days, showed excellently smooth curves which did not join up with each other. After some consideration barometer height was looked on as a possible cause and the readings for the three days were obtained from the records of the Physics Department. The discrepancies between the results fitted very well with the variation in atmospheric density. Confirmation was sought by getting the whole range of speed on days of high and low barometer, but the search for a measurable difference was fruitless. The exact conditions of the original experiments were then re-examined and it was found that there had been a variation in twist in the three instances. At that
early stage it had not been realised that twist could play so important a part in balloon diameter, but the application of results obtained in the interval showed the discrepancies to be much more probably due to this than to variation in the height of the barometer.

The precise effect of humidity and air density will be the subject of a separate investigation.

Further work on balloon diameter will probably be preceded by research on the forces concerned such as the friction at the cap edge and air resistance to the moving yarn. An instrument reading the ratio of centrifugal force to air resistance on a short length of yarn over a wide range of speed has already been constructed and approximate measurements made, but some refinement of design is necessary for accurate work.

CONCLUSION.

Of the proximate aspect of this research little need be said. The tables are there for use as may be required. From the point of view of fundamental spinning research, it is a link in a chain which began with the observation of licking and was continued in the measurement of top and bottom drag and minimum bobbin diameters. The next links will probably be the measurement of air resistance and cap edge friction and accurate observation of the yarn curve. It should then be possible to co-relate the measurements by graphical or analytical methods and to construct a general theory of what happens in cap spinning.

The whole of the experimental work, including the making of the apparatus, was carried out by Mr. Sidney Townend, Junior Assistant in the Engineering Department.

REFERENCES.
1. Observation of Licking. Publication No. 18.
5. Dynamic and Static Balancing. Hammond. (Machinery Publishing Co.)
Paper read at the Meeting of the British Association for the Advancement of Science, Leeds, September 1st, 1927.
33—WORSTED SPINNING RESEARCH
By Howard Priestman and A. W. Stevenson, B.Sc. (Edin.), Wh. Ex.
(British Research Association for the Woollen and Worsted Industries)

INTRODUCTION

Before dealing with research, a very brief survey of the processes of worsted manufacture may be of interest. While the woollen industry is frequently carried on from raw material to finished cloth within the same mill gates, the worsted industry is as a rule divided into a number of sections—top-making, combing, spinning, weaving, finishing, dyeing.

The top-maker does not actually make tops, but selects and buys the wool from which they are to be made, putting the actual work out on commission to a comber. The raw wool is taken by the comber, scoured to remove sand and natural grease, carded to separate the fibres from each other, and incidentally remove vegetable matter, combed to straighten the fibres and separate the short material (rejected as "nools"). The long fibres, after further straightening by gilling, form a soft, twistless rope about one inch diameter, wound in a ball about eighteen inches diameter, and known as a "top."

The tops are bought by the spinner, given a preliminary gilling process, drawn smaller and smaller in about ten stages, and finally spun into yarn, the last drawing stage being on the spinning frame itself. Spinning is most commonly on the cap principle, but the flyer frame and the mule have each spheres peculiarly their own, and the ring frame is being considered as a competitor of both the cap frame and the mule. After spinning, the yarn is usually two-folded on cap or ring frame, and is delivered in cheeses or hanks, on bobbins or on warp beams.

The weaver, or as he is more usually termed the "manufacturer," buys the yarn in one form or another, and makes from it serges, gaberdines, repps, linings, or other of the typical Bradford cloths. These cloths he either sells "in the grey" to a merchant, who has them finished and dyed, or he himself puts them out to dye and finish and sells them ready for the market.

A large quantity of yarn finds its way, not to the loom, but to the hosiery frame, and a smaller quantity is absorbed by the weaver of fine woollens for use alongside his own yarns.

The research work described in this paper has been concentrated round the cap spinning frame, the essential parts of which are shown in Fig. 1. Roving from a bobbin is drawn in by rollers AB at, roughly, one inch per second. Rollers CD have a surface traverse of about six inches per second, so that the material delivered by them has about one-sixth the weight per unit length that it had when taken in by AB, the fibres having slipped over each other to attain this fineness, or fewness of fibres in the cross-section. The ratio of the surface speed of rollers CD to the surface speed of rollers AB is the "draft."

From CD the material passes through a guiding pot-eye and then to the spindle, which puts in twist and winds the yarn on a bobbin. As a matter of fact the twist runs back to the nip of the rollers CD as fast as it is put in by the rotation of the bobbin. The spindle in the cap spinning
mechanism is stationary or "dead," and carries the cap, which is also stationary and has as its sole purpose the guiding of the yarn to its right place on the bobbin. Around the stationary spindle is a brass tube (see Fig. 9); fast on the brass tube is a whorl or pulley driven by a tape and in turn driving the bobbin by dogs on its upper face. In addition to rotating on the spindle to twist and wind the yarn, the brass tube, whorl, and bobbin reciprocate on the spindle to distribute the yarn over the length of the bobbin.

The behaviour of the cap spindle has been studied in various aspects by specially designed instruments with interesting and useful results. Experiments on the drafting or drawing operation have led to an almost revolutionary change in ideas of what is and is not possible in the drawing of wool fibres. Applied to the spinning frame, the new ideas promise to eliminate the two largest of the previous drawing processes, and applied to the drawing processes themselves should still further reduce the plant necessary to convert tops into yarn.

**DRAFTING**

The rollers shown on Fig. 1 and already referred to, may be taken as typical not only of the spinning frame but of five or more preceding processes in the Bradford system of yarn production, variously named drawing, slubbing, finishing, reducing or roving (Fig. 4). In all these processes the material is extended or drafted, as explained in the introduction, and this
draft seems to have very definite limits for a given wool and a given mechanism. If a certain wool gives its best results at a draft of six on the mechanism shown in Fig. 1, a draft of either 4 or 8 would give a product so irregular as to be useless, and an attempt to draft 10 would probably give no continuous product at all, the material being delivered from the front rollers in lumps.

Just what underlies these very definite limits to drafting is still a matter of speculation, and will certainly be the subject of future research. The limits, while depending mainly on the wool, are by no means independent of the mechanism. For instance, a wool which would be given a draft of six in all the machines of a Bradford set of drawing would probably be drafted 4½ in the porcupine machines of a French set, and 10 on the French rule.

The fact that the permissible draft depends on the kind of wool is expressed in a trade formula which says that the draft should be equal to the fibre length. Though it happens to be fairly near the mark, this formula is obviously a mere coincidence, as a different length unit would make the same wool require a different draft. In scientific terms, the formula has not the same dimensions (length, mass, and time) on each side, and therefore cannot be a rational one. On one side there is a length and on the other a ratio or pure number of no dimension. Further, wool of less than one inch length would, according to the formula, require a fractional draft, that is to say, the front rollers would have to run slower than the back rollers.

Strangely enough, a similar formula finds acceptance on the Continent, but in this case the average length is used instead of the maximum length, which roughly but not entirely compensates for the change from inches to centimetres. If the average length is 60 per cent. of the maximum length, this rule will give a draft about 1½ times that given by the English rule. For merino wools the best draft is probably midway between those given by the two rules. On this side the matter is usually explained by saying that a skilful spinner can go better than the rule, while one French text-book blames electrification for the failure of wools to come up to the centimetre rule. Needless to say, no explanation is necessary of the failure of wools to comply with irrational formulae. The surprising thing is that the formula get so near the mark as they do.

While it is quite likely that future research will materially alter the limits of drafting as described above, we have as yet found no success in that direction. In all our modifications of roller drafting mechanism we have found the best draft for a single pair of rollers to be not greatly different from present trade practice. But we have found great promise of increasing the effective draft on each machine by making two drafts in succession, previously believed by the trade to be impossible, and virtually so with the usual mechanism.

Reversal in Drafting

In the past, as soon as material has been given a draft of, say, six, the machine winds it on to a bobbin before putting it through another operation, the very fact of unwinding from this bobbin making it necessary that the second drafting should take place in a direction which is the reverse of the first.

Apparently the necessity for this unwinding has induced people to believe that no other method is possible, and on this opinion they have
based the theory that wool cannot be drafted twice in the same direction with any success. Priestman, in 1906, pointed out that the 3-roller systems as used in cotton did actually give two successive drafts, and formed an exception to the practice of reversal for each draft. The first experiment of this series was therefore to unwind roving from one bobbin to another, and to spin it in the ordinary way. By this method two consecutive drafts were made in the same direction, yet this made practically no difference to the levelness of the yarn.

**Successive Drafting**

It was a very short step from the above experiment to that suggested by Priestman, based on the fundamental difference between cotton spinning and the spinning of worsted yarn. In the former the back and front rollers are separated by nearly double the length of the fibre, and the intermediate pair of rollers hold the fibres so tightly that they form an intermediate grip dividing the draft into two parts; the first draft being about 2 and the second 8. Though the three or four lines of rollers in a cotton frame are superficially similar to those on a worsted frame, there is a radical difference. In worsted spinning as usually practised it may be said that the intermediate rollers or carriers do not grip the fibres at all; they only control the twist, and thereby steady the movement of the short fibres, the control of which makes worsted spinning so much more complicated than cotton spinning.

The problem before the writers was therefore to endeavour to apply the principle of successive drafts, or a heavily loaded middle roller, to worsted, and at the same time to maintain control of the short fibres. Figs. 2 and 3, described in detail later, are typical arrangements.

**Carrier Lapping**

So long as carriers were used in the second draft, great trouble was experienced with fibres lapping themselves round the carriers, and to a lesser extent round the middle and back rollers. Such laps seem to begin with one stray fibre, which usually passes round the roller two or three times before attracting others. Once it begins doing so the accumulation usually grows more and more rapidly until it absorbs the whole of the roving, thus breaking down the "end." Much less frequently the lap breaks down at an early stage, and passes into the yarn as a "slub."

Many types of carriers variously adjusted were tried, also wipers of many designs, without getting a consistently good spin. The difficulties would seem to be overcome for a day or two, but a change in the atmosphere, condition of the rovings, or something quite intangible would bring a recurrence of the trouble. No real progress was made until the bold step was taken of dispensing with carriers altogether, and using a false twist tube in their place. There were, of course, no carriers on which fibres could lap, but what was more surprising was that the lapping on the middle and front rollers ceased also, and yarn spins on the new system in a way which would be entirely satisfactory to any spinning manager.

**False Twist**

Some explanation of false twist may be of interest to those unacquainted with the principle. It is usually applied to a sliver or roving by passing it through a rotating tube which tends to put in permanent twist, but is prevented from doing so by a roller nip just ahead. Such a tube gripping the material fairly tightly by a jaw is an essential feature of the only successful
woollen spinning frame, while rotating funnels of various designs are frequently used to smooth down and strengthen the slivers coming from cards, gill-boxes, and combs.

In its present application it has probably two distinct effects, smoothing down and entwining the projecting fibres and improving the drafting by putting a little twist (comparable with usual roving twist) into the roving during the first half of the second ratch.

An interesting experiment on the action of the tube was made by running down together a black and a white roving, so that any twist put in by the false twist tube could be observed. The drafted material was taken by hand from the front rollers instead of being spun, so that any twist passing through the front rollers could also be observed. When the rollers were started with the false twist tube standing the black fibres remained parallel with the white ones all the way down. When the false twist tube was started, at once about one-and-a-half turns of right-hand twist appeared behind the tube, and a similar amount of left-hand twist in front of it. But while the twist behind remained there, that in front slowly passed through the front rollers, the black being noticed as crossing, re-crossing, and crossing again. No further change took place, the sliver between the middle rollers and the twist tube always having about one-and-a-half turns of temporary twist, and that between the tube and the front rollers being parallel. The material delivered by the front rollers was also quite parallel.

**Twist in Roving and Fibre Control**

The success of the false twist tube without carriers, together with accumulated study of drafting processes, have led the writers to a conception of the action of carriers rather different from that frequently held. A common impression seems to be that carrier rollers by their weight and slow surface speed press on the short fibres and hold them back. That they do act in this way is proved by their successful use in the spinning, on mule or frame, of twistless rovings produced by the French process, but in dealing with rovings produced on the Bradford system there is another and more important function, that of retaining as long as possible during drafting the twist put into the roving in the previous process.

A simple experiment shows this action clearly. If a marl roving with, say, one turn per inch be passed through the usual drawing and carrier rollers, it will be seen to have practically its full twist while between the back roller and the back carrier, but between the front carrier and the front roller it is almost devoid of twist. Simple theory would say that it had there the original twist divided by the draft, but actually it seems to have less than this. In the space between the carriers it has about half its original twist. If now the back carrier be lifted out, there will be a slight redistribution of twist which might pass unnoticed, but if the front carrier is also lifted out there is an instant and striking redistribution. The twist which is normally held back by the carriers now distributes itself, binding the fibres together too tightly at the front and too loosely near the back roller.

**False Twist Tubes**

Although the false twist tubes do not apply any pressure, they nevertheless control the short fibres by applying twist. A single false twist tube was observed to put in, as might have been expected, more twist near itself than near the back roller, the cross section of the sliver diminishing as it
### Plant Lay-out for Botany Worsted Spinning

<table>
<thead>
<tr>
<th>CAN GILLS</th>
<th>SPINDLE GILLS</th>
<th>DRAWING BOX</th>
<th>DRAWING</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 HEADS</td>
<td>4 SPINDLES</td>
<td>6 SP.</td>
<td>8 SP.</td>
</tr>
</tbody>
</table>

#### Machine Arrangement

- **2nd Finishers**
  - 48 SPINDLES

- **1st Finishers**
  - 16 SPINDLES

<table>
<thead>
<tr>
<th>REDUCERS</th>
<th>96 SPINDLES</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>DANDY ROVERS</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>288 SPINDLES</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>SPINNING FRAMES</th>
<th>2000 SPINDLES</th>
</tr>
</thead>
</table>

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**Fig. 4**—With usual drafting on spinning frame.

**Fig. 5**—With new drafting on spinning frame.
progressed forwards. A second false twist tube was added, the two tubes being approximately in the usual positions of the carrier rollers, and being so adjusted that a marl roving, which would otherwise have emerged twistless from the middle rollers, had in its various stages twist similar to that in a twisted roving being drafted in the usual way with carriers. The twist inserted by a false twist tube was found to depend on its speed and the angle which the roving made with the axis of the tube at either entry or exit. If the roving came straight down in line with the axis of the tube, the twist inserted was negligible. The angles used have ranged from $10^\circ$ to $30^\circ$, but much larger angles can be used if found desirable.

The two short false twist tubes mentioned above were soon replaced by a single long tube, the roving making an angle with the axis of the tube at both entry and exit, as shown in Fig. 2. In order to observe the effect of the exit angle on the roving inside the tube (corresponding to the roving between the carriers in ordinary drafting), some tubes were made with openings in the sides. Very satisfactory spinning has been carried out on wool of about 70's quality at drafts of about 30. Figs. 4 and 5 show how the plant required for botany yarn production would be affected by the application of the new drafting on the spinning frames.

For crossbred the single long tube, with its two points of twist insertion, was found to be insufficient, which is not surprising when it is remembered that such material is usually spun with three rows of carriers. A frame was fitted up with two rows of tubes as shown in Fig. 3, corresponding to four lines of carriers. With this arrangement crossbred roving of about 50's quality and 8-inch fibre length has been spun with a draft of 103, the yarn being passed by many competent judges as satisfactory.

To prevent nicking of the front rollers the twist tubes are traversed in the same way as the roving guides in an ordinary frame. In addition to this mechanical traverse, each tube can be moved to one side by a slot device for threading purposes, or removed altogether for cleaning.

While we have found the difficulties surrounding carrier rollers in the second draft for the time being insurmountable, we are well aware that they would be more acceptable to the trade than false twist tubes. It is quite likely that the difficulties may yet be surmounted either by some different mechanical arrangement or by a different treatment of the fibre in its earlier stages.

Atmospheric conditions are also important, but here our experiments have been contradictory and inconclusive. We are certain that a good or bad spinning atmosphere, whether for ordinary drafting or that under consideration, cannot be entirely described in terms of temperature and bulb difference, but what the others factors are we do not yet know.

**SPINNING**

Cap spindles run at speeds from 5,000 to 9,000 r.p.m. The first essential for the study of such a process is a suitable stroboscope. The conditions to be fulfilled are arduous. The speed is much higher than in most mechanisms; the valve gear of an aero engine, for instance, seldom makes more than 1,000 cycles per minute. The definition required is high, the yarn under observation being about 0.005 in. (0.1 mm.) in diameter. The speed must be capable of fine adjustment to synchronise with the speed of the spindle, a speed which proved to be even less steady than was anticipated.
Finally, if the observations are to be carried out not only in the laboratory but also in mills, the instrument must be sturdy, portable, and as far as possible self-contained.

All the instruments at the time (1922) available were considered, but none were found suitable. Those consisting of a reciprocating or rotating shutter controlled by a tuning fork had only a few definite speeds, and were not capable of fine adjustment when running. They also had a small aperture requiring accurate light concentration. One of the early Neon lamp types was tried without success, the contact breaker, though very successful
on petrol engine work, being too heavy to drive at the high speed required. H. J. W. Bliss suggested the reflecting of an arc lamp beam by a disc mirror revolving about one of its diameters, and the writers developed from this a stroboscope which amply fulfils the conditions laid down above. The definition is such that newspaper pasted on a bobbin one inch diameter, and revolving at 9,000 r.p.m., can be read. The instrument is driven from the spinning frame, and thus follows any variation in general speed, the ratio of the drive having both coarse and fine adjustments. Except for electric supply to the arc lamp (alternatively an oxy-acetylene outfit) the instrument is self-contained. It forms its own stand, is easily handled, and takes up very little room in the spinning frame "gate" (Fig. 6).

With the instrument the behaviour of the balloon in various conditions has been observed, and known peculiarities explained. For instance, the tendency of the balloon to "lick" the lower portion of the cap, well-known but previously difficult to understand, now seems to be the only reasonable thing for the yarn to do when the bobbin is nearly full. The instrument has also been used, as will be explained later, for the observation of instruments designed to measure the tension in the yarn as it winds on the bobbin, but its most important practical use has been the accurate observation of variations in spindle speed. Small variations in the absolute speed of the spindle are not of great importance, but variations in the speed of the spindle relative to the rest of the machine are of great importance, as they produce variations in the twist of the yarn. When the spindles of a frame are lit up by the stroboscope any variation of speed from spindle to spindle is obvious to the eye. If the rate of flashing is synchronised with the majority of the spindles, any spindle running slow appears to move backwards, and any spindle running fast appears to move in its real direction. To compare the mirror speed with the speed of the rest of the machine, and thus with an ideal spindle, a marked band of paper is fixed round the main driving cylinder. If the cylinder were 10 in. diameter driving on to a 1 in. diameter whorl, this band might be marked out with 10, 9, and 8 divisions. When the row of 10 appeared stationary the mirror would be flashing at the speed of an ideal spindle. When the row of 9 appeared stationary it would be flashing at the speed of a spindle losing 10 per cent. on its nominal speed. Similarly the row of 8 would correspond to a 20 per cent. loss. The bands actually in use are much more finely divided to get more precise observation, and also because the main cylinder diameter is seldom an exact multiple of the whorl diameter. The accuracy of measurement of the speed ratio is within $\frac{1}{2}$ per cent.

Since the mirror stroboscope was developed others have come on the market, and some have been investigated. We have an Ashdown rotoscope and find it useful. The definition is not as good as with the mirror instrument. The instrument is much more portable and requires a strong general light instead of partial darkness, a convenience for mill use. On the other hand, only one observer sees the stroboscopic image, and must himself carry out the synchronising. With the mirror instrument simultaneous observations of the same or different events can be made by different observers, and demonstrations can be given to persons unskilled in its manipulation.

**Drag**

One of the most important factors in spinning is the "drag" or tension in the yarn after it leaves the front rollers. If this tension is too
high for the count and quality being spun at the moment, the yarn will break frequently and require to be "pieced." Not only does this mean labour cost, but the most skilfully made piecing will show in the finished cloth.

This tendency to break down, usually referred to as a "bad spin," is met and counteracted in various ways, such as reducing the speed, hardening the twist, shortening the balloon, or modifying the cap or bobbin sizes. Unfortunately all these, with the exception of alteration of balloon length, increase costs in one direction or another.
This all points to the need for accurate numerical information on the factors influencing drag. Instruments have been devised by the writers for the exact measurement of drag both as the material leaves the front rollers (CD on Fig. 1) and as it is being wound on the bobbin. The former has usually been referred to as "top drag" and the latter as "bottom drag."

The most recent form of top drag measuring instrument is one developed for measuring drag in ring roving under mill conditions. It is shown in Fig. 7. Fine wire arms, A and B, are fixed in a spindle C, the latter revolving in centres similar to those used for the balance wheel of a clock. Arm A is bent, and carries a glass tube which bears against the roving or yarn much as a spinner feels the drag with his finger. Arm A is screwed with a fine thread on which weight D can be run out or in. In order that the roving may be deflected the same amount each time a fixed pointer E is provided.

![Fig. 8](image)

In making the measurement the weight D is run out or in until A and E are exactly in line, or rather until A vibrates equally on each side of E. The distance of the weight from the centre of the spindle is then measured by a precision steel rule. The greater this distance, the greater the drag.

A similar instrument has been used recently for drag measurements in comparative tests of ring and cap spinning, but for thorough research work on drag a more elaborate form was necessary. The arm corresponding to B was connected to a pen mechanism which drew a diagram such as shown in Fig. 8. Calibration was made by removing the spindle and running through a length of yarn with known weights on the end. The scale derived from this calibration is seen on each side of the diagram in Fig. 8.

Measurement of bottom drag was a much more difficult problem, as the bobbin on to which the yarn is being wound is rotating at anything up to 9,000 r.p.m., and the yarn itself in its balloon is swinging round at very little less. An indirect method was first tried, the yarn being spun on an accurate parallel bobbin in a single layer. An exact number of turns were marked and the yarn unwound alongside a vertical scale. The unwound length of yarn was then loaded until it had the same length as when on the bobbin. The method was a complete failure through hysteresis effects in the yarn.

A return was then made to direct methods by the apparatus shown in Fig. 9. On the left-hand side is a cross-section of the ordinary cap spinning tube. As explained in the introduction, this runs on a stationary spindle, driven by a tape on the whorl D, the bobbin B being driven in turn by dogs C on the upper face of D.

On the right-hand side of the figure is an equivalent spinning tube and bobbin designed to allow the tension in the yarn to be measured. As before, A is the brass tube and D the whorl for the driving tape, E is a flywheel added to reduce the momentary speed fluctuations which occur in all tape
driving each time the joint passes the whorl. The bobbin B is a light steel shell held clear of tube A by ball bearings, and carried round by a fine rubber cord F. This rubber cord stretches more or less according to the drag on the yarn as it is being wound on to the bobbin. Round the bottom flange of the steel bobbin is a divided scale on which can be seen by stroboscopic lighting the amount by which the pull of the yarn makes the bobbin lag behind the brass tube, whorl, and flywheel.

Calibration is by the apparatus shown in Fig. 10, which is virtually a rope brake as used in the measurement of horse-power, but carried out in silk and aluminium for the measurement of forces round about 10 grams (½ oz.). A silk cord GH was passed round the bobbin B, and an aluminium grooved pulley J, the grooved pulley being supported in pivot bearings. To it was fixed an aluminium wire K, on which a brass weight L could be set at any desired radius from the centre of the pulley. B is, of course, running, and J is stationary except for a slight floating movement, and it is immaterial whether the cord slips on B or J, or partly on each. The drag on B is the difference between the pull on G and that in H, and it is also this difference that is available for supporting wire K and weight L in a horizontal position.

Closely associated with the tension in the yarn as being spun is the minimum diameter of bobbin on to which the yarn will spin, and also the
diameter of the balloon under various conditions. Both have been the subject of extensive series of measurements, but as the apparatus used was simple and of obvious design, it need not be described here.

REFERENCES

Publications of the Research Association for the Woollen and Worsted Industries.

No. 15—Variations in Cap Spindle Speed and Stroboscopic Observation of Spinning.
No. 18—Observation of Licking and Some Methods of Measuring Drag in Cap Spinning.
No. 37—A Note on Cap and Bobbin Dimensions and the Reduction of Doffings, also a Description of an Improved Form of Stroboscope.
No. 40—Drag or Tension in the Yarn in Cap Spinning.
No. 61—Higher Drafts in Bradford Spinning.
No. 76C—An Instrument for Measuring Drag in Ring Roving.

Textile Institute Diplomas

Election to Fellowships and Associateships of the Institute have been completed as follows since the publication of the previous list—

FELLOWSHIPS

BASTARD, William (Leicester).
GAUNT, Gerald Rayner (Farsley, near Leeds).
PICKARD, Robert Howson (Wilmslow, Manchester).
TOWNSEND, Emile Henry (Bradford).
WITHERS, John Charles, (Didsbury, Manchester).

ASSOCIATESHIPS

SLATER, William Henry (Oldham).

REVIEWS


According to the preface, this book is intended as a work of reference serviceable not only to professional chemists, but also to all classes of the community, including medical practitioners, pharmacists, barristers, brokers, manufacturers, and merchants.

It is remarkably up to date, but the author does not always give full consideration to the non-chemical reader. For instance, what the average man now calls "Ethyl" is designated "Ethyl gasoline." It is probably excusable that the new solvent "Cellosolve" (ethylene glycol mono-ethyl ether) has not been included in the Encyclopaedia, but one would expect to find "Nitrate of Iron" which, although a misnomer, is the name under which a commodity is often bought and sold. Inaccuracies are perhaps unavoidable, even in a fourth edition; still there is no excuse for confusing "zymase" with "invertase," or the statements (p. 274) that zyme is more active than yeast cells, and (p. 377) that samples (of indigo) are said to contain 70 per cent. of glucose.

Fortunately there are copious references to standard works and papers where more authoritative information can be obtained, so that if care is taken to eliminate inaccuracies from future editions the Chemical Encyclopaedia will become a very useful work of reference.

R. GAUNT

A Treatise on Advanced Worsted Drafting. H. Edmondson. Published by Ernest Benn, London.

Theworsted spinner’s notebook is usually jealously guarded and handed down to the next-of-kin. The industry owes a debt to a manager who is willing to publish for the benefit of the trade in general the data accumulated and the methods developed in the course of a long experience. It is as such a record that the book under consideration has its chief value. The reader will look in vain for theory or speculation, but will find abundance of facts presented in a readily accessible form. Very full tables are given of almost everything an overlooker can require, so that if he is content to accept the author’s experience he need make few calculations. On drafts and doublings alone there are over 200 tables, each giving ends up, drafts, draft wheels, twist wheels, revolutions of front roller and weight of sliver for producing a particular count from a particular quality, the counts ranging from 64’s to 60’s and the qualities from 28’s to 64’s. Further tables give the number of roving and reducing spindles required for an equally wide range of conditions, the number of such spindles per operative, their speed, suitable roving twists, bobbin sizes, etc. Further pages give specifications of the machines required for drawing all classes of wools. Unfortunately in all these tables and specifications there is much duplication. Perhaps in a future edition the author may be able to condense his tables and give us a little more theory and some reminiscences, such as he must have, of how he has overcome the difficulties which occur from time to time in every spinning mill. Such
things as electrification of fibres and the effects of weather on drawing are not even mentioned, nor is the every-day question of drag and the choice of drag washers. Draft is made proportional to the mean length of the fibres ascertained in a particular way, this length being multiplied by a constant varying from 1¼ to 2½, according to the quality and the process. We cannot agree with the author that logarithms are more useful than the slide-rule in the ordinary hurly-burly of mill life, and would suggest that the habitual use of the slide-rule might have prevented the unnecessary precision with which almost all the figures in the book are given. 538-838 Roving spindles required under certain conditions might have been given as 540, and the pitch of screws in a gill-box as ⅜ inch instead of 10-58 sixteenths of an inch.

Two points of interest which are frequently overlooked are emphasised throughout the book. The first is that there is a take-up due to twist in every process which if neglected will throw draft and doubling calculations out. This take-up the author places rather erratically at 2½ or 3 per cent. for each process, which would seem from the present writer's experiments to be high, but it is certainly a factor to be considered. His second point is that the production of a set of drawing depends almost entirely on the speed of the fallers in the spindle gill. This lends emphasis to the work of recent years on the improvement of cans and fallers with a view to increased speed, though such work is not mentioned by the author. He bases all his tables on a fuller speed of 360 drops per minute for a ¾ inch pitch screw. Again, some account of the experiences with broken fallers and other troubles which led the author to fix on this speed would have been most interesting, but perhaps we are expecting too much of a book which, as it stands, fills an empty place in worsted spinning literature and provides the manager or observer with a ready reckoner de luxe for all his calculations.

A. W. STEVENSON

Die Gewebeherstellung. (CLOTH MANUFACTURE, WITH SPECIAL REFERENCE TO HAIR-CLOTH MANUFACTURE.) H. Brüggemann. Published by R. Oldenburg, Munich.

Hair-cloth upholstery is popularly associated with the Victorian parlour, and the modern vogue for short-life factory-made clothing does not encourage the use of expensive hair inter-linings. But quite apart from commercial importance, the keen textile student will always be interested in the methods and mechanisms by which unusual fibres are made amenable to spinning and weaving. This book gives a complete and well-illustrated account of the spinning, weaving and finishing of horse-hair products. It commences with the classification of hairs, their micro-structure and chemistry, and the manufacture of artificial horse-hair. Detailed description is given of the various ways in which the long stiff hairs are combined with ordinary yarns, either as core or wrapping to form threads which can be manipulated in subsequent processes. Various methods of manipulating such yarns and also the straight hairs as warp and weft are given, and numerous looms, with and without shuttles, are described and illustrated. The latter portion of the book deals with the finishing, glazing and stiffening of the fabrics. A useful glossary and a list of 137 references complete the volume.

As far as we can trace, there is no text-book in English on the subject, and little reference either in general text-books or periodicals. Apart from the subject matter, the author's diagram technique will repay study. At first glance rather confusing, when acquaintance has been made with his conventions, the diagrams give a very clear picture of the working of the machine in little space.

A. W. STEVENSON

The Cotton Year Book 1928. Produced by the Editor of The Textile Mercury and various contributors. Published by the Illustrated Newspapers Ltd., London. (Price 7s. 6d. net.)

The book under notice is the twenty-third of the Cotton Series, and the style and make-up is exactly like its companion, the Wool Year Book. The publishers should be congratulated on their choice of appropriate advertisers to take space on the marker of each section. The Finishing Section shows that considerable attention has been given to the question of colour fastness, and much useful data is given, including a resumé of literature already published on the subject.
The British Research Association for the Woollen and Worsted Industries

Observation of Moving Bodies by Intermittent Illumination

By

A. W. STEVENSON B.Sc., Wh.Ex. and M. C. MARSH B.A., B.Sc.

May 1928

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Dr. F. A. E. Crew, Director of the Animal Breeding Research Department, The University, Edinburgh, has kindly offered his co-operation.
OBSERVATION OF MOVING BODIES BY INTERMITTENT ILLUMINATION

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ABSTRACT

Various types of stroboscope producing synchronous intermittent illumination are reviewed and compared with instruments giving intermittent vision. A type is described in which a focussed beam of light is deflected by a revolving mirror and sweeps over the objects under observation. The use of such an instrument has been extended to the observation of aperiodic motions. The technique and limitations of such asynchronous intermittent illumination are given. Various applications are mentioned and comparison made with spark photography and the high-speed cinema.

CONSIDERATION OF VARIOUS TYPES OF STROBOSCOPES

Since the stroboscope was invented by Plateau about 1834, many instruments have been devised for the observation of bodies in periodic motion.1,2 Some, like his, provide for intermittent viewing of the object; others, in general more useful for research purposes, provide intermittent illumination of an object otherwise in darkness.

Intermittent Vision Stroboscopes

Such instruments do not strictly come within the scope of this paper, but a choice has often to be made between intermittent viewing and intermittent illumination as experimental methods. Where exact definition is not required, as in stroboscopic speed measurement, the disc with radial slots used by Plateau is simple and compact, and can be used without darkening the room, but if a high speed and sharp definition are required, the linear speed of the disc soon becomes uncomfortably high. A recent intermittent vision instrument, the Ashdown Rotoscope,3 is a distinct advance and is binocular.

Intermittent Illumination Stroboscopes

When the action to be observed can be isolated in a partially darkened laboratory, this class is more suited than the first for research purposes. The degree of darkness required depends on the intensity of the intermittent illumination, and also on the observer's acquaintance with the phenomenon. They give unhampered binocular vision from all sides for several observers. This class may be divided into three types—those in which the light beam is periodically (a) extinguished at the source, (b) obscured, and (c) deflected.

As examples of type (a), sparks from a condenser through a recurring spark gap have been used by Bairsto4 for photographing model airscrews; Elverson5 uses a Neon lamp operated by a rotating contact breaker and induction coil; Harrison and Abbott6 use a similar arrangement with an electrically maintained tuning fork as contact-breaker; L. and A. Seguin7 use a large Neon lamp with a rotating contact-breaker which only passes a small portion of the current used.

The second section (b) of this class, in which a shutter is operated in the path of the light, is said8 to have been used by Doppler in 1845, and was used recently by Davis8 in ripple investigations. The system does not
lend itself to sharp definition, for while a slit 1 mm. wide will suffice for purposes of vision, it will not pass the beam from an arc lamp or similar source unless a complex lens system is used. An example of this type, intended mainly for speed measurement, the Crompton-Robertson Stroboscope, has shutters attached to an electrically maintained tuning fork.

The Mirror Stroboscope—The only representative of type (c), as far as we know, is the one developed by the British Research Association for the Woollen and Worsted Industries. When they took up worsted spinning research in 1921, the first requirement was a stroboscope which would show the curve of a thread revolving like a skipping rope at 6,000 r.p.m. in a path about 10 centimetres in diameter. Several instruments on the market were considered and rejected owing to cost, insufficient sharpness, or lack of fine speed adjustment. H. J. W. Bliss suggested reflecting the focussed beam of an arc lamp by a disc mirror revolving about one of its diameters, as shown diagrammatically in Fig. 1. From this suggestion one of the authors developed the instrument shown in section in Fig. 2 and in use on a spinning frame in Fig. 3. The revolving mirror is of stainless steel, 5 centimetres diameter to allow for the spherical aberration of an ordinary condenser and the finite size of the source, also to give some latitude in centring. The mirror spindle is driven by a flat cotton tape 1.5 centimetres wide from the machine being investigated. Coarse adjustment of the mirror speed is made by changing the driving pulley and fine adjustment of ±10 per cent. by the cone pulley A (Fig. 2) and adjustable guide pulley B. The two stationary mirrors C and D are introduced to keep the instrument compact and portable.

The definition given is by no means so good as that claimed by Bairsto or Seguin, but it is much higher than can be obtained by most shutter instruments. Ordinary printing from 12-point type can be read on a bobbin 2.5 centimetres diameter, running at 8,000 r.p.m., the definition being almost independent of speed when above 1,000 r.p.m. Equal black and white spaces 0.5 mm. wide can be distinguished and counted on a bobbin 6.7 cms. diameter, corresponding to an angle of about 0.9 degree each for line and space.

Up to the present the revolving mirrors used have been of burnished stainless steel, only approximately flat. For more exacting requirements the mirror could be optically worked with curved surfaces of spherical, cylindrical, or ellipsoidal form. A spherical surface would narrow and intensify the zone of illumination and shorten the duration of the flash, while
a cylindrical surface with its axis parallel to the axis of rotation would only decrease the flash duration.

The instrument is extremely simple and robust, the only moving parts being a spindle in two bearings and a guide pulley. The only electrical parts are those belonging to the projecting arc lamp. Where electricity is not available, limelight and oxy-acetylene have been successfully used. The Pointolite and metal filament lamps of the grid type have been tried, but they do not give the clearness and brilliancy obtained with arc or oxy-acetylene illumination.
The instrument has been used by one of the authors for exact study of the yarn loop in cap spinning\textsuperscript{11} under centrifugal and aerodynamic forces, and for reading measuring instruments integral with the rotating portion of the spinning mechanism,\textsuperscript{13,15} also for the measurements of discrepancies in the velocity ratio of the tape drive.\textsuperscript{10,14,15} With the aid of a band similar in principle to the Drysdale disc this ratio can be measured to within $\frac{1}{2}$ per cent. These experiments were first made in a completely darkened laboratory, but after the stroboscopic "image" of the spindles and yarn became familiar, it could be recognised in a moderately well-lit mill.

**Fig. 3**

**ASYNCHRONOUS INTERMITTENT ILLUMINATION**

During some investigations of the action of woollen carding machines, it became desirable to watch the behaviour of the wool at higher speeds than could be followed with the eye in ordinary light. The mirror stroboscope as described above has often been suggested as a probable means of investigation of carding action, although the action was not truly periodic, and the best that might be expected would be an "average" of succeeding wool fibres behaving in similar ways.

At first the stroboscope, independently driven, was used on a small carding machine of the ordinary type, but it was impossible to see even an average of wool fibres. Another small machine, specially built for ease of observation and illumination, was then brought into use. This machine is virtually a longitudinal sectional model, 1 in. thick, of the large machines. It was still impossible to see individual fibres as long as they were viewed from the illuminated side, in spite of attempts at synchronous adjustment of the stroboscope over a wide range of speeds.

It was then discovered that, if the observation were from the side opposite to that of the light, the wool fibres became very distinct and could be seen
even when the machine was running at high speed, without any synchronisation between the stroboscope and the machine. With a neutral background behind the fibres, and the stroboscope mirror as near to the line of sight as possible without being itself seen, the wool appeared to be almost self-luminous.

**Experimental**

This method of observing bodies in aperiodic motion seemed to be interesting and to hold possibilities. Some experiments on the principles involved were therefore devised. To avoid possible confusion of synchronous and asynchronous effects, and at the same time to get a steady and measurable velocity, the object to be observed was placed on an endless belt running over pulleys about 5 metres apart and driven by a variable speed motor. The motor was controlled by one rheostat in series with it and at low speeds, another in parallel with the armature. The maximum speed used was 27 metres per second.

The motor speed was indicated throughout by a tachometer, but owing to the possibility of belt slip, important measurements were checked by timing revolutions of the belt by stop watch. By this apparatus it was possible to obtain a known and widely variable linear velocity without there being any risk of synchronisation between the object observed and the stroboscope.

When arranged thus, the velocity of the belt for which certain figures and letters, or other objects, could be seen distinctly in steady lighting was measured. It was found that it was possible to follow the object with the eye in a way not comparable with the observation of wool fibres at a point, so all observations were made through a 15 cm. gap. The illumination was by a 100 watt gas-filled lamp in an enamelled reflector at a distance of 1 metre. The use of an arc lamp made no appreciable difference in the ease of reading; in fact, with very intense beams, it was found that reflection from the surface of a black tape made the contrast with white letters weaker.

Intermittent illumination was then started, and although the speed of the belt was increased, the object could be seen clear, sharp, and stationary at regular intervals along its path. Each impression lasted only for a very brief time and, as it was stationary, there was no tendency for the eye to follow the motion, and hence viewing through the 15 cm. gap was unnecessary. Good contrast was essential to seeing the object.

**Results**

The frequency of the flashes was found to have little effect on the clearness over a wide range of speeds for any given motion. When the frequency was very low there was the usual discomfort due to flicker, but there was also a blurring of the impression at low speeds due to the fact that the angular width of the beam was constant and therefore the duration of the flash was proportional to the period. Thus, even when flicker was absent, a too low speed was indicated by blurring. On the other hand, when the mirror speed became too high, the impressions of the object were faint because of the very brief time of illumination. Also, due to the short period, the “images” were very close together and sometimes overlapped.

In some cases it may happen that there is both blurring and overlapping. This can sometimes be eliminated by blackening one side of the mirror and running it at a higher speed. In this way the period is increased and the flash duration decreased at the same time.
Three types of belt were used—
(1) White belt with black letters.
(2) Black belt with white letters.
(3) A “rope” of wool made from twisted worsted roving with fibres brushed up.

With each of these, speed measurements for steady and intermittent illumination were made, and the results are set out in the table below.

<table>
<thead>
<tr>
<th>Object under Observation</th>
<th>Maximum Speed at which Object is Visible with</th>
<th>Ratio of Speeds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steady Illumination</td>
<td>Intermittent Illumination</td>
</tr>
<tr>
<td>12 mm. letters—Black on white belt</td>
<td>0.85</td>
<td>16</td>
</tr>
<tr>
<td>12 mm. letters—White on black belt</td>
<td>1.2</td>
<td>27*</td>
</tr>
<tr>
<td>2 mm. letters—White on black belt</td>
<td>0.46</td>
<td>8.8</td>
</tr>
<tr>
<td>Wool fibres projecting from rope</td>
<td>0.30</td>
<td>12</td>
</tr>
</tbody>
</table>

* This speed was the highest obtainable at the time, so an even higher ratio could be obtained.

It was quickly realised when measurements were started that definite figures have little meaning, so only a few readings were made. The maximum speed with both systems of illumination depends on factors which cannot be readily defined, e.g. contrast, stray light, rest or lack of rest of the eye before observing, and skill of the observer. Further investigation is felt to be a physiological rather than a physical matter, but the figures given indicate that the ratio of the maximum speed in intermittent illumination to that in steady illumination is 20 or above. The high value in the case of wool fibres is due to their great brightness, the cause of which is discussed later.

From the experiments it was concluded that to get the best results from intermittent illumination—
(1) A good contrast should be provided.
(2) The duration and period of the flashes should be such that there is no blurring on the one hand, and no over-lapping of faintness of impression on the other.
(3) The light should be as intense as possible.

**Visibility of Fibres**

An investigation was then taken up with a view to determining the reason why wool fibres appear very much brighter when viewed from the side opposite to that of the light than from the same side. This brightness increases as the light approaches the line of vision,* 16 but the effect is vitiated by dazzle if the source can be seen. A black wool fibre gave much less effect than a white one, and a metal wire of the same diameter did not appear bright at all under similar circumstances. Also the brightness was greatest when the wool was perpendicular to the plane containing the eye and the incident beam.

As a further test, wool fibres strongly illuminated and viewed through a microscope containing a dark screen, were compared with a glass rod and the appearance was found to be the same. The chief brightness was due to refraction, the reflection being much less intense and from one side, while diffraction caused a very faint line on the opposite side. These facts

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* A similar arrangement is used to detect small quantities of dust in pure liquids (Krishnan, Phil. Mag. 50, 698, 1923 B).
all point to the effect being due to refraction through the fibre. Irregular refraction, however, occurs at the surface of the wool due to the scales.

This effect is not dependent on the intermittency of the lighting and should have uses in other branches of textile research where the observation of individual fibres is necessary.

**COMPARISON WITH SYNCHRONOUS INTERMITTENT ILLUMINATION**

While synchronous intermittent illumination may be looked at as only a particular case of asynchronous, the effects produced are so different that each has a field of its own. Both synchronous and asynchronous depend on momentary impressions made on the eye. In the synchronous type these impressions are more or less superposed and give a continuous illusion of the object observed being stationary or in slow motion. Its form and behaviour can be studied at leisure and observations made of dimensions and positions, either with the naked eye or cathetometer. If the apparatus producing the intermittent illumination is satisfactory, it is unnecessary for the object to present bright lines or sharp contrasts, and no care is needed in the selection of a background.

Perhaps it is the eminently satisfactory nature of the results from good synchronised intermittent lighting that has caused the possibilities of similar lighting not synchronised with the moving object to be neglected. Very frequently the effect of dropping out of synchronism is so distracting that the utility of asynchronous lighting might well be doubted. But research is necessary on many objects which have no periodic motion, a periodic motion too slow for stroboscopic observation, or a combination of several periodic motions not in harmony with each other.

The experiments described above show that much information can be obtained with intermittent illumination though synchronisation is impossible or useless, provided a vivid appearance can be obtained by the use of bright lines or sharp contrasts. Observation is by no means as easy as when synchronisation can be used and measurements cannot be made with the same certainty, but when compared with observation of the same phenomena by ordinary light the difference in result is very marked. The blurred effect produced by rapid movement is replaced by an illusion, not of rest, as with synchronised lighting, but of motion in short jerks with brief stationary intervals during which shape and position can be observed.

**USES**

Besides the observation of the irregular motion of wool in carding, which led to these investigations, other possible textile uses are the observation of loom shuttles and observation of the fibres in some types of combing machines where the motion is intermittent. Water jets and splashes might prove interesting subjects, also circuit-breakers and other mechanical trip devices, such as valve gears on slow-speed engines.

The last suggests an interesting comparison of the uses of synchronous and asynchronous intermittent lighting. A petrol engine valve gear which repeats its cycle 1,000 to 2,000 times a minute, would be investigated on the synchronous system, but if this were applied to a steam or gas engine valve gear making 80 to 100 cycles per minute, each image would fade from the eye before the next reached it. Yet portions of the movement would be too rapid to be followed by the eye in the ordinary way. With intermittent lighting of such frequency that the parts moved a small amount between flashes, the movement could be followed and peculiarities noted.
Another suitable subject would be the movement of a rail joint as a train passed over it at various speeds, and another the action of the collecting shoe of an electric train as it enters or leaves a section of third rail. Belts and ropes could be examined while in motion either for peculiarities of action or faulty places. Many other uses will readily suggest themselves.

The mirror stroboscope has been used throughout these experiments, but there seems no reason why other forms of instrument producing intermittent illumination, or even good vision instruments, should not be equally effective.

**COMPARISON WITH OTHER METHODS**

Alternative methods for observation of moving bodies are spark photography and high-speed cinematography. Both these have the advantage over intermittent illumination that they give a permanent record, but the development of this record is a matter of time and trouble. There are also many cases where it is desirable to watch what is happening at any particular moment rather than to wait for the development of a record. As far as intermittent illumination by the mirror system has yet been developed, spark photography has the advantage also in point of speed, but the apparatus required is complex and expensive. The high-speed cinema is in course of rapid improvement, but as far as we can learn \(1/1000\) of a second is reckoned a very short exposure, except for such elaborate examples as the Heape and Grylls.\(^{17,18}\) During this period of time the belt used in the foregoing experiments would move two and a half centimetres. When it is remembered that letters \(1.2\) centimetres high were perfectly legible, the effective exposure to the eye must have been about \(1/10,000\) of a second.

**CONCLUSION**

Intermittent illumination can be used, with certain limitations, in the study of bodies in aperiodic motion. The bodies must present bright lines or sharp contrasts, the intermittent illumination must be derived from a suitable apparatus, and the linear speed, as far as the method has been developed, should not exceed twenty times that at which the object can be seen in ordinary light.

**REFERENCES**

3. Engineer, 1925, 140, 272; 1927, 143, 82; or Ashdown, Jour. Sci. Instruments, 1925-26, 3, 15.
11. Ibid, No. 18, 1923.
12. Ibid, No. 37, 1924.
15. Priestman and Stevenson, British Association 1927 (published by Textile Institute).
ARTIFICIAL SILK

THE YORKSHIRE PRODUCERS have been bidding for one of the most spectacular prizes of the new year —apparel silk yarns. The news has spread in the trade with which all familiar with the Yorkshire textile world are acquainted. The Yorkshire producers have been out in force at the Birmingham Exhibition, and there has been no contest. The Yorkshire producers have scored a decisive victory by securing the contract for the manufacture of the new yarns for the Australian market. The contract is for the supply of 1,000,000 yards of yarns, and the contract price is $2,000,000. The yarns are to be manufactured at the Yorkshire mills, and the production will commence immediately. The manufacturers are confident of the success of the contract, and the yarns will be delivered to the Australian buyers in the shortest possible time. The contract is a great triumph for the Yorkshire producers, and it is expected that it will result in increased trade for the industry. The Yorkshire producers have been working hard to secure this contract, and they have been successful. The news has been received with great joy by the Yorkshire mills, and there is a general feeling of confidence and optimism in the industry.
RESIZE INTO TEXTILE PROCESSES.

FACTORS WHICH ARISE IN WORSTED SPINNING.

A LECTURE was delivered to the Hubberfield Textile Society by Dr. S. G. Barker, Director of Research, and Mr. A. W. Stevenson, head of the Engineering Department, of the Research Association for the Woolen and Worsted Industries, Leeds.

Dr. Barker stated that his part in the lecture was merely to give an outline of the work which was now proceeding at the Research Association's Laboratories, and then to ask Mr. Stevenson to enter into more precise details.

As far as the worsted industry was concerned, the Research Association had for some years been laying the foundation of fundamental research into the principles underlying various processes, and as a result considerable progress had been made from the practical standpoint.

The Research Association had now reached the stage when they felt that they might commence the practical exploitation of the work of the worsted side to a nice correspondence with its importance. The Council had therefore authorized expenditure on large buildings, which were in course of erection at the present moment, to house a fully equipped plant for scouring, combing, carding and spinning, and it was ultimately intended to develop further the whole of the worsted side until the process would be completely represented from the fleece to the finished yarn. This would involve an expenditure of money, and it was necessary for the Council to feel assured that the money would be thoroughly well spent.

The association had decided to undertake the requirements of the worsted industry, and by the middle of next year the equipment at Torrilli would be the finest that could possibly be obtained. It was further proposed to have a complete system of individual drive for all machines, and arrangements to avoid belts and shafting. A further innovation was a new system of dealing with certain processes and the reduction of waste by means of a centrifugal pump. Experiments on this were now proceeding, and it was hoped to get the maximum possible advantage out of a factory basis as soon as these experiments could be completed.

A FIRM SCIENTIFIC BASIS.

Dr. Barker emphasized the two sides to their work, namely that fundamental and the immediate practical, and that the fundamental side was being steadily developed, and considerable progress made. Papers from the woolen workers at Torrilli had been accepted by all the learned societies, and it was now the firm belief of the Association that the fundamental research work carried out in the laboratories was already recognized by the scientific societies as being scientifically sound.

They thus had a basis of a firm nature upon which to develop their practical work, and already in the first few months of work some advantage began to accrue to the trade.

During the last twelve months, the researches had given increased encouragement to the institution, but much more was necessary yet. On the other hand, the Research Association had been able to solve sixty of their 300 problems during the twelve months of that year, and be it noted that the letters of thanks had been accompanied by handsome donations towards the research work.

Dr. Barker urged everybody to rely on the success of the research, and stated that if additional help was forthcoming, then developments ought to be accelerated.

Mr. Stevenson concluded, saying that the Research Association had now reached a state of development which would enable all that was happening at high speed to be speeded up even more. Most instruments of research were stroboscopes, and had been in use in the laboratories for the past seventy years, but at the time the Research Association started its work they were in no form really suitable or efficient for the work of spinning. A new one had been bought, and though there had been great anxiety given to it, the results during the last few years, it was said, were the most suitable for the work and recent experiments at Torrilli indicated that its use might be extended to the whole of the worsted industry for which stroboscopic observation was thought to be impracticable.

The principle of the Research Association was, he said, that is a powerful light of from an arc lamp could be covered to sweep over the spinning rapidly and extensively, thus illuminating them at regular intervals for very high speed work. The effect of such illumination was to change the spindles and yarn appear to be stationary, whereas the field between the frames coincides with the time taken by the spindle to make one revolution. This is so for the majority of the spindles, one running slower than the rest appears to move backwards, while one running faster would appear to move slowly in its real direction. This very elementary condition of the stroboscope, although one thing that was set in motion, had been a very important one practically, and had enabled some very practical cases of uncertainty to be halted and investigated.

TESSER IN SPINNING.

One of the most important factors in spinning is the "draft," that is, twisting the yarn as it is being spun. If this tension is too high for the count and quality, the yarn will break frequently and require to be "piece." Not only does this cause labour cost, but also the addition of much wool grease will harm the finished cloth. This tendency to break does not generally referred to as "breakage," but can be converted in various ways, such as reducing the speed, hardening the yarn, and allowing the breaking tension of the spindles to be set at a constant value. However, it is believed that modifying the pack or bobbin oval, that is, changing the shape of the instrument used for spinning the draft, may be modified and applied successfully to spinning purposes.

DRAFTING.

Drafting in mechanized spinning has been largely neglected. There is no doubt that the draft should equal the maximum flow length in inches, and that this doubt may be easily solved by a simple formula. The formula is as follows: the first rule is obviously illegal if the use of a different draft would mean the same total length of wool required for the same draft, and that the number of draws and the number of draw fibers (i.e., composition). The Research Association is, however, not as yet in a position to change the draft, but it has undergone some changes during the last twelve months. The framework day in day out at drafts of 60 to 80 is being composed of two types, one equal to present practical conditions, and the other in a draft with a draft of over 100.
PRINCIPLES OF DRAFTING IN WORSTED SPINNING.

Results Obtained by the Research Association.

One of the main objects of the British Research Association for the Woollen and Worsted Industries has been to develop improvements in worsted spinning.

The most recent improvement, which in due course will be made public by the Association, is based on a principle which has proved to be a great success for over 20 years in the cotton industry. Howard Priestman in his "Principles of Worsted Spinning," which was published in 1906, pointed out that the principles of drafting were absolutely different in the two trades, and that the cotton spinning machine could work well when drafting twice in the same direction and extending $1\frac{1}{2}$ inch cotton to twenty times its original length in one operation.

Investigations on this subject have been going on for a number of years at the Research Association laboratories in Leeds and it has now been demonstrated that drafting twice in the same direction is not only easy but satisfactory.

This work has led, by a few intermediate steps, to the construction of a frame in which two drafts follow one another as they do in cotton machinery. The results are quite simple but quite extraordinary. This method involves a 50 per cent. reduction in the number of machines employed in the drafting processes. At the present time it is common to reduce a single roving weighing 1.8 grains to 1-48's yarn or a 2.5 grain roving to 1-32's. By the new method the whole of the roving and reducing processes are eliminated and spinning on a bobbin $\frac{1}{3}$ inches x 10 inches, which is six times as thick as the roving, is made to make 1-32's.

It is the opinion of many people that as material goes down a drawing, it reaches its greatest levelness at the slubbing box, and if this is true, as seems to be likely, there must accrue several advantages from this new method. It will save 50 per cent. of the space now occupied by drawing, and whatever appears to be of more importance is the fact that the yarn will be produced in such a way as to resemble yarn spun from rovings that have no twist. This will give some of the effects of French yarn, which is also spun from roving having no twist in it.

The interests of the Research Association are both theoretical and practical, and the results in this case must have wide practical application. The first object of the investigation was to prove or disprove the oft-repeated statement that worsted slivers could not be extended twice in the same direction. It has ended in the discovery that carriers are unnecessary for the control of the short fibres, and the result which has been obtained is not only interesting as a product of the work of the Research Association, but may open a new field for the production of a different type of cloth from Bradford yarn.

The whole of the mechanical alterations which are shown at Torridon, Headingley, were made by the Engineering Department of the British Research Association, and anyone who cares to follow the alterations that have been made, before a satisfactory method was finally arrived at, will understand the necessity which exists in work of this description for collaboration of men whose profession and experience are widely different. Such collaboration can only effectively be obtained by a Research Association combining a scientific staff with those having a practical knowledge of trade processes.
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"10 per cent. approximately are highly decorative shades such as Bright Violets, Royal Blues, Peacock Blues, Bright Greens, Mauves, etc., and are generally used in small proportions. These shades cannot be guaranteed by any dyer, the dye makers as a body support us in this contention."

"Should not a guarantee to be of value be honest?"

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PRACTICE WITH SCIENCE.

Achievements of the Research Association.

A comprehensive exhibition at the Science Museum, South Kensington, arranged by the British Research Association for the Woollen and Worsted Industries, was opened on Tuesday by the Earl of Balfour. In the absence of Sir James Hinchliffe, chairman of the Association, Mr. Henry Bliss, the new Director of the Museum, arranged the opening ceremony. The exhibition has been arranged to illustrate the application of science to the woollen and worsted industries at all stages, from the sheep to the finished fabric.

Lord Balfour said: "I am really proud to have the opportunity to declare open the first of what I hope is to be a series of exhibitions illustrating the work which is being done by the various industries of the country in co-operation with the Department of Scientific Research. We have to look to the future, and the efforts with which industry is concerned are not merely to maintain the standard reached by our forefathers and ourselves, but to watch the process by which that standard is being improved, and further progress is being assured."

The Application of Science.

"I do not think that the public at large even now realises the necessity, if we are to be a great progressive nation, of calling to their aid the application of science. I should like everyone concerned in industry, in whatever degree it may be, to realise that if the general level of the standard of life is to be maintained and improved it can only be by the more and more successful application of increasing knowledge to the production of wealth, in which the whole community is to share. The standard of comfort is, what I presume, all persons interested in the growth of the material side of civilisation are primarily interested in. But quarrels about the production of wealth and prosperity, how ever important and inevitable, are really insignificant so far as the standard of life is concerned, compared with the amount of production which a given number of people can raise by conquering the forces and using the reserves of nature."

"Production" is a word which we must bear in mind. In the case of a secondary thing, signs of increased production per head of the population can only be secured by improved methods of scientific application to industry, and that really lies at the root of all efforts to increase the prosperity of our race. If these are plati tudes, they are platitudes which are constantly being forgotten.

Industrial Revolution.

Lord Balfour added that the Exhibition revealed that the scientific department of the great wool industry had been most successful in its operations, and deserved the gratitude not only of the industry, but of the whole industrial community. He was concerned, indeed, with the outlook of world industry. This country was the pioneer of the great industrial revolution, and he had gained greatly from that fact, but possibly we had also lost something. It was impossible to be a pioneer without losing something, and it was our business to see that any advantages possessed by other countries in freshness of outlook and so forth should not allow us to fall behind in the race.

"If that result is to be achieved," he concluded, "it will only be if we see how important is the application of science to modern industry, and it is because I think this Exhibition clearly shows we are fully awakening to that great national necessity that I welcome the opportunity of opening it."

Mr. Clough, in thanking Lord Balfour, said that the work of the Association had already affected trade practices and methods. They proposed now to undertake a large and important piece of work on the standardisation of dyestuffs, and to investigate the conditions which affected dyed fabrics in every kind of use and every part of the world. The Association hoped to be able to publish in a form suitable for teaching the results of such investigations.

DRAFTING IN WORSTED SPINNING.

A Practical Demonstration.

A correspondent writes: The exhibition is a wonderful tribute to the energy and foresight of Dr. Barker, the new Director of the British Research Association, and it is also a tribute to the ability of the staff who now work under him.

Many of them also did much of the spare work under Major Bliss.

The prospectus of the exhibition gives the head of the departments whose work is there displayed. It is not only difficult to explain to non-technical people all the meaning of the results of prolonged scientific investigation; but there is in this exhibition plenty of evidence that the British Research Association is rapidly harnessing science in the interest of industry.

Although very difficult amongst so many exhibits, to pick out those of outstanding interest; few people who are connected with the trade could pass by Section 29 without being interested, not to say alarmed, at the evidence there displayed of the damage which is daily done by bacteria, most often in the form of mildew. Those who read the scientific journals will know that Mr. Hirst has already made public many of the valuable results that he has achieved; but the samples which are now displayed form an object lesson so plain that he who runs may read how deadly and widespread are the effects of mildew.

Associated with Mr. Hirst in the article above referred to is the work of Mr. King, which is illustrated in Section 22. This shows that when damp pieces which contain even a vestige of alkali are allowed to dry the alkali travels or migrates as the water evaporates, becomes concentrated where the evaporation is most rapid, and there after causes irregularities in the consequent dyeing that give all kinds of trouble.

Tar Marking of Sheep.

The same department has also done work regarding the use of tar for marking sheep, and here exhibits a new sheep marking fluid more easily removable though quite as efficient as tar compounds. It deserves the close attention of sheep growers, as well as scourers; for the substitution of the new for the old could not fail to be of advantage to both.

The Department of Physics, under Mr. Hedges and Dr. Barker shows delicate instruments designed to obtain accurate estimates of the dimensions, weight, strength and elasticity of fibres which are of the greatest interest and importance, and there are micro-photographs which illustrate beautifully the nature and structure of normal fibres, but show how deadly is the disintegration which ensues when such fibres are attacked by the fungus of mildew.

But after all, the average man associates the manufacture of wool with revolving rollers and whirring spindles. The rollers are illustrated by
THE WOOL RECORD & TEXTILE WORLD.
March 3, 1927.

Dumoulin & Gosschalk
Head Office: FINKLE STREET, HULL.

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Valley Scouring Co.
Canal Mills, SHIPLEY.
Wool Scourers and Carbonizers.

CARLO HALENKE
Established 1869.
BIELLA, Italy.
Wool Import and Export.

The output of disinfected material from the Government Wool Disinfesting Station (Home Office) in the periods indicated below has been as follows:

- Compulsorily Disinfected:
  - Egyptian Wool: 107,444 lbs
  - Egyptian Animal Hair: 2,933 lbs
  - East Indian Goat Hair: 13,940 lbs
  - Voluntarily sent for Disinfestation:
    - East Indian Wool: 7,127 lbs
    - Persian Wool: 542 lbs
    - Chilian Wool: 13 lbs
    - East Indian Goat Hair: 124 lbs
  - Drawn China Goat Hair (Shaving Brush Hair): 126 lbs
  - Alpaca: 67,341 lbs
  - Russian Horse Hair: 84,338 lbs

DISINFECTED MATERIAL.

TASMANIAN CLIPS IN LONDON.

Really fine wool is always comparatively scarce and, since this year's clip contains a still smaller proportion than usual, buyers of super merinos will be interested to note the recent arrival of these well known Tasmanian clips Ross, Fordon, Kelvin Grove, Hampden, Patterdale and York Park, some 900 bales in all, which will be available for the March auctions in Messrs. Hughes & Williams' catalogues.

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Limited.
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SPECIALTY:
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Marino and Crossbred Noils.
Enquiries solicited.

a small model of a carding engine which stands still to be looked at, but does not give any results of great interest or technical importance.

The wheels that go round and the spindles that hum are to be found at the other end of the room, where three sample frames are busy producing yarn in a manner that ought to interest both theoretical and practical people. One of them is of the well-known standard type, which has been in use with little or no alteration in principle for 100 years or more. It has been made for the exhibition by the well-known firm of Prince Smith & Son. The other two, one for merino and one for crossbred, represent an entirely new departure in spinning practice. They have also been made by the same firm and they are of outstanding interest, because they are producing yarn on a principle that is in flat contradiction of a favourite theory very often quoted, but never experimentally demonstrated in Bradford. For these frames are drafting the same roving twice in the same direction, as was suggested by Mr. Howard Priestman in his spinning book written about 18 years ago. Now the Research Association has provided him with an able collaborator in the person of Mr. Stevenson, and the two have put into practice the principles suggested so long ago.

The frames may now be seen not only drafting 5½ to one in one direction, as in the old method, but doing the same thing twice over in the same direction, making a total draft of 30 instead of 5½. This means that an 18 dram slubbing is reduced in one operation to 1½-30's yarn; or in other words, that two operations (the reducing and roving) are entirely eliminated. As these two processes require half the floor space and half the power in a Bradford drawing, there must be some saving in the cost of production. Other advantages are likely to accrue, for the yarn in theory is akin to French spun; and if the exhibition only draws attention to the theories that make these things possible the exhibition will have served some purpose.
Principles of Drafting in Worsted Spinning.

Results of Investigations.

(By HOWARD PRIESTMAN and A. W. STEVENSON, The British Research Association for the Woollen and Worsted Industries.)

A short article on the possibility of drafting wool twice in the same direction was published in "The Wool Record and Textile World" of December 2, 1926, and details were promised at a later date. These details the writers now propose to give. Some portions of this article were published confidentially to members of the Research Association last July, together with records and discussion of many unsuccessful attempts. These discussions are well worth the attention of any serious student of worsted spinning problems.

Almost exactly 200 years ago, a man called Wyatt took out a patent for machine spinning. The specification shows that the inventor had grasped the two great principles of spinning, the first and foremost being the extension of the material between two or more pairs of fixed rollers. Before the century was out Arkwright and other inventors had developed this idea into a spinning frame which hardly differed at all from the machinery in use to-day. Although the same apparatus is used both for cotton and for wool, it has long been obvious that there is a strange want of knowledge of the principles underlying drafting, for the simple reason that a sliver of cotton having a fibre length of 1½ inches can be extended twenty times in one operation, whereas a sliver of wool composed of 8-inch fibres can only be extended to six times its length. Yet in dealing with wool it is an accepted rule that the longer the fibre the greater the permissible draft. The hope that the difference between the two might be eliminated, which was expressed by Priestman twenty years ago, has never been absent from our minds and was the original cause of this investigation, for it is a pretty well established fact that the machinery employed in the worsted trade has undergone no great change in the principles it embodies for more than 100 years.

The cost of the production of a worsted yarn depends very largely on the amount of extension which is possible in any given machine, and it must therefore be obvious to everybody that if the draft which is possible in any process can be materially extended (as it has been in the cotton trade) the conversion cost will be reduced to a proportionate extent.

It is believed by many eminently practical worsted spinners that when the material reaches the slubbing box,* the sliver is as level as at any other point in the course of manufacture, and therefore if it were possible to increase the draft from 6 to 36 the two processes of reducing and roving would altogether be done away with and yarn produced in a single spinning frame direct from a bobbin 10 inches by 5 inches. Fig. 4 is a typical worsted plant lay-out on the present system. Fig. 5 shows the effect of the new drafting being applied to the spinning frames, and it is quite possible that its application to earlier processes may be equally startling.

In every one of the processes which compose a set of Bradford drawing the yarn is extended between two rollers as described by Wyatt in 1730. This is shown in Fig. 1 in which A B are a pair of back rollers with a surface traverse of one inch per second, C D being another pair with a surface traverse of 6 inches per second, the distance from the line A B to the line C D being slightly greater than the length of the wool they are working. If the wool fibres were all of one length, these two pairs of rollers would in all probability turn out a perfect yarn, but because there are short fibres as well as long ones present, it has been found necessary to place two pairs of small rollers, which are called carriers, between A B and C D in such a position that they control the movement of the short fibres which would otherwise run through the front rollers in lumps.

For many years it has been well known that when wool was less than six inches long, slivers could not be extended by more than six times

---

* Second finisher on Figs 4 and 5.
Lyons, to raise the necessary capital by a 6½ per cent, debenture issue, an issue of preference shares, and an issue of ordinary shares. The concession the company was asking from the Government was a guarantee of interest on the debenture issue. A considerable portion of the raw material required was available in Tasmania, and it was said that the whole production of the factory should be readily absorbed in Australia.

(CARDING MACHINE CONSTRUCTION—Continued from Page 22.)

motion to the overhead lattice. Grooves of different sizes are provided for obtaining a variety of speeds for the overhead lattice. This lattice is suspended from the roof by a stout shaft to which a cross-bar is fixed. This cross-bar carries the driving bobbin of the lattice, and also carries a swing rod on which the other bobbin is fixed in a position over the fluted rollers of the carriage.

The reason for having the delivery end of the lattice on a swing shaft is to keep the delivery end of the lattice always the same distance from the nip of the fluted rollers. This is arranged for by having a band attached to the swing shaft and the traversing carriage; as the carriage reaches the end of the stretch the roller is pulled down. By means of a spring attached to a rod over the cross-bar and to the swing shaft the point of delivery is gradually pulled up again as the carriage comes towards the centre of the traverse.

The traversing carriage is employed for the purpose of distributing the sliver evenly across the feed sheet of the carder. From a pulley on the first swift shaft a 2-inch belt drives another pulley which gives motion to all parts of the carriage. A sleeve on the inside of this carries a change wheel gearing into another wheel on the carriage shaft. This shaft has a deep groove from end to end which by means of the revolving shaft and bevel gearing the fluted rollers receive their motion. The traversal of the carriage is obtained by means of a chain driven up with the carriage. The sprocket wheels on which the chain runs are adjustable as changes in length of traverse are frequently required, and for convenience a patent chain is used the links of which are easily removed or added as required. All parts of the carriage are affected by a change of gear wheel driving the carriage. The small wheel driving the fluted rollers is also a change wheel, but is only used when it is desired to alter the speed of the fluted rollers independent to that of the carriage.

**DISINFECTED MATERIAL.**

The output of disinfected material from the Government Wool Disinfector Station (Home Office) in the period indicated below has been as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Four Weeks</th>
<th>Financial Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compulsory disinfected:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Indian Goat Hair</td>
<td>11,657</td>
<td>34,352</td>
</tr>
<tr>
<td>Egyptian Wool</td>
<td>33,358</td>
<td>42,523</td>
</tr>
<tr>
<td>Volutarily sent for disinfection:</td>
<td>3,135</td>
<td>3,135</td>
</tr>
<tr>
<td>China Goat Hair</td>
<td>178</td>
<td>178</td>
</tr>
<tr>
<td>White Drawn Bristle</td>
<td>11,801</td>
<td>11,801</td>
</tr>
<tr>
<td>Irish Wool</td>
<td>3,814</td>
<td>13,318</td>
</tr>
<tr>
<td>Alpaca</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>63,997</td>
<td>105,361</td>
</tr>
</tbody>
</table>

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Reuben Gaunt's Single Yarns

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   - CORSET CLOTHS
   - COVERTS
   - DELAINES
   - GABARDINES
   - HOISERY
   - IMPERIALS
   - ITALIANS
   - Jockey Cloths
   - Parmattas
   - Poplins
   - SATINS
   - SERGES
   - Taffetas
   - Tennis Cloths
   - Umbrella Cloths
   - Whipcords

2. consistently standard in quality.
3. carefully produced by skilled workers on specialised machinery.
4. correct in count.
5. regular in twist and strength, ensuring few broken picks.
6. spun with few and small piecings.
7. spun with maximum length of yarn on each spool to minimise shuttling; moreover the yarn will weave off with a minimum of "bits."
8. in correct and regular condition.
9. clean; they are spun in atmosphere cleansed from fog and smoke.
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YARNS FOR CREAM GOODS AND DELICATE SHADES; A MINIMUM OF BLACK HAIR AND VEGETABLE MATTER.

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their length at one operation. It was in the hope that some modification of these rollers might result in a greatly increased draft that the present investigations were undertaken, and they were based on a profound doubt of the truth of the statement that drafting twice in the same direction is an impossibility.

Reversal in Drafting.—In the past, as soon as material has been given a draft of, say, six, the machine winds it on to a bobbin before putting it through another operation, the very fact of unwinding from this bobbin making it necessary that the second drafting should take place in a direction which is the reverse of the first.

Apparently the necessity for this unwinding has induced people to believe that no other method is possible, and on this opinion they have based the theory that wool cannot be drafted twice in the same direction with any success. Priestman in 1906 pointed out that the 3-roller systems as used in cotton did actually give two successive drafts and formed an exception to the practice of reversal for each draft. The first experiment of this series was therefore to unwind roving from one bobbin to another and to spin it in the ordinary way. By this method two consecutive drafts were made in the same direction, yet this made practically no difference to the smoothness of the yarn.

Successive Drafting.—It was a very short step from the above experiment to that suggested by Priestman based on the fundamental difference between cotton spinning and the spinning of worsted yarn. In the former the back and front rollers are separated by nearly double the length of the fibre, and the intermediate pair of rollers hold the fibres so tightly that they form an intermediate grip dividing the draft into two parts; the first draft being about 2 and the second 8. Though the three or four lines of rollers in a cotton frame are superficially similar to those on a worsted frame, there is a radical difference. In worsted spinning as usually practised it may be said that the intermediate rollers or carriers do not grip the fibres at all; they only control the twist and thereby steady the movement of the short fibres, the control of which makes worsted spinning so much more complicated than cotton spinning.

The problem before the writers was, therefore, to endeavour to apply the principle of successive drafts, or a heavily loaded middle roller, to worsted, and at the same time to maintain control of the short fibres. Figs. 2 and 3, described in detail later, are typical arrangements.

Carrier Lapping.—So long as carriers were used in the second draft great trouble was experienced with fibres lapping themselves round the carriers and, to a lesser extent round the middle and back rollers. Such laps seem to begin with one strand fibre, which usually passes round the roller two or three times before attracting others. Once it begins doing so the accumulation usually grows more and more rapidly until it absorbs the whole of the roving, thus breaking down the "end." Much less frequently the lap breaks down at an early stage and passes into the yarn as a "shib."

Many types of carriers variously adjusted were tried, also wipers of many designs without getting a consistently good spin. The difficulties would seem to be overcome for a day or two, but a change in the atmosphere, condition of the rovings or something quite intangible would bring a recurrence of the trouble. No real progress was made until the bold step was taken of dispensing with carriers altogether and using a false twist tube in their place. There were, of course, no carriers on which fibres could lap, but what was more surprising was that the lapping on the middle and front rollers ceased also, and yarn spins on the new system in a way which would be entirely satisfactory to any spinning manager.

False Twist.—Some explanation of false twist may be of interest to those unacquainted with the principle. It is usually applied to a sliver or roving by passing it through a rotating tube which tends to put in permanent twist, but is prevented from doing so by a roller nip just ahead. Such a tube gripping the material fairly tightly by a jaw is an essential feature of the only successful worsted spinning frame, while rotating funnels of various designs are frequently used to smooth down and strengthen the slivers coming from cards, gill-boxes and combs.

In its present application it has probably two distinct effects, smoothing down and entwining the projecting fibres and improving the drafting by putting a little twist (comparable with usual
LAY-OUT OF BOTANY SPINNING PLANT.

Fig. 4. With usual drafting on spinning frame.
Fig. 5. With new drafting on spinning frame.
See accompanying article on Principles of Drafting in Worsted Spinning.
roving twist) into the roving during the first half of the second batch.

An interesting experiment on the action of the tube was made by running down together a black and a white roving, so that any twist put in by the false twist tube could be observed. The drafted material was taken by hand from the front rollers instead of being spun, so that any twist passed through the front rollers could also be observed. When the rollers were started with the false twist tube standing the black fibres remained parallel with the white ones all the way down. When the false twist tube was started, at once about one-third of the twist-hand appeared behind the tube and a similar amount of left-hand twist in front of it. But while the twist behind remained there, that in front slowly passed through the front rollers, the black being noticed as crossing, re-crossing and crossing again. No further change took place, the sliver between the middle rollers and the twist tube always having about one-and-a-half turns of temporary twist, and that between the tube and the front rollers being parallel. The material delivered by the front rollers was also quite parallel.

Twist in Roving and Fibre Control.

The success of the false twist tube without carriers together with accumulated study of drafting processes have led the writers to a conception of the action of carriers rather different from that frequently held. A common impression seems to be that carrier rollers by their weight and slow surface speed press on the short fibres and hold them back so that they do not act in this way is proved by their successful use in the spinning, on mule or frame, of twistless rovings produced by the French process, but in dealing with rovings produced on the Bradford system there is another and more important function, that of retaining as long as possible during drafting the twist put into the roving in the previous process.

A simple experiment shows this action clearly. If a marl roving with, say, one turn per inch be passed through the usual drawing and carrier rollers, it will be seen that one third of its twist while between the back roller and the back carrier, but between the front carrier and the front roller it is almost devoid of twist. Simple theory would say that it had the original twist divided by the draft, but actually it seems to have less than this. In the space between the carriers it has about half its original twist. If now the back carrier be lifted out, there will be a slight redistribution of twist which might pass unnoticed, but if the front carrier is also lifted out there is an instant and striking redistribution. The twist which is normally held back by the carriers now distributes itself, binding the fibres together too tightly at the front and too loosely near the back roller.

False Twist Tubes.

Although the false twist tubes do not apply any pressure, they nevertheless control the short fibres by applying twist. A single false twist tube was observed to put in as might have been expected, more twist near itself than near the back roller, the cross section of the sliver diminishing as it progressed forwards. A second false twist tube was added, the two tubes being in the usual positions of the carrier rollers and being set so that they had the same twist as a simple roving, which would otherwise have emerged twistless from the middle rollers, had in its various stages twist similar to that in a twisted roving being drafted in the usual way with carriers. The twist inserted by a false twist tube was found to depend on its speed and the angle which the roving made with the axis of the tube at either entry or exit. If the roving came straight down in line with the axis of the tube, the twist inserted was negligible. The angles used have ranged from 10 deg. to 30 deg., but much larger angles can be used if found desirable.

The two short false twist tubes mentioned above were soon replaced by a single long tube, the roving making an angle with axis of the tube at both entry and exit as shown in Fig. 2. In order to observe the effect of the exit angle on the roving inside the tube (corresponding to the roving between the carriers in ordinary drafting) some tubes were made with openings in the sides. Very satisfactory spinning on wool of about 70's quality at drafts of about 30. Cloths made from the yarn are open to inspection of members of the Research Association visiting Torridon, and samples of the yarn have been freely distributed.

For crossbred the single long tube with its two points of twist insertion was found to be insufficient, which is not surprising when it is remembered that such material is usually spun with three rows of carriers. A frame was fitted up with two rows of tubes as shown in Fig. 3, corresponding to four lines of carriers. With this arrangement roving crossbred twist of 50's quality and 8-inch fibre length has been spun with a draft of 103, the yarn being passed by many competent judges as satisfactory.

To prevent nicking of the front rollers the twist tubes are traversed in the same way as the roving guides in an ordinary frame. In addition to this mechanical traverse, each tube can be moved to one side by a slot device for threading purposes or removed altogether for cleaning.

SHEEP AND WOOL IN NORTH AFRICA.

From the report of the Administrative Council of the Ovine Union of Northern Africa we have extracted the following which we found to be interesting information on the situation in the North African wool market.

Flocks of sheep constitute one of the essential riches of Northern Africa, above all in the plateaux and mountain regions, the area of which is approximately double that of France. Whilst it may be estimated that in January, 1926, there were about 13 million head of sheep in Northern Africa, it is probable that in January, 1927, there only remained 13 million head. Adverse climatic conditions seriously affected lambing and caused mortality rates which were really catastrophic.

The imports into France of fleeces and skin wools from Northern Africa amounted to 215,284 metric cwts. in 1926, against 156,875 metric cwts. in 1925.

Forty-seven merino rams and ewes proceeding from one of the best Australian stations will shortly arrive in Northern Africa; 25 will be sent to Morocco and 22 to Tunis. An Australian expert engaged by the Ovine Union is accompanying the sheep from Australia.

To help in the development of sheep breeding in the French Colonies, the Government has prepared a scheme, fixing a supplementary tax of 10 per cent. on wool imported under the duties and customs analogous to the tax of 1 Fr. per 100 kilos on imported cotton which has been established by the law of March 31, 1927. The Central Wool Committee is studying means of making up the deficiency in the State tax contemplated, by the establishment of a small tax of 0.65 per cent. on the imports of wool.
BRITISH RESEARCH ASSOCIATION FOR THE WOOLLEN AND WORSTED INDUSTRIES.

A HIGH SPEED STROBOSCOPE.

Reprinted from
"ENGINEERING,"
August 31, 1923.

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OFFICES OF "ENGINEERING," 35 and 36, BEDFORD STREET, STRAND, W.C.2.
1923
A HIGH SPEED STROBOSCOPE.

There are many cases in which the movement of mechanism is far too rapid for the eye to follow it in detail. Hence when matters go wrong the engineer has to rely on surmise as to where and how the trouble is originating. It has long been known that by means of the stroboscope it is possible to reduce the apparent rate of motion of any cycle of operations, and we illustrate on this page an apparatus of this kind which has been developed by the British Research Association for the Woollen and Worsted Industries, Leeds, for the observation of cap spinning. It has already been applied to other spinning processes, and has possibilities of much wider application. The field of illumination is larger than that of most stroboscopes, and the frequency is practically unlimited.

In cap spinning the yarn revolves skipping rope fashion at about 6,000 r.p.m., and in the past it has only been possible to guess the reason for certain peculiarities in the behaviour of the yarn, such as its tendency at certain times to "lick" or cling to the cap instead of flying clear as it does at other times. No existing stroboscopic apparatus seemed to be exactly suitable for the conditions. The spindles are usually arranged in a long row, and it is desirable to illuminate as many as possible at one setting of the instrument. It is also necessary that there should be free access to the spindles for "piecing," changing bobbins, &c.

The mirror type of stroboscope which has been developed illuminates objects in a horizontal plane for a considerable radius from the instrument, the distance depending only on the intensity of the light source and the darkness of the room.

A general view of the instrument is reproduced in Fig. 1, and the methods of mounting it and driving it are represented in Figs. 2 and 3, whilst Fig. 4 shows it in position as applied to an actual spinning frame. The central part is a small double-sided mirror—of silver or stainless steel, rotated about one of its diameters at half the speed of the spindle under observation. A beam of light from an arc lamp (see Fig. 3) is focussed on the mirror, and by reflection therefrom is caused to sweep through a circle, illuminating each object in its path intermittently. As already stated, the illumination and size of field in a horizontal plane, or rather in a plane at right angles to the mirror spindle, depends only on the intensity of the light source. The vertical dimension of the field can be varied by adjusting the divergence of the beam, and of course at the same time the distance from

---

Fig. 1

Fig. 2

Fig. 3

Condenser
Electric Arc Lamp
the lamp to the mirror. Increasing the distance from the mirror to the object also increases the vertical dimension of the field. Generally, however, a wider field means not only less intense illumination but also less precise definition, because the ratio of the illuminated period to the period of darkness is increased, and the object under observation moves further during the illuminated interval. With careful adjustment, however, the maker's name, stamped in $\frac{1}{10}$ in. letters on a wood bobbin in rapid rotation, can be clearly read.

As an alternative to the dispersion of the beam synchronise the mirror with the spindles, and exact synchronism was necessary if the form of the yarn was to be studied.

It was therefore found preferable to drive from the spinning frame itself by a flat cotton tape of the type already used for the spindle drives. To provide the requisite speed adjustment the driving pulley C (Fig. 1) of the mirror was made conical and the guide pulley D arranged to control the position of the driving tape of the cone. Further speed adjustment could be made by fitting different sizes of driving bobbins at A (Fig. 2). Flat cotton tapes of the type used have a sewn joint, which would have caused a marked irregularity in the running of the mirror. To prevent this, a flywheel G (Fig. 1) is provided on the mirror spindle. The short tape is run slack, just tight enough to overcome the friction of the mirror. Whenever the effect of the joint would be to change the speed of the mirror momentarily, the inertia of the flywheel resists such a tendency, provided the tape is slack enough to slip slightly. With this arrangement the image of the yarn can be made practically stationary, so that its behaviour can be accurately observed.

While the behaviour of the yarn was the main

![Fig. 4.]

by focussing, the mirror could, of course, be made with slightly cylindrical faces giving dispersion in a vertical but not in a horizontal plane. It is also found that a slightly imperfect silver mirror is preferable to a much more perfect glass one. The latter gives a concentrated beam with no fringe; the former, not quite plane and with imperfect polish, gives an outer zone of faint illumination besides the brilliantly illuminated central path.

In its first form the mirror was driven by a small variable speed motor to which a tachometer or counter could be permanently attached. Owing to slight irregularities in the speeds of motor and spinning frame, it was found very difficult to

...
object for which the apparatus was devised, a side issue of importance soon showed itself. The apparatus had not been in use many minutes before large and unexpected variations in the speed of the spindles were discovered. To adapt the instrument for measurement of these variations, the marked paper band shown in Fig. 5 was stretched round the driving cylinder K (Fig. 2), and the mirror arranged to illuminate the driving cylinder and the spindles simultaneously. This band is divided into 40, 39, 38, 37, 36, 35, 34, divisions, the even number rows having marks about 3/16 in. long and 3/16 in. wide, and the odd numbered rows black spots 3/16 in. diam. In the experimental frame, the driving cylinder is 10 in. diam. and the whorle on the spindle tube 3/4 in. diam. The nominal speed of the spindle tube is therefore $10 \div \frac{3}{4}$ or 13 1/3 times that of the tin cylinder.

If the flash frequency given by the mirror is equal to the speed of such a theoretical spindle, the tin cylinder will turn $\frac{1}{13\frac{1}{3}}$ or $\frac{3}{40}$ of a revolution between

\[ \text{Fig. 5.} \]

flashes, so the band of 40 divisions will move forward an amount equal to three of its own divisions every flash. This band will therefore appear to be stationary. At the same flash frequency, the next band will have moved the same fraction of a circle between flashes, but here the pitch of the marks is slightly greater and the distance moved will be rather less than the distance between three marks. The band of marks will therefore appear to move slowly backwards. If the flash frequency be decreased by shifting the tape on the cone pulley until the 39 band appears stationary, the tin cylinder will then be making $\frac{2}{39}$ or $\frac{1}{13\frac{1}{3}}$ of a revolution between flashes. Table VIII shows the flashes per revolution of the tin cylinder when various bands appear stationary.

<table>
<thead>
<tr>
<th>Number of divisions in band</th>
<th>Flash per revolution</th>
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The intermediate percentages below nominal speed were determined by setting the mirror speed to bring the image of the nearest band stationary, and then counting the r.p.m. of the spindle image. The velocity ratio of spindle to driving cylinder could be determined to well within $\frac{1}{2}$ per cent. Measurement of absolute speeds could be made by reference to a tuning fork or other standard of frequency. With the help of the stroboscope used in the foregoing manner the variations of spindle speed were measured and the cause located. The instrument is, of course, still being used for its original purpose of investigating what happens to the rotating yarn.

As already stated, this type of stroboscope should prove useful in other fields than that for which it has been designed. There is nothing in the way of vibrating electrical contacts to limit the speed, and the only limitation is the mechanical strength of the rotating part. This could for higher speeds be made of a solid piece of stainless steel, with two or more faces, and there seems no reason why a flash frequency of over 100,000 per minute should not be attained. The revolutions of the mirror are, of course, equal to flash frequency + number of faces. Neither the definition nor the illumination are effected by an increase of speed.

The Research Association are about to have a supply of these instruments made for its members, and will be pleased to increase the number (and so reduce the cost) if others interested will enter into communication with the Secretary, British Research Association for the Woollen and Worsted Industries, Torridon, Headingley, Leeds.
TEXTILES.

We mentioned previously that the Department of Textile Industries of the University of Leeds and the British Research Association for Woollen and Worsted Industries (which for brevity we may refer to as the Wool Research Association), of Torridon, near Leeds, had arranged for special textile sessions in what was practically a textile section, which met on four days in one or the other of these institutes. The Department, endowed by the Clothworkers' Company of the City of London, has five sections, with three-year courses, for woollen yarn spinning, worsted spinning, designing and weaving, finishing, and testing and research. Professor Alfred F. Barker, is head of the Department. Associated with it are the University Departments of Colour Chemistry and Dyeing and of the Leather Industries; evening courses are arranged in all these departments. The Wool Research Association was founded, in 1916, by manufacturers of the West Riding, and, three years later, was allied with the Department of Scientific and Industrial Research. It now comprises some four hundred firms, representing 60 per cent. of the capital of the industry. The director is Dr. S. G. Barker. Both the institutions seem to be very well equipped for practical instruction. The papers, read either at Leeds or at Torridon, well characterise the wide range of the activities of the institutions with which the authors of the papers to be noticed are, in most cases, connected.

WORSTED SPINNING.

Important advances in processes and machinery were described in a paper by Messrs. Howard Priestman and A. W. Stevenson on Higher Drafts in Worsted Spinning. In this class of spinning, they explained, the top, i.e., the product of combing and associated processes, was reduced to the size required for yarn formation by a series of drawing or drafting processes, the material being wound on a bobbin for each stage and unwound for the next, when it approached the rollers in reversed direction. The reversal practice had become a trade axiom, but they had succeeded in developing a capping-spinning frame for two successive drafts. At first the fibres had frequently strayed and lapped on the rollers, until a false twist had been introduced in the second draft by a special mechanism. Cross-bred wools were given two false twists in series, but a single twist might suffice. In each case the draft could exceed the length of the fibre which had so far been considered inadmissible. The new frames on this principle, shown at Torridon, required less plant for converting tops into yarn. In the study of the working of the parts, various new devices comprising a stroboscope had been used. The arc beam and rotating mirror of the stroboscope* showed the spindle quite steady, so that slack twist and irregularities due to speed fluctuations were at once discovered. At the same time, the tension in the yarn was measured, both as the yarn left the front roller (top-drag) and as it was being wound on the bobbin, which was making 5,000 to 9,000 r.p.m. (bottom-drag).

* The early forms of the stroboscope and of some of the instruments now used for measuring pieces of the order of half an ounce, at speeds up to 9,000 r.p.m., were described by Mr. Stevenson in ENGINEERING, vol. cxvi, pages 255 and 256.
Electric Driving

in

Scottish Woollen Mills

The

ENGLISH ELECTRIC
Company Limited.

Head Office:
QUEEN'S HOUSE, KINGSWAY,
LONDON, W.C. 2.
ELECTRIC DRIVING

IN

SCOTTISH WOOLLEN MILLS

Reprinted from The Electrician, February 22nd, 1922

The

ENGLISH ELECTRIC
Company Limited.

Head Office:
QUEEN'S HOUSE, KINGSWAY, LONDON, W.C. 2.

July, 1922.
Publication No. 370.
Electric Driving in Scottish Woollen Mills

By A. W. STEVENSON, B.Sc. (Edin.), Wh.Ex.

(British Research Association for the Woollen and Worsted Industries).

The author generally considers the conditions which obtain in the Scottish woollen mills. This is a localised industry in a district where water power is often available in sufficient quantities or can be economically supplemented by the public electricity supply. The claims of steam driving under these conditions are considered and various processes necessary to produce the finished wool product are described in detail.

The outstanding feature of the Scottish woollen industry is the number of comparatively small mills engaged in the making of high-class cloths, in most cases from pure new wool. The bulk of the product finds its way to West-end tailors, though a considerable proportion is exported to America and to tropical countries, and before the war there was also a large trade with Germany, Austria, and the Balkans.

The majority of the mills are located on the Tweed and its tributaries, but the name of the staple product does not originate from the river, but from the misreading of the word "tweeds" on a consignment note many years ago. The mills of the north and west work, as a rule, the rougher tweeds, but vicunas are made at Elgin and best overcoatings at Aberdeen, to name two exceptions.

Sometimes spinning, weaving and dyeing are carried on by separate firms, but a more general rule is to find the whole process, from fleece to fabric, carried on within the same gates.

Power Sources—Water.

At one time the water was the only power, and for this reason, and to obtain a supply of scouring water, all the older mills were located on streams. In most cases power requirements have far outstripped the low-fall water supply, though a few mills are still driven mainly by water. There is usually a steam engine as a stand-by for drought or frost, and, in some cases, this engine is run continuously for governing purposes, carrying perhaps 10 per cent. of the load. Many more mills could be driven by water-power at the cost of a few miles of electrical transmission, and last year's strike has made many manufacturers wish to be less dependent on coal.

A firm at Walkerburn, on the Tweed, has put an interesting scheme into operation recently. The river water being of large volume and low fall, direct storage was out of the question. While the mill is standing, the river turbines are used to pump water to a reservoir on the top of a neighbouring hill, 1,000 ft. up, this water returning when the mill is running to a Pelton wheel, in parallel with the river turbine.

A Hawick firm obtain more from their water-power in a different way. During the day a considerable portion of the mill is driven from the public supply by a large d.c. motor, and at night, when the town lighting load is on, this motor runs as a dynamo in parallel with the power station engines.

Public Electricity Supply.

In a few towns public electricity supply is available, mostly direct-current, which is not too suitable for textile purposes. Nevertheless, Hawick, from its d.c. supply, runs three-quarters of the hosiery workshops, woollen spinning and weaving mills in the town. Galashiels is more fortunate in having a three-phase supply laid down specially for mill requirements. The supply network has recently been extended to Selkirk, and will in time be extended to some of the other manufacturing towns.
The Position of Steam Driving.

Whether the transmission is mechanical or electrical, steam still holds a strong place as prime mover in woollen mills, for the very good reason that most mills require steam for other purposes than power. Where there is a dye-house the steam for process purposes may exceed that used for power. There is here a good field for the pass-out or heat-extraction engine or turbine, or, where public supply is available to supplement the steam power, a plain back-pressure engine or turbine. As an alternative to a generator in parallel with the public supply, one or more of the larger motors might be of the simplified synchronous type, and a simple two-cylinder high-speed engine coupled to each, the throttle being, of course, controlled by the pressure in the exhaust main.

Existing Millgearing.

While individual driving has strong claims where capital is available, most existing mills, and some new mills, will be group-driven, in the former case by using the existing millgearing as far as convenient. In the older mills the drive was invariably by spur gear from the engine to the second-motion shaft, and from this to the other main shafts by bevel gearing, upright and "lying" shafts. In the newer mills, and, by alterations, in many of the older ones, ropes have superseded gearing. Where the shaft speed is so low that double reduction is already necessary, an existing rope pulley may be utilised for the motor drive, but even then the diameter of the motor rope pulley is liable to be much smaller than that given by the well-known "thirty diameter" rule. Silent chains form a good drive when the ratio is suitable, i.e., when the shaft speed exceeds 150 revs. per min., or where the cost of an eight or ten-pole motor is not objected to. Most shafts will be found to run under this speed, common practice being 130 revs. per min. for weaving and finishing, rather less for spinning, and 80 revs. per min. for carding. Millhouse shafts sometimes run as slow as 55 revs. per min.

Wool Scouring, Willeying and Teasing.

The wool from the bales, after being sorted into its various grades, is passed slowly through long tanks of soap solution, the excess liquor being squeezed out under heavy rollers fixed on the end of each tank. After being dried either on racks or in a mechanical drier, it is opened out in the willey or teaser before going forward to the carding machines. In some mills willeying precedes scouring and teasing follows it. Oil is applied to the wool either before teasing or by an attachment on the teasing machine, and, for fire prevention, willey and teasers are frequently in a separate building. Direct-current motors and the slip
rings of induction motors should be totally enclosed for the same reason. As in carding machines, the drive is heaviest at starting, though the ratio of starting to running torque is not quite so high. Wool scouring is a fairly light drive, but the motors should have damp-proof impregnation.

**Carding.**

In the carding process the wool fibres are separated from one another, cleaned, remixed and placed more or less parallel, perhaps rather less than more. There are usually three machines in series, the essential feature of each being one or two "cylinders" about 4 ft. in diameter and 5 ft. long, running at 80 to 90 revs. per min., and surrounded by a number of small rollers—"workers" and "stripers." All these are covered with fine wire teeth, and run a few thousandths of an inch clear of each other, the clearance diminishing as the wool progresses. The delivery from the first two machines is in the form of a loose rope or "sliver," which either passes over a small conveyer ("Scotch feed") to the next machine, or is wound in a "ball," sixty balls being placed in a "bank" to supply the next machine of the series. When the ball and bank feed is used the machines are independent of one another, but where the Scotch feed is used the machines so connected must keep the same speed ratio throughout the day. From the third machine of the series the wool is delivered in a large number of small slivers, each containing sufficient wool to make one strand of yarn. To give this small sliver more cohesion it is rubbed between leather aprons, which oscillate crosswise while travelling forwards, this part of the machine being known as the "condenser." The most modern form, and the heaviest to drive, is that in which the slivers—twice as many as in the older types—are each carried on a narrow leather tape, but it has not found great favour in the high-class trade.

The old millwrights' rule for a set of cards was 10 H.P., but this is well on the top side. Five or six would be nearer the mark, with a starting torque of two to three times normal.

**Spinning.**

Spinning is almost entirely by mule, the woollen ring frame finding only a limited application. The action of a woollen mule, or, for that matter, any spinning mule, looks almost human in its complexity. The "condenser bobbins"—about 5 ft. long and 8 in. in diameter—from the carding machines are mounted on the stationary part of the mule, part of which is the "headstock" containing the gearing and clutches for the various motions. The moving part or carriage bears the spindles. In the first part of a cycle the carriage runs sharply out, sliver being delivered from the bobbins during the first half of the run. During the second half the sliver, or rather the partially made yarn—for the spindles have been running all the time—is drawn out, the thick parts, curiously enough, stretching most. At the end of the outward travel the speed of the spindles is greatly increased, the carriage remaining stationary or moving slightly inwards in response to the shortening of the yarn as twist is put in. When twisting is completed the spindles are given a few reverse turns to release the loose coils from the spindles, the carriage moving out again a few
inches, this time by power. The final operation of the cycle is to return the carriage to the starting point, the spindles being driven slowly in a forward direction to coil on the completed length of yarn under guidance of the faller wires.

**An Irregular Power Curve.**

It will be obvious that such a cycle of operations gives rise to a very irregular power curve, the highest peak being three or four times the average. Further, steadiness of speed during the spinning period is very important in the high-class fine yarns common in the Scottish trade. Individual driving is well worth while, but, if for reasons of economy group driving is installed, the groups should be as large as possible. Even with a large group there is always the possibility of a number of mules getting into synchronism, causing severe variations in speed, and even pulling the motor out of step. The practice occasionally adopted of driving the mules in pairs from one motor is the worst possible, as a peak load from one mule, due to the acceleration of the spindles or the running in of the carriage, is bound sometimes to occur during the spinning period of the other mule, when it is essential that the speed should be undisturbed.

**Twisting, Winding, Warping.**

Twisting or doubling is invariably done on ring frames, usually known as "throstles." The load is a steady one, and fairly heavy. Practically all the yarn is rewound between spinning and weaving, warp yarn being wound in "cheeses" or on large double-ended bobbins, and weft yarn on pirns somewhat similar to those used on the mule, but of smaller bore and more tightly wound. Most winding machines are light, steady drives. Warp mills, which wind the yarn in proper sequence on the loom warp beams, take up a large amount of space, but are quite light.

**Weaving.**

Space does not permit description of the fundamental mechanism of the loom, and, in any case, it is common to all textile trades, and familiar to most engineers. The typical loom of the Scottish trade has a 90 in. "reed-space," or maximum width for material, and puts in 90 to 100 picks or "shots" of weft per minute. This is not always the speed of the driving pulley, as there is often a bevel or spur reduction gear embodied in the loom. Shedding, or movement of the warp threads for correct interlacing, is invariably by dobby, this having usually capacity for twenty-four shafts or healds. Picking is always of the "under" variety, and the shuttles for fancy coloured wefts are carried and controlled by drop boxes, usually with four compartments each. The favourite makes are Dobcross, Hattersley and Hodgson. The actual power taken by these looms is sometimes over 1 H.P., but about half this is a sufficient allowance in group driving. For individual drive they are a fairly tough proposition, though less so than the heavy Jacquard looms of the Belfast trade, which have been successfully dealt with by at least one firm. The Scottish field would appear to be a good one, as, in addition to the well-known advantages of regularity, beneficial in so high-class a trade, there may be a substantial saving in power. As pointed out by Dr. Crowley some years ago, the
saving in power with individual driving increases rapidly as the percentage of standing time of the machines driven increases. A fancy loom has more and longer stoppages than a loom weaving plain goods, and all the time it is standing its little bit of shafting, its belt and its loose pulley are absorbing power in a group drive scheme.

**Scouring and Milling.**

After leaving the loom the "piece" undergoes inspection, also picking and darning—hand processes. From these it passes to the "mill-house" for scouring and milling. Scouring machines take a heavy torque at a slow speed—about 50 revs. per min., the horse-power being about three. Milling machines, or "box mills," take considerably more power at higher speed, and, in addition, are a somewhat jerky drive. In a few mills the old-fashioned fulling stocks, or "wauk mills," large wooden hammers, lifted by cams like tilt hammers, are used, but most firms whose work requires this type of milling use "fast stocks," in which the hammer heads are driven positively. Where both milling machines and stocks are installed they are to some extent alternative processes, and need not be provided for simultaneously in a group drive. Most mill-houses have a hydro-extractor, which is a good case for individual drive, preferably by a built-on motor.

Mill-house motors must have damp-proof impregnation: starters, slip-rings and d.c. machines being totally enclosed.

**Finishing.**

Leaving the mill-house partially dried, the pieces are fully dried and stretched to width on the tentering machine. The power taken by this machine is from 2 to 3 H.P., but its location often makes it worth a motor of its own, which should be placed outside the tentering-room, the temperature inside often reaching 180° F.

The finishing house contains an assortment of machines, varying with the class of trade, all very light to drive, and seldom all running. The cropping machine, or "Yankee," which cuts the loose fibres much as a lawn-mower cuts grass, is, as now electrical throughout in most finishing sequences, some pieces returning to it several times. Other machines are brushes and raising gigs, both of which vary widely in design. Steam blowing machines, fitted with a vacuum pump, are fairly heavy to drive, but not so much so as the pulleys on some would indicate. Pressing is invariably hydraulic, with belt-driven pump.

**Photographs.**

The illustrations accompanying this article show some of the driving arrangements adopted in the conversion to electric drive of Tweed Mill, Galashiels, belonging to P. and R. Sanderson, one of the leading firms in the Scottish tweed trade. The drive was previously from a Corliss steam engine through the usual gears and ropes, but is now electrical throughout from the mains of the Galashiels and District Electric Supply Company through a 6,000/500 volt transformer. It was converted from steam to electrical drive in 1914 by Dr. J. F. Crowley, the plant being installed by Siemens Bros. Dynamo Works (now The English Electric Company). The installation is remarkable for the arrangement of the drives and the large amount of shafting that was eliminated in the conversion through careful attention to lay-out details. There are over twenty motors in the installation, ranging from 1 to 37 H.P. in output.
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Observation of Moving Bodies by Intermittent Illumination.

By
A. W. Stevenson, B.Sc., Wh. Ex.
and
M. C. Marsh, B.A. B.Sc.,

ABSTRACT.

Various types of stroboscope producing synchronous intermittent illumination are reviewed and compared with instruments giving intermittent vision. A type is described in which a focussed beam of light is deflected by a revolving mirror and sweeps over the objects under observation.

The use of such an instrument has been extended to the observation of aperiodic motions. The technique and limitations of such asynchronous intermittent illumination are given. Various applications are mentioned and comparison made with spark photography and the high-speed cinema.

(IN COURSE OF PUBLICATION)
Since the stroboscope was invented by Plateau about 1834 many instruments have been devised for the observation of bodies in periodic motion. Some, like his, provide for intermittent viewing of the object; others, in general more useful for research purposes, provide intermittent illumination of an object otherwise in darkness.

**Intermittent Vision Stroboscope.**

Such instruments do not strictly come within the scope of this paper but a choice has often to be made between intermittent viewing and intermittent illumination as experimental methods. Where exact definition is not required, as in stroboscopic speed measurement, the disc with radial slots used by Plateau is simple and compact and can be used without darkening the room, but if a high speed and sharp definition are required, the linear speed of the disc soon becomes uncomfortably high. A recent example, the Ashdown Rotoscope is a distinct advance and gives binocular vision.

**Intermittent Illumination Stroboscopes.**

When the action to be observed can be isolated in a partially darkened laboratory this class is more suited than the first for research purposes. The degree of darkness required depends on the intensity of the intermittent illumination and also on the observer's acquaintance with the phenomenon. They give unhampered binocular vision from all sides.

This class may be divided into three types - those in which the light beam is periodically (a) extinguished at the source, (b) obscured and (c) deflected.

As examples of type (a) sparks from a condenser through a recurring spark gap have been used by Birste for photographing model air screws, Elversen uses a Neon lamp operated by a rotating contact breaker and induction coil. Harrison and Abbott use a similar arrangement with an electrically maintained tuning fork as contact-breaker. J. & A. Seguin use a large Neon lamp with a rotating contact-breaker which only passes a small portion of the current used.

The second section (b) of this class, in which a shutter is operated in the path of the light is said to have been used by Doppler in 1845, and was used recently by Davis in ripple investigations. The system does not lend itself to sharp definition for while a slit 1 mm. wide will suffice for purposes of vision, it will not pass the beam from an arc lamp or similar source unless a complex lens system is used. An example of this type, intended mainly for speed measurement, The Crompton-Robertson Stroboscope, has shutters attached to an electrically maintained tuning fork.

**The Mirror Stroboscope.**

The only representative of type (c) as far as we know, is the one developed by the British Research Association for the Woollen and Worsted Industries.
When they took up worsted spinning research in 1921, the first requirement was a stroboscope which would show the curve of a thread revolving, like a skipping rope, at 6000 r.p.m. in a path about 10 centimetres in diameter. Several instruments on the market were considered and rejected owing to cost, insufficient sharpness or lack of fine speed adjustment. H.J.W. Bliss suggested reflecting the focused beam of an arc lamp by a disc mirror revolving about one of its diameters as shown diagrammatically in Fig. 1. From this suggestion one of the authors10-12,14,15 developed the instrument shown in section in Fig. 2, and in use of a spinning frame in Fig. 3. The revolving mirror is of stainless steel, 5 centimetres diameter to allow for the spherical aberration of an ordinary condenser and the finite size of the source, also to give some latitude in centring. The mirror spindle is driven by a flint cotton tape 1.5 centimetres wide from the machine being investigated. Coarse adjustment of the mirror speed is made by changing the driving pulley and fine adjustment of ±10% by the cone pulley A and adjustable guide pulley B. The two stationary mirrors C & D are introduced to keep the instrument compact and portable.

The definition given is by no means so good as that obtained by Baird's or Seguin's but it is much higher than can be obtained by most shutter instruments. Ordinary printed line from 12-point type can be read on a bobbin 3.5 centimetres diameter running at 8000 r.p.m.; the definition being almost independent of speed when above 1000 r.p.m. Equal black and white spaces 1/20 inch can be distinguished and counted on a bobbin 1 cm. diameter, corresponding to an angle of about 3° degree each for line and space.

Up to the present the revolving mirrors used have been of burnished stainless steel, only approximately flat. For more exacting requirements the mirror could be optically worked with concave surfaces of spherical, cylindrical or aspherical form. A spherical surface would narrow and intensify the zone of illumination and shorten the duration of the flash, while a cylindrical surface with its axis parallel to the axis of rotation would only decrease the flash duration.

The instrument is extremely simple and robust, the only moving parts being a spindle in two bearings and a guide pulley. The only electrical parts are those belonging to the projecting arc lamp. Where electricity is not available, limelight and oxy-acetylene have been successfully used. The Pointolite and metal filament lamps of the arc type have been tried, but they do not give the clearness and brilliancy obtained with arc or oxy-acetylene illumination.

The instrument has been used by one of the authors for exact study of the yarn loop in cap spinning under centrifugal and aerodynamic forces and for reading measuring instruments integral with the rotating portion of the spinning mechanism11-13, also for the measurement of discrepancies in the velocity ratio of the tape drive4,14,15 with the aid of a band similar in principle to the Drysdale disc this ratio can be measured to within 0.1%. These experiments were first made in a comparatively darkened laboratory, but after the stroboscopic 'image' of the spindles and yarn became familiar, it could be recognised in a moderately well-lit mill.
ASYNCHRONOUS INTERMITTENT ILLUMINATION.

During some investigations of the action of woollen carding machines, it became desirable to watch the behaviour of the wool at higher speeds than could be followed with the eye in ordinary light. The mirror stroboscope as described above has often been suggested as a probably means of investigation of carding action, although the action was not truly periodic and the best that might be expected would be an "average" of succeeding wool fibres behaving in similar ways.

At first the stroboscope, independently driven, was used on a small carding machine of the ordinary type but it was impossible to see even an average of wool fibres.

Another small machine, specially built for ease of observation and illumination, was then brought into use. This machine is virtually a longitudinal sectional model, 1" thick, of the large machines. It was still impossible to see individual fibres as long as they were viewed from the illuminated side, in spite of attempts at synchronous adjustment of the stroboscope over a wide range of speeds.

It was then discovered that, if the observation were from the side opposite to that of the light, the wool fibres became very distinct and could be seen even when the machine was running at high speed, without any synchronisation between the stroboscope and the machine. With a neutral background behind the fibres and the stroboscope mirror as near to the line of sight as possible without being itself seen, the wool appeared to be almost self-luminous.

Experimental.

This method of observing bodies in aperiodic motion seemed to be interesting and to hold possibilities. Some experiments on the principles involved were therefore devised. To avoid possible confusion of synchronous and asynchronous effects and at the same time to get a steady and measurable velocity, the object to be observed was placed on an endless belt running over pulleys about 5 metre apart and driven by a variable speed motor. The motor was controlled by one rheostat in series with it and at low speeds another in parallel with the armature. The maximum speed used was 30 metres per second.

The motor speed was indicated throughout by a tachometer but owing to the possibility of belt slip, important measurements were checked by timing revolutions of the belt by stop watch. By this apparatus it was possible to obtain a known and widely variable linear velocity without there being any risk of synchronisation between the object observed and the stroboscope.

With this arrangement, the velocity of the belt for which certain figures and letters or other objects could be seen distinctly in steady lighting was measured.
It was found that it was possible to follow the object with the eye in a way not comparable with the observation of wool fibres at a point so all observations were made through a 15 cm. gap. The illumination was by a 100 watt gas-filled lamp in an enamelled reflector at a distance of 1 metre. The use of an arc lamp made no appreciable difference in the ease of reading; in fact, with very intense beams it was found that reflection from the surface of a black tape made the contrast with white letters weaker.

Intermittent illumination was then started and although the speed of the belt was increased the object could be seen clear, sharp and stationary at regular intervals along its path. Each impression lasted only for a very brief time and, as it was stationary, there was no tendency for the eye to follow the motion and hence viewing through the 15 cm. gap was unnecessary. Good contrast was essential to seeing the object.

Results.

The frequency of the flashes was found to have little effect on the clearness over a wide range of speeds for any given motion. When the frequency was very low there was the usual discomfort due to flicker, but there was also a blurring of the impression at low speeds due to the fact that the angular width of the beam was constant and therefore the duration of the flash was proportional to the period. Thus, even when flicker was absent, a too low speed was indicated by blurring. On the other hand, when the mirror speed became too high the impressions of the object were faint because of the very brief time of illumination. Also, due to the short period, the 'images' were very close together and sometimes overlapped.

In some cases it may happen that there is both blurring and overlapping. This can be frequently remedied by blacking one side of the mirror and running it at a higher speed. In this way the period is increased and the flash duration decreased at the same time. An alternative would be the use of a concave mirror.

Three types of belt were used:–

(1) White belt with black letters.
(2) Black belt with white letters.
(3) A "rope" of wool made from twisted worsted roving with fibres brushed up.

With each of these, speed measurements for steady and intermittent illumination were made and the results are set out in the table below.
Object under Observation | Maximum speed at which object is visible with | Ratio of Speeds.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steady Illumination</td>
<td>Intermittent Illumination</td>
</tr>
<tr>
<td>12 mm. letters—black on white belt</td>
<td>0.85</td>
<td>16</td>
</tr>
<tr>
<td>12 mm. letters—white on black belt.</td>
<td>1.2</td>
<td>27*</td>
</tr>
<tr>
<td>2 mm. letters—white on black belt</td>
<td>0.46</td>
<td>8.8</td>
</tr>
<tr>
<td>Wool fibres projecting from rope.</td>
<td>0.30</td>
<td>12</td>
</tr>
</tbody>
</table>

* This speed was the highest obtainable at the time so an even higher ratio could be obtained.

It was quickly realised when measurements were started that definite figures have little meaning, so only a few readings were made. The maximum speed with both systems of illumination depends on factors which cannot be readily defined, e.g. contrast, stray light, rest or lack of rest of the eye before observing and skill of the observer. Further investigation is felt to be a physiological rather than a physical matter, but the figures given indicate that the ratio of the maximum speed in intermittent illumination to that in steady illumination is 20 or above. The high value in the case of wool fibres is due to their great brightness, the cause of which is discussed later.

From the experiments it was concluded that to get the best results from intermittent illumination:

1. A good contrast should be provided.
2. The duration and period of the flashes should be such that there is no blurring on the one hand and no overlapping of faintness of impression on the other.
3. The light should be as intense as possible.

Visibility of Fibres.

An investigation was then taken up with a view to determining the reason why wool fibres appear much brighter when viewed from the side opposite to that of the light than from the same side. This brightness increases as the light approaches the line of vision but the effect is vitiated by dazzle if the source can be seen.

* A similar arrangement is used to detect small quantities of dust in pure liquids. (Krishnan, Phil.Mag.50. p.698)
A black wool fibre gave much less effect than a white one, and a metal wire of the same diameter did not appear bright at all under similar circumstances. Also the brightness was greatest when the wool was perpendicular to the plane containing the eye and the incident beam.

As a further test, wool fibres strongly illuminated and viewed through a microscope containing a dark screen were compared with a glass rod and the appearance was found to be the same. The chief brightness was due to refraction, the reflection being much less intense and from one side while diffraction caused a very faint line on the opposite side. These facts all point to the effect being due to refraction through the fibre. Irregular refraction, however, occurs at the surface of the wool due to the scales.

**Comparison with Synchronous Intermittent Illumination.**

While synchronous intermittent illumination may be looked at as only a particular case of asynchronous, the effects produced are so different that each has a field of its own. Both synchronous and asynchronous depend on momentary impressions made on the eye. In the synchronous type these impressions are more or less superposed and give a continuous illusion of the object observed being stationary or in slow motion. Its form and behaviour can be studied at leisure and observations made of dimensions and positions, either with the naked eye or ophthalmometer. If the apparatus producing the intermittent illumination is satisfactory, it is unnecessary for the object to present bright lines or sharp contrasts and no care is needed in the selection of a background.

Perhaps it is the eminently satisfactory nature of the results from good synchronised intermittent lighting that has caused the possibilities of similar lighting not synchronised with the moving object to be neglected. With many objects the effect of dropping out of synchronism is so distracting that the utility of asynchronous lighting might well be doubted. But research is necessary on many objects which have no periodic motion, a periodic motion too slow for stroboscopic observation, or a combination of several periodic motions not in harmony with each other.

The experiments described above show that much information can be obtained with intermittent illumination though synchronisation is impossible or useless, provided a vivid appearance can be obtained by the use of bright lines or sharp contrasts. Observation is by no means as easy as when synchronisation can be used and measurements cannot be made with the same certainty, but when compared with observation of the same phenomena by ordinary light the difference in result is very marked. The blurred effect produced by rapid movement is replaced by an illusion, not of rest as with synchronised lighting, but of motion in short jerks with brief stationary intervals during which shape and position can be observed.

**Uses.**

Besides the observation of the irregular motion of wool in carding which led to these investigations, other possible textile uses are the observation of loom shuttles (which are still "throw" mechanically from one side of the cloth to the other), and observation of the
fibres in some types of combing machines where the motion is intermittent. Water jets and splashes might prove interesting subjects, also circuit breakers and other mechanical trip devices, such as valve gears on slow-speed engines.

The last suggests an interesting comparison of the uses of synchronous and asynchronous intermittent lighting. A petrol engine valve gear which repeats its cycle 1000 to 2000 times a minute would be investigated on the synchronous system, but if these were applied to a steam or gas engine valve gear making 80 to 100 cycles per minute, each image would fade from the eye before the next reached it. Yet portions of the movement would be too rapid to be followed by the eye in the ordinary way. With intermittent lighting of such frequency that the parts moved a small amount between flashes, the movement could be followed and peculiarities noted.

Another suitable subject would be the movement of a rail joint as a train passed over it at various speeds and another the action of the collecting shoe of an electric train as it enters or leaves a section of third rail. Many other uses will readily suggest themselves.

The mirror stroboscope has been used throughout these experiments, but there seems no reason why other forms of instrument producing intermittent illumination or even good vision instruments should not be equally effective.

Comparison with other Methods.

Alternative methods for observation of moving bodies are spark photography and high-speed cinematography. Both these have the advantage over intermittent illumination that they give a permanent record, but the development of this record is a matter of time and trouble. There are also many cases where it is desirable to watch what is happening at any particular moment rather than to wait for the development of a record. As far as intermittent illumination by the mirror system has yet been developed, spark photography has the advantage also in point of speed, but the apparatus required is complex and expensive. The high-speed cinema is in course of rapid development, but as far as we can learn 1/1000 of a second is reckoned a very short exposure, except for such elaborate examples as the Heape and Grylls17, 18. During this period of time the belt used in the foregoing experiments would move two and a half centimetres. When it is remembered that letters 1.2 centimetres high were perfectly legible, the effective exposure to the eye must have been about 1/10,000 of a second.

Conclusion.

Intermittent illumination can be used, with certain limitations, in the study of bodies in aperiodic motion. The bodies must present bright lines or sharp contrasts, the intermittent illumination must be derived from a suitable apparatus, and the linear speed, as far as the method has been developed, should not exceed twenty times that at which the object can be seen in ordinary light.
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13. Ibid. No. 40, 1924.
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Fig. 1

Fig. 2

Fig. 3 - Photograph as Fig 3 of Publ. No 37 or Fig 6 of B.A. Paper.
WORSTED SPINNING RESEARCH.

A Thesis by

A. W. Stevenson, B.Sc.(Edin.), Wh.Ex.

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April 30th, 1928.
INTRODUCTION.

The greater part of the writer's research work on Worsted Spinning is described in the printed publications which accompany these pages, which provide an introduction to the printed matter, a summary of it and an indication of the lines of present and future development.

With this in view they begin with some personal notes on the writer's connection with textiles. Some observations follow on the lack of fundamental progress in textile machinery and, as a possible cause, the lack of scientific data for the design of such machinery. Next is an outline of worsted spinning processes in general and a more detailed description of the cap spinning frame, on which most of the writer's work has been done. That work is outlined, first consecutively under various headings and secondly as abstracts of the publications submitted.
The writer has been in touch with textiles throughout his engineering career, and for the last seven and a half years he has been engaged in research work on textile machinery.

His apprenticeship (1902-1908) was in the shops and drawing office of Messrs. Aimers, McLean & Co., Galashiels, an old established firm of millwrights, engine builders and textile machinists, who have planned and equipped woollen mills from Banff to Somerset. Concurrently with his apprenticeship he was an engineering and textile student of the Technical School at Galashiels, and during his graduate and post-graduate course at Edinburgh (1909-1913) he was head of the engineering department of the South of Scotland Technical College, a development of the old Technical School and now the Scottish Woollen Technical College. In his University course he was medallist in Natural Philosophy and Engineering Drawing, and graduated with distinction in the latter subject. His post-graduate work included research on combined stress at the University under Prof. Beare. At Galashiels he was City and Guilds Honours medallist in both mechanical and electrical engineering, and South Kensington honours medallist in geometry.

As head of the engineering department at the Technical College he investigated what was then a novelty, the electric driving of textile mills, and prepared a report to the College governors on the subject. Members of that body were shortly afterwards the pioneers of a public electric supply for Galashiels, and it may be of interest to note that of the four public supplies on the
Borders this is the only one really suitable for textile driving and under the new Act will probably absorb the others.

These investigations of electric driving brought him in touch with Messrs. Siemens Brothers Dynamo Works, and he eventually joined their staff as a specialist in textile electric driving under J.F. Crowley, B.A., D.Sc. Subsequent to graduation and before joining them he spent some time in the study and practice of woollen spinning and weaving at the Technical College, taking City and Guilds certificates in both subjects. In September 1922, at the request of the Editor of the "Electrician", he contributed a special article on "Electric Driving in Scottish Woollen Mills".

The Great War brought more urgent problems than textile-electric development, amongst them aero-engine design and research. At the Royal Aircraft Factory the writer carried through the stress and bearing-pressure calculations for RAF8, a 14-cylinder air-cooled design which eventually became the famous "Siddeley Jaguar", and he did a large amount of flying with the experimental models of RAF 3a, a 12-cylinder water-cooled engine. Following his chief Mr G.S. Wilkinson, to Hendon he was intimately concerned in the detail design and bench tests of Airco 1, holding the position of chief draughtsman.

Peace, and the establishment of the Department of Scientific and Industrial Research with its subsidiary trade associations, made the way clear for a return to textiles, and in 1920 the writer was appointed Research Engineer to The British Research Association for the Woollen and Worsted Industries with headquarters at Leeds.
With them his work has been largely concentrated on worsted spinning, in which he has had the collaboration of Mr Howard Priestman, a well-known textile writer and practical spinner. At the time of writing he is engaged on the layout of a new building for worsted spinning research, of which he will have charge.

Amongst other work was collaboration with the late Director of Research, Major H.J.W.Bliss on such problems as the design of a machine for the wet stretching of yarn (not drafting), and the installation of a constant temperature and humidity room, collaborating with the sub-committee on woollen spinning, and the installation of a woollen carding plant.
TEXTILE MACHINERY.

Spinning, weaving and dyeing are amongst the oldest of human arts. The Book of Job draws its metaphors freely from textile pursuits and they are referred to in the earliest records of almost every race. It is therefore not surprising that they were the first to be affected by the wave of mechanical ingenuity which brought about the industrial revolution, and that the first factories were textile factories. Similarly in the manufacture of textile machinery; "mass production" of similar parts was standard practice long before the petrol engine was invented.

The last fifty years seem to have brought about a relative lull. Certainly in worsted spinning there has been no fundamental change in either processes or machines. The writer has in his laboratory a spinning frame at least thirty years old which is indistinguishable from present-day machines alongside except for a few minor details. It is frequently urged in mitigation of this lack of change that the machinery has reached the limit of possible development and that because a wool fibre remains a wool fibre no change can be expected in the apparatus for its treatment. One need only look at other classes of machinery to realise that this is a fallacy. Today's lathes and planers are widely different from those of fifty years ago and for many purposes have been replaced by machines unthought of at that time, though the material worked on is little different. Steam is still steam, but the uniflow engine and the tubbine have little in common with Newcomen's engine.

It does not seem unreasonable to connect the stagnation in textile machinery with a lack of application
of the scientific principles which have contributed so much to progress in other branches of engineering.

Such theories as there are of the action of textile machines are vague in the extreme, and are unsupported by measurements of performance other than those required for the marketing of the product. The count, or length per unit weight, of the finished yarn is a frequent subject of measurement, as are the twist and the tensile strength, because the requirements of the cloth constructor must be met in these respects. But what might be called internal measurements in spinning such as the tension in the yarn as it is being spun, the forces controlling its behaviour while spinning, even the precise measurement of the speed of the spindles, were as far as the writer knows untouched previous to his own work on the subject.

It is noticeable that progress in the examples given above has been associated with accurate measurement not only of the product-machine parts or mechanical power—but of every detail of the action. It is generally admitted that lathe design took a fresh impetus from research work on cutting steels in which everything measurable in their performance was measured. Engine development without an indicator would have been slow and much of the work to be described bears the same relation to spinning that the detailed study of the indicator diagram does to steam engine theory and performance.
As there is much popular confusion between woollen and worsted and even between spinning and weaving a few notes which will give the setting of the research work may not be out of place.

Textile manufacture in general consists of breaking up the natural arrangement of the fibres concerned, placing them side by side in a continuous strand, twisting this strand to form a yarn or thread and interlacing such threads to form a fabric. Weaving interlaces two sets of threads at right angles; knitting in its simplest form interlaces one thread with itself in a series of loops.

The processes by which wool fibres are made into yarn fall into two main classes, the woollen and the worsted processes. In the former there is no great attempt to get the fibres parallel to each other previous to twisting together or spinning, and in the wet processes subsequent to weaving the fibres are encouraged to interlock with their neighbours in the same and adjoining yarns, making the fabric somewhat felt-like. In worsted process, on the other hand, the fibres are combed out so as to lie parallel to each other and the short fibres which might be curly and straggling are rejected. The product of the combing and allied processes is known as a "top" and in it the fibres form a loose twistless rope about an inch in diameter which is wound into a ball about eighteen inches in diameter. The top, after a few weeks rest, is passed through one machine after another, being drawn smaller and smaller, not by molecular movements as in wire drawing but by the fibres slipping over each other.
lengthwise so that there are fewer and fewer of them in the cross-section as it leaves each succeeding machine. When drawn to the necessary fineness the fibres are twisted together sufficiently firmly to prevent further slipping, the result being a yarn or thread which has a tensile strength approximating to that of the fibres of which it is composed.

In more than half the world's worsted spinning the final drawing-out of the fibres and their twisting into yarn take place on a cap spinning frame and it is on this machine that most of the writer's research work has been carried out.
CAP SPINNING FRAMES AT ASHFIELD MILLS, BRADFORD.

CROSS SECTION OF CAP SPINNING FRAME.
THE CAP SPINNING FRAME.

It is an interesting coincidence that the writer should be summarising what he believes to be the first scientific research on the cap spinning frame exactly a century after the process was invented. Danforth in June 1828 and Thorp in November of the same year described slightly different forms to the United States Patent Office and Hutchison, a Liverpool merchant, took out the British patent in 1829. To-day there are nearly two million cap spindles in Yorkshire alone.

Though overlooked by most textile historians, it is a remarkable invention. Simple in construction, it is perhaps the least obvious in conception of the spinning inventions of the period and for originality stands alongside the flyer-spindle sketched by Leonardo da Vinci in 1519 and constructed by Jurgen, probably independently, in 1530. The wonderful inventions which laid the basis of the industrial revolution and as such occupy the attention of textile historians were mechanised versions of existing processes. Hargreaves's jenny (1760) and Crompton's mule (1779) copy the motions of the spindle-point type of hand spinning wheel (the Scotch "muckle wheel" and the Irish "long wheel"), itself a short step from the primitive finger-spun spindle, while Arkwright's water-frame (1769) is simply a multiple and power-driven version of the flyer or "small" spinning wheel of Jurgen, at that time in universal use in all civilised countries.
The function of the cap frame is threefold. It draws out the strand of fibres supplied to it to a greater fineness, twists the fibres together to give them strength and winds the yarn so made on to a bobbin. These three operations go on simultaneously. The rollers AB draw from a bobbin the roving made in a previous process at a speed of one inch per second. Rollers CD have a surface speed of six inches per second so the strip of material delivered by them has one-sixth the weight per unit length that it had when entering rollers AB, the fibres having slipped over each other to attain this fineness or fewness of fibres in the cross-section. This process is called drawing or drafting and its accomplishment by rollers was invented by Wyatt and Paul in 1737. It was used by Arkwright in his "water-frame" and had reached a fair stage of perfection before being associated with the cap spindle in 1828.

In the lower part of the figure are seen the driving whorl, the bobbin and the "cap" from which the frame takes its name. Not shown on the figure is the stationary or "dead" spindle which passes up through the whorl and bobbin and into the head of the cap, which is also stationary. The whorl is driven by a flat cotton tape and in turn drives the bobbin by dogs on its upper face.

One way of starting the operation is to run the rollers until about eighteen inches of drafted roving has been delivered by them and taken clear of the spindles by hand. This drafted roving, a filmy strip of loosely adhering fibres about an eighth of an inch wide, is twisted between finger and thumb until the fibres bind each other together and form a yarn of moderate tensile strength. The end is then attached to the bobbin and the machine re-started.

The yarn flies round with the bobbin and by
GAP SPINNING BALLOON.

Bobbin empty, yarn flying clear.

Bobbin full, yarn "licking" gap.
centrifugal force flies outwards like a skipping rope, putting twist into itself with every turn of the whorl. If no fresh material were fed through rollers CD the yarn would soon break through excessive twisting. But material is being fed forward and the first effect of this supply is to make a larger balloon. If there were no air resistance to the yarn as it flies round, the balloon would go on increasing, but the further the skipping rope of yarn gets out the greater its linear velocity and the greater (as the square of the linear velocity) the air resistance it encounters. Due to this air resistance the yarn leans back in its flight instead of remaining in a radial plane and soon begins to wind itself on the bobbin. A state of equilibrium has now been reached in which the balloon no longer increases in diameter but as much material as is delivered by the rollers CD is wound on the bobbin as finished yarn.

As this yarn cannot be allowed to accumulate in one place on the bobbin the whorl and bobbin are made to reciprocate on their stationary supporting spindle, the cap edge guiding the yarn and distributing it evenly over the length of the bobbin.

The research work described in the following pages and in the accompanying publications includes the observation of the spinning process by a specially devised stroboscope and the precise observation of spindle speeds by the same instrument. Some of the causes of accidental variation of spindle speed have been investigated, and the tension in the yarn both as it leaves the rollers CD and as it winds itself on the bobbin has been measured under a wide variety of working conditions. The drafting mechanism ABCD has been investigated and improvements made which may have far-reaching practical results.
The phenomenon whose investigation was the keynote of the writers worsted spinning research now seems a very trivial one. But amongst the many things which practical men found to be mysterious about cap spinning perhaps the most obvious and concrete was the way the yarn has at times of apparently adhering to the cap when it ought to be flying clear. This phenomenon, known as "cap licking" had always, because not understood, been the cause of anxiety and endeavours for its elimination. The writer was asked to investigate the matter and from a suggestion made by the then Director of Research developed a stroboscope which soon showed why the yarn licked the cap and that it would be unreasonable to expect it to do otherwise. It was also obvious that it was doing no harm to itself or to the spinning process and that efforts to avoid licking were not only unlikely to succeed but quite unnecessary.

But as so often happens in research work the search for one thing resulted in the finding of another. While a few minutes of effective stroboscopic lighting were enough to show the true nature and cause of licking, it was also seen that there were considerable variations in spindle speed. The investigation and measurement of these is described with the construction of the stroboscope in the next section.

There are still however other mysteries in cap spinning awaiting solution and for these the stroboscopic
study of the revolving yarn will be essential. Knowledge of what is happening, what the various forces and tensions are, is very fragmentary and those supervising worsted spinning factories are almost entirely dependent on past practice and rule of thumb. Some spinners of more than usual intuition, supported by their own and their forerunners' experience, are probably getting the most from their plant. Most however are in a less fortunate position and when one looks round for information with a view to advancing machine design, getting the most from existing designs or even comparing one method of spinning with another in a scientific way the information simply does not exist.
THE MIRROR STROBOSCOPE.

The speed of the spindles on a cap spinning frame is often over 6000 r.p.m., the yarn is only a few thousandths of an inch in diameter and its speed is not constant. The conditions for stroboscopic observation are therefore arduous and no existing design of instrument seemed likely to be successful.

The suggestion was made of focussing an arc lamp beam on a small disc mirror rotating about one of its diameters, which would make the reflected beam sweep round at twice the angular velocity of the mirror. From this suggestion the writer has developed a stroboscope which has proved itself very well suited for the observation of spinning processes and is finding much wider application. The stroboscopic image is of unusual clearness and brilliance. Not only can the finest yarn be observed with ease but as will be seen later measuring instruments rotating at 9000 r.p.m can be read. The instrument is simple and sturdy, the only moving part being the mirror, its spindle and conical driving pulley and a small guide pulley for the driving tape. It is driven off the machine under observation so that it follows any change in speed of the machine as a whole and is therefore a more sensitive detector of variations of relative speed within the machine itself which are the variations that cause bad work. In the particular case of the cap spinning frame it was desired to study the behaviour of the tape drive to the spindles. The mirror was synchronised with each spindle in turn and the ratio of the spindle speed to the speed of the main tape drum ascertained by pasting a marked band of paper round the drum. By observing which row of marks on the band
appeared to be stationary the ratio of spindle speed to drum speed could be ascertained within about $\frac{1}{2}$%.

A number of instruments have been applied to spinners for use in their mills, both in the routine checking of spindle speed and in their test rooms on new spinning devices. Instruments have also been supplied to other industries such as ball bearing manufacturers and boot and shoe machinery makers.

For a considerable time it was thought that stroboscopic observation could only be applied to motions with which the stroboscope could be synchronised, that is to say periodic motions of fairly steady periodicity. But frequent requests were made that it should be applied to the observation of wool fibres in a carding machine, in spite of the writer's protests that this motion was essentially non-repetitive. In response to these requests some trials were made on a miniature experimental carding machine, and after a few failures to get any result an image of considerable clearness was unexpectedly obtained.

Further observation and experiments give promise that such "asynchronous intermittent illumination" as it has been termed may have wide uses where synchronous intermittent illumination cannot be applied. One of the main essentials of its success is brilliance of illumination such as is given by the mirror stroboscope. Other essentials are strong contrasts or bright lines on the object to be observed and a neutral background. The illusion produced, instead of being one of rest as with the synchronous variety, is of motion in a series of jerks, the object appearing clear, sharp and stationary in each successive position.
The underlying cause of the spinner's anxiety about licking was an idea that it had some effect on what he refers to as "drag", the tension in the yarn as it is being spun. Drag is an all-important feature in spinning and is one of the spinning overlooker's chief concerns. If it is too high the yarn will break frequently, especially just as it emerges from the front rollers. If it is too low the bobbins may not be sufficiently firm, but more important, if it is any lower than necessary production is being sacrificed. Almost every adjustment that lowers drag decreases productivity and increases costs.

It is obvious that so important a factor should be the subject of numerical information, but until the writer took the matter up no attempt had been made to measure drag. The spinner felt the yarn with his finger as it left the front roller and felt the finished bobbin. He knew from experience that certain alterations increased the drag and others decreased it, but why or how much he hardly even guessed.

Its measurement was not easy. Even the "top drag" between the front rollers and the fly board required delicate apparatus, practically a replica in fine steel and glass of the spinner's finger with an autographic attachment to give a record. But the measurement of "bottom drag" as the yarn winds on the bobbin was much more difficult, so much so that direct measurement was not considered feasible and an indirect method devised. Spinning was so carried out that the yarn formed a single layer on an accurately turned metal bobbin.
A line was drawn with a soft pencil across the coils of yarn, parallel to the axis of the bobbin and an exact number of coils unwound alongside a vertical scale. A tiny scale-pan was attached to the yarn and weights added until the length of the yarn was the same as when spun on the bobbin. It was assumed that the total weight was equal to that under which the yarn was spun. Further work showed this assumption to be in error by about 60%, but the failure of the method served a useful purpose in drawing attention to the wide difference between wool yarn and metal wire in their elastic behaviour under conditions such as prevail in spinning.

"Bottom drag" was eventually measured by arranging a very light steel bobbin "floating" clear of the spinning tube on ball bearings and carried round by the equivalent of a fine spring, lagging behind about a quarter of a turn under the influence of the yarn tension. The amount of lag and the behaviour of the apparatus were observed by stroboscopic lighting. Calibration was by a "rope" brake carried out in aluminium and silk cord, the forces involved being of the order of 10 grams.

With the instruments just described a large number of measurements have been made of both "top drag" and "bottom drag" under a wide variety of conditions. The most immediate use has been in showing that larger caps and bobbins do not increase the drag as much as was generally supposed. Such bobbins reduce costs by requiring less handling, as each bobbin holds a much greater quantity of yarn. The figures also allow machine adjustments to be carried out with much greater certainty and less "rule of thumb" and guess-work.
The unwinding method which proved unsatisfactory as a means of measuring drag is at present used in a modified form for other investigations. The take-up of yarn due to the twist inserted in the spinning process, investigated theoretically and on the laboratory bench by Oliver (Proc. Roy. Soc. Edin. 1906, Vol. 26, Part 3, p.182.) has been measured under actual spinning conditions. In these investigations again slight discrepancies have been found under certain conditions, and these discrepancies are at the present moment expected to yield a very valuable method of investigating the limits of application of various spinning processes. Such limits are usually determined by the breakage of the yarn; when this breaks more frequently than a girl attending to a reasonable number of spindles can repair, the "spin" is said to have reached its limit either in fineness of drawing or softness of twist. It is hoped to substitute for these rather uncertain breakages an earlier effect which can be watched while it grows.

The discrepancies of the unwinding method are also expected to throw light on a problem now being approached, that of measuring the "count" or linear density of yarn. This is done by winding about a hundred yards on a reel one or one and a half yards circumference. The resulting "hank" is weighed and the number of hanks of 560 yards to a pound are calculated. This quaint figure gives the equivalent of the "wire gauge" of the yarn. But due to various causes the measurement is subject to large errors and two mills or even two operators will often give from the same material figures differing by more than ought to be allowed even in a commercial measurement. This is a matter of frequent complaint
and research has been started on the subject. The methods it is intended to use will have derived something from those used for drag measurement, the very failure of these methods for their intended purpose being in all probability related to the inadequacy of the present methods of "reeling for count".

Closely associated with drag while spinning is the minimum diameter of bobbin on to which spinning with a given cap is possible. A number of measurements, again the first of their kind, have been made and published. Like other aspects of the cap spinning balloon they show striking anomalies. One of these is that lengthening the balloon - an adjustment frequently made by the spinner according to his judgment - while increasing the tension or drag almost in proportion to the square of the length of the balloon actually allows a smaller minimum diameter of bobbin. Yet the smaller the diameter of the bobbin for a given cap diameter the greater the drag, so that two adjustments which individually increase the drag together make the yarn less liable to break.
JUST AS THE SPINNING OPERATION IS TYPICAL OF SEVERAL WHICH FOLLOW, THE DRAFTING OPERATION BETWEEN ROLLERS ABCD IS TYPICAL OF A NUMBER OF PREVIOUS OPERATIONS. THE OBJECT OF THESE OPERATIONS IS TO EXTEND THE "TOP" OF COMBED WOOL FIBRES UNTIL IT IS FINE ENOUGH TO TWIST INTO YARN.

These processes have been controlled by two rules which, though never proved, have come by constant assertion to dominate the trade - firstly that the draft should equal the length in inches of the fibre, and secondly that two drafts must never be made in succession on the same machine.

As yet, the writer has made no effective challenge to the first rule, except to show that it has not the requisite physical dimensions of a law. It makes a pure ratio equal to a length and therefore variable according to the unit in which the length is measured. Further any attempt to apply the law at or below unit length, results in a "reductio ad absurdum".

The second has been effectively challenged after considerable research to obtain a closer insight into the principles underlying the practice which has been handed down from generation to generation. The first attempts to make two successive drafts using a repetition of the usual drafting mechanism merely resulted in failure, as any practical man would have told us. But by several critical experiments it was found that the rule had no scientific foundation and that therefore the failure to draft twice successively was not a matter of principle but of mechanical details. These failures were therefore closely examined experimentally and a wide variety of combinations tried in which dimensions, speed and...
constructional materials were varied over wide ranges, all with a view to better control of individual fibres. Partial and temporary success was frequently attained but never a consistently good "spin". The movement of the fibres was watched through a reading telescope and roller modifications based on such observations. Little practical result followed except a better understanding of the causes of failure, and a better comprehension of what happens in all drafting of textile fibres.

Eventually a "false twist" was applied to the material while undergoing its second draft, and with a developed form of this attachment consistently good spinning has been accomplished. It is only now being applied to a full-sized frame, but a 16-spindle experimental frame has been run for long periods on a wide variety of material. The spinning has been excellent and on favourable occasions it has run for four or five days without a "broken end". One per hour on 16 spindles would be considered good spinning.

The result of its application on a commercial scale would be to approximately halve the machinery necessary to prepare "tops" for the spinning frame. Perhaps more important than the immediate result in the cutting out of operations is the shock to established theories of what happens in the drafting process, and the encouragement of investigation on scientific lines of this and other processes which have become encrusted by tradition.
The experimental work which has been described particularly that on drafting, has convinced the writer that the most necessary line of work is to put the testing and grading of yarns on a more scientific basis. Not only do the present tests need overhauling but new tests must be devised to replace personal judgment of what is and is not a good yarn. Admittedly the final test is whether the cloth made from the yarn will please the wearer or user, but short of this there are many points at which measurement might be introduced in place of a personal estimate. This would have two great advantages; in the first place errors due to the bias or lack of skill of the person judging would be eliminated and in the second place smaller effects could be detected as the result of smaller process changes. These changes might not be sufficient individually to make a bad yarn but several of them concurrently might do so. Personal judgment would only be able to assess the effect of the concurrent causes; measurement would locate each separately and enable it to be correlated to the machine adjustment or alteration by which it was produced.

The one invariable test applied to all yarns is that of count or length per unit weight. Next most common is to test for twist and a long way behind is to test for strength and what is called "elasticity", really stretch at the moment of breaking. Regularity and roughness are estimated by eye against a suitable background.

One would have expected testing for count to be in a high stage of perfection but such is not the case. The apparatus in general use leaves much to the judgment of
the operator and different operators and different instruments will give values as much as 5% different for the same yarn.

The procedure is to wind on a revolving frame or reel about a hundred yards of the yarn and weigh this, calculating the yards per pound. The error is hardly likely to come in the weighing as the balances in use of fairly good quality and certainly not responsible for errors of the order of 5%.

The errors are certainly in the measurement of the length or more precisely in the tension under which the length is measured. The writer has designed a special reel, at present under construction, in which the reel itself is driven by a spring (like a transmission dynamometer) and the extension of the spring recorded graphically. It is proposed to use this instrument to test the tension devices generally in use and, if they are found to be at fault, to design other tension devices which will be satisfactory when thus tested. Whether this is the whole problem remains to be seen. It is more than likely that hysteresis effects such as invalidated the indirect method of measuring "bottom drag" may also underlie the erratic nature of tests on the usual type of apparatus. A further question which will arise will be the standardisation of tensions at which count is to be measured and for this purpose the drag measurements of the writer will be invaluable. At present it is specified that the yarn must be reeled at mill tension, but what mill tension is no one can say.

Twist is a less frequent subject of measurement and also less satisfactory. One reason for this is that the calculation of twist is not on a sound basis. The
simplest form of calculation is subject to various corrections which are either ignored or vaguely estimated at 10% by some spinners, 5% and 15% by others. The writer has nearly completed a long range of experiments, which may possibly be published in time to accompany these pages, in which the corrections have been carefully determined and yarns so made with accurately known twist tested on standard and specially designed instruments.

Strength testing is probably better catered for than any other test. Some of the machines, particularly those of Swiss make, are instruments of precision. Further progress here will be more on the line of interpreting the tests in terms of spinning process. Strength pure and simple is a quality to be desired on yarn both from the point of view of satisfactory weaving and from the point of view of a satisfactory finished cloth. But the mere fact that a yarn is weak conveys little to the spinner, particularly if the twist is not accurately known. Strength can nearly always be increased by putting in more twist, but while this may make a stronger cloth it may give it a different handle and make it less saleable.

Regularity is a very essential feature and at present is only estimated by eye. Instruments have been devised for the continuous measurement of regularity of cotton yarns but their application to worsted is of doubtful value. Twist per inch or per half-inch is an indirect measure of regularity and probably the means by which irregularity most often makes itself felt in the finished cloth, but its measurement by existing apparatus is tedious. Some of the new instruments mentioned above may give not only more precise results
but more rapid operation, and if successful may provide a useful means of measuring regularity. Other criteria are the weight of inch or half-inch lengths, the diameter under a microscope, the thickness or width when compressed under a shoe.

The writer has in view the investigation of all these to ascertain their order of merit as yarn regularity criteria and the devising of quick-acting, automatic or semi-automatic instruments for the measurement of the most satisfactory.
Abstracts of

PUBLICATIONS SUBMITTED.

Reports of the British Research Association for the Woollen and Worsted Industries:--

No. 15 . Stroboscope . . . . Page 27.
No. 76 . Drag in Ring Roving . . Page 32.

Paper before British Association for advancement of Science.
Worsted Spinning Research . . . . Page 34.

"Wool Record" - Principles of Drafting in Worsted Spinning, etc. . . . . Page 35.

"Scotch Tweed" - Worsted Spinning Research etc. . . . . . . Page 37.


Variations in Cap Spindle Speed and Stroboscopic Observation of Spinning.

This paper and No. 18 are unsigned, as was the custom for publications of the Wool Research Association prior to 1924, but like those that follow it is the joint work of the present writer and his spinning colleague Howard Priestman. Part I describes the apparatus and procedure largely in Priestman's words for the less scientific members of the Research Association; Part II gives the results of the speed variation experiments in tables and curves; Part III covers the ground of Part I in the words of the present writer and also deals with the accuracy of the measurements and alternative forms of stroboscope tried and considered.

Though devised for the detailed observation of the spinning process the stroboscope found immediate practical use as a detector of spindle speed variation. Such variations cause faults in the yarn and subsequently in the cloth woven from the yarn. This publication describes the construction of the Stroboscope, its application to an experimental spinning frame and the precise measurement of speed variation due to tape pressure on the flanges of the driving whorl. This is not the only cause of speed variation and the use of stroboscopes as routine instruments in mills is advocated. A later publication (No. 37) describes a more portable form of the instrument.
Observation of Licking and some Methods of Measuring Drag in Cap Spinning.

The experimental work in the first portion of this publication was really earlier than that in No 15 but was held back to give prominence to speed variation which is more important from the practical point of view.

Attempts were made to photograph the balloon by stroboscopic illumination but owing probably to slight irregularities in the tape drive no image could be obtained on the plate. The next best thing was to model the yarn in wire on an adjacent spindle to that on which stroboscopically illuminated yarn was being spun, and when the model was satisfactory to stop the frame and photograph the model in several positions.

Closely associated with balloon form is the drag or tension in the yarn. The measurement of this at both ends of the balloon was thought desirable and methods devised. The direct measurement of the drag as the yarn was winding on the bobbin was thought to be impracticable and an indirect method adopted. It was found later that hysteresis effects in the yarn were so great that the results given were wholly misleading and a direct method, described in Publication No. 40, had to be developed. Measurement of the drag in the yarn just before entering the balloon, as it leaves the front rollers, was relatively easy, and the method first devised was quite satisfactory in a long series of measurements.
A note on Cap and Bobbin Dimensions and the Reduction of Doffings, also a description of an Improved Form of Stroboscope.

The measurements of drag given in the next publication, No. 40, were not quite ready for publication but were sufficiently far advanced for a useful practical conclusion to be drawn. They show that caps and bobbins larger than those generally in use do not involve a greatly increased drag while allowing the frame to run a much longer time between "doffings" or changing of full bobbins for empty ones.

The stroboscope described and illustrated is a more portable development of the type described in Publication No. 15. The rotating mirror and its drive are unchanged but the arc lamp etc. are arranged in a more compact manner. The instrument in this form is in use in the mills of a number of members of the Research Association also by makers of ball bearings and boot and shoe machinery.
Drag or Tension in the Yarn in Cap Spinning.

This publication follows on No. 18, in which general observations on drag and its measurement are made. One of the methods described in the earlier paper was found quite unreliable and a better method had to be devised. The construction and calibration of an instrument which has to measure forces of the order of 10 grams and at the same time revolve at 4000 to 8000 r.p.m. round a dead spindle is described in the appendix to this publication.

The results of the measurement of drag are given in detailed tabular form for reference and study and are also given as approximate formulae for everyday mill use. Special slide rule methods are also given.

In addition to records of drag under various conditions there are measurements of the smallest bobbin on to which a given cap will spin and also the diameter, always smaller still, on which it will continue spinning when started on a larger diameter.

These measurements, like all the others, have a two-fold interest. In the first place, they are numerical data of everyday practical utility but hitherto unavailable; in the second place they are steps towards a theory of cap spinning, fitting in with previous work on observation of licking and of the yarn curve, later work on balloon diameter and work still to be done on air resistance and cap edge friction.
Higher drafts mean less plant for the same output and had much attention in cotton spinning at home and abroad. This publication describes experiments, only partially successful at the time it was written, on the possibilities of much higher drafts in worsted spinning on the "Bradford" system. They had the definite object of performing two drafts in succession on the same machine, never done in practice and declared by many theorists to be impossible. That it was difficult is evident from the description of the experiments and the many devices tried to overcome "carrier lapping", but experiments of a critical nature such as spinning from a reversed roving and with three successive drafts showed clearly that the difficulties were matters of detail rather than principle.

Much was learned in the course of the unsuccessful experiments of the true nature of carrier lapping, a trouble by no means unknown in ordinary practice and also of the effects of atmospheric humidity and static electricity on the drafting process.

Of the three lines indicated in the last paragraph of "Conclusions", false twist has proved by far the most successful and with a developed form of false twist tube thoroughly satisfactory spinning has been carried out, as reported in the "Wool Record" and also before the Leeds meeting of the British Association.
An Instrument for Measuring Drag in Ring Roving.

A firm of worsted spinners, members of the Research Association, were experimenting on improvements in their roving machinery and wished to know the effect of these alterations on the drag or tension in the roving. The writer modified his yarn drag measuring apparatus and gave the firm the figures they wished to know. The figures threw considerable light on the behaviour of the machine but having been done on a consulting basis are confidential to the firm for whom they were taken.
In the course of the research on licking and drag it was often noticed that the diameter of the balloon did not behave in the way one might expect. As this was the most readily measurable feature of the balloon an exhaustive series of measurements were made of the diameter of the balloon, varying every possible controlling factor over a wide range. Quite apart from the fact that they provide practical data not even indicated elsewhere they form in themselves an interesting study and led the writer to an approximate theory of the forces in the balloon. It is possible that someone may develop a rigid mathematical theory but the problem is difficult. The curve is a sort of catenary in three dimensions, the force corresponding to gravity being in one plane proportional to the dip $\left( \omega z \right)$ and in the other to the square of the dip $\left( \omega^2 z^2 \right)$. In addition there is at one point solid friction of wool on steel fairly well lubricated by air.
Paper at Leeds Meeting of the British Association,  
Sept. 1st. 1927.  

printed in the Journal of the Textile Institute.  

Worsted Spinning Research.  

A brief survey is given of the processes of worsted manufacture to give the setting of the research and the cap spinning process is described in some detail. The first section of the paper is concerned with drafting and begins by criticising the customary formulae for the draft certain fibres will stand. The convention that two drafts must not be made in the same direction is discussed and experiments showing it to be incorrect are described. The causes of early failures to draft twice are stated and the successful mechanisms described and illustrated. Lay-out plans are given showing the floor space that would be saved by the adoption of successive drafting on the spinning frame.

The next section relates to spinning and begins with a description of the improved stroboscope and its use in speed measurement. Instruments for measuring drag both above the balloon and as the yarn winds on the bobbin are described together with their methods of calibration.

In the discussion (for some reason obliterated by the Textile Institute when reprinting, but easy to read by holding up to light) a critic states his disagreement with the principle of making two drafts in succession, contending that the fibres will not be regularly arranged, and alternatively suggests that all the drafts should be made in succession. Priestman replied to the first criticism by referring the critic to users of the yarn and the present writer said it would be wrong to push the principle too far.
Principles of Drafting in Worsted Spinning.

A preliminary announcement is made of the successful drafting of wool twice in the same direction, contrary to present practice and theory. The saving in floor-space, plant and handling of bobbins are pointed out and the article concludes with a note on the work of the Research Association and the collaboration of the scientific and practical members of its staff.


Lord Balfour's speech at the opening of a Wool Research Exhibition is quoted at some length and followed by a description of the chemical and physical exhibits. Towards the end of the article reference is made to the three spinning frames exhibited, one a standard frame as made without radical alteration for the last hundred years, the other two drafting the material twice in the same direction in flat contradiction to present practice and theory.
A short review is given of the development of mechanical drafting of wool fibres from the time of Wyatt. The successful experiments in drafting wool twice on the same machine are described with drawings of the mechanisms employed. Carrier lapping, the cause of many failures in the earlier stages (and by no means an unknown trouble in ordinary drafting) is discussed and experimental observations described. False twist, already used on certain machines but not properly understood, is similarly discussed in the light of experimental observation, and a new conception of the action of carrier rollers stated. The drafts attained on the experimental frames are reported - 30 for fine wool and 103 for crossbred. (The normal drafts on present practice would be about 6 and 9 respectively.)
Footnote on Carding Calculations.

The editor refers to ignorance of what really happens between carding machine rollers, and expresses a wish that stroboscopic analyses as applied to worsted spinning by A.W.S. should be extended to carding action.

Worsted Spinning Research.

This article corresponds to that in the Wool Record of about the same date, and merely claims the success of the drafting experiments, indicating the possibilities of their practical application without at the time disclosing much of their nature. (A full description was given later in the Wool Record and before the British Association).

Note on Physical and Optical Societies' Exhibition.

Reference is made to the exhibition of the mirror stroboscope and its successful application to the aperiodic motion of wool fibres in a carding machine, as requested in the same magazine in 1924. (This application of the stroboscope to aperiodic motions, in other words the use of asynchronous intermittent illumination, is the subject of an article at present in course of publication and its application to carding is proceeding.)
A High Speed Stroboscope.

This article, like all the other publications of the Research Association, is unsigned. It is largely a repetition to a wider public of part III of Association Report No. 15. The construction of the early form of stroboscope, which was bolted to the spinning frame, is described, also the method of measuring the speed of the spindles in relation to their driving roller. It is suggested that for very high speeds the mirror might be made from a solid cube or polygon of stainless steel with polished faces, the only limit to the frequency of illumination being the bursting speed of the metal block.

Worsted Spinning.

A short summary is given of the paper on this subject read before the British Association by the writer and his colleague. The earlier unsigned article on the stroboscope is referred to in a footnote as by the present writer.

Electric driving in Scottish Woollen Mills.

This article has nothing to do with worsted spinning, but is included as an example of the writer's earlier work on textiles. It begins with a review of the Scottish woollen trade and its power sources.
A novel method of combining public electricity supply and a demand for pressure steam is suggested. The various processes and machines of the trade are described from the driving engineer's point of view, and photographs are given of an installation carried out by Messrs. Siemens Brothers Dynamo Works while the writer was on their staff as assistant to Dr J.F. Crowley.

Not yet published. Printed copy to follow as soon as available.

Observation of Moving Bodies by Intermittent Illumination.

Various types of stroboscope producing synchronous intermittent illumination are reviewed and compared with those giving intermittent vision. A type is described in which a focussed beam of light is deflected by a revolving mirror and sweeps over the objects under observation.

The use of such an instrument has been extended to the observation of aperiodic motions. The technique and limitations of such asynchronous intermittent illumination are given. Various applications are mentioned and comparison made with spark photography and the high-speed cinema.