

FRAME v. MULE SPINNING IN THE WOOLLEN AND WORSTED INDUSTRIES.

By PROF. ALDRED F. BARKER (Bradford).

It is held by many that the mule—and more particularly the woollen mule—is the most wonderful of all the machines appertaining to the textile industries. Whether the cycle of operations of the mule has been witnessed for the first time in early youth or in middle or old age, we have all felt at one time or another respect for the men who have evolved such a machine and have been fascinated in watching again and again the coming and going of the carriage with its array of wonderfully controlled spindles.

But to very many of us the thought has not been slow to develop that the coming and going of the carriage represents so much wasted

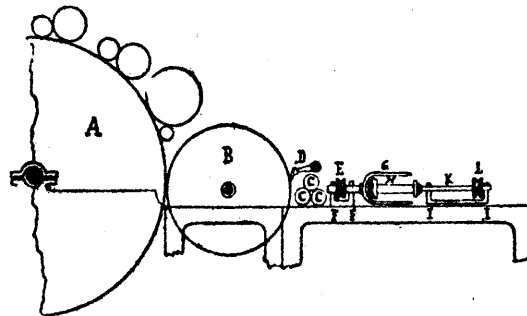


FIG. 1.—FLYER ATTACHED TO CONDENSER.

time and energy and that it should be possible to construct a machine which would act continuously instead of intermittently. As a youth the writer of this paper thought he had got the idea for such a machine, and on going to a mechanic with the object of having his idea rendered into the concrete he was shown the exact thing which a worker in the same field had evolved some years previously. Eleven years later he was asked to report upon a "frame woollen spinner," and upon arriving at the mill where it was in operation was again shown his old friend in very slightly different garb. In the endeavour to solve this problem fools have stepped in where angels fear to tread—and have proved themselves fools. Perhaps no better example of this can be given than that illustrated in Fig. 1, in which the inventor probably thought that he had solved the problem by attaching a flyer frame in a horizontal position to the

condenser, not realising that with this arrangement he could not really "spin," but merely twisted a condensed sliver, that the speed of his spindles must be controlled by the delivery of the condenser or *vice versa*, that the pitch of the condenser rings must control the pitch of his spindles or *vice versa*, and that many other minor difficulties would arise rendering the idea impracticable. The truth is that the principles involved in woollen mule spinning are very complex, and are hidden in apparent trivialities, and it is only within the last few years that the problem has been tackled in a truly scientific manner.

The fundamental principle of woollen mule spinning is "spindle-draft," and the method of affecting this is—

- (a) By the stoppage of the delivery of the condensed sliver before the carriage reaches the extremity of its traverse, the necessary "drafting twist" holding the sliver together while the one yard of delivered sliver is drawn out to, say, two yards of spun yarn;
- (b) By the minute but innumerable tugs which the yarn receives during the drafting, due to each turn of the spindle necessitating the slipping of the thread over the comparatively thick spindle point.

The revolution of the yarn on its own axis also must not be overlooked, but this will be dealt with later (see Fig. 1A).

Contrast this spindle drafting for one moment in your mind's eye with ordinary roller drafting, and the remarkable difference will be realised.

We are now in a position to understand the reasons for failure in all the woollen frame spinners—whether attached to the condenser or detached—constructed up to quite recently. Those reasons may briefly be summarised as follows:—

(1) To achieve continuity of action "roller drafting" must be employed but this necessitates two "held" ends, and the problem of inserting "true" twist between two held ends is impossible of solution (see Fig. 2).

(2) If by some mechanical means "artificial drafting twist" be introduced there is still the problem of fixing the fibres in the spinning position, as is done in the mule, to be faced; and, as in all the frames in question, the "true twist" is inserted after the "drafting twist," usually by means of a ring frame, it naturally follows that the fibre arrangement cannot be the same under these conditions as under the mule conditions.

(3) The value and necessity of the minute tugs referred to had not been realised, and no provision was made for these, with the result that in no case was it possible to obtain satisfactory "drafting," and as a consequence the production of the frames in question might best be described as "twisted" condensed sliver rather than "spun" thread.

(4) There is probably some point in the length of sliver being drafted and in its freedom to turn on its own axis which was never taken into account and satisfactorily arranged for.

Before proceeding to describe how Platt's frame meets these objections, attention must be directed to certain accessory prin-

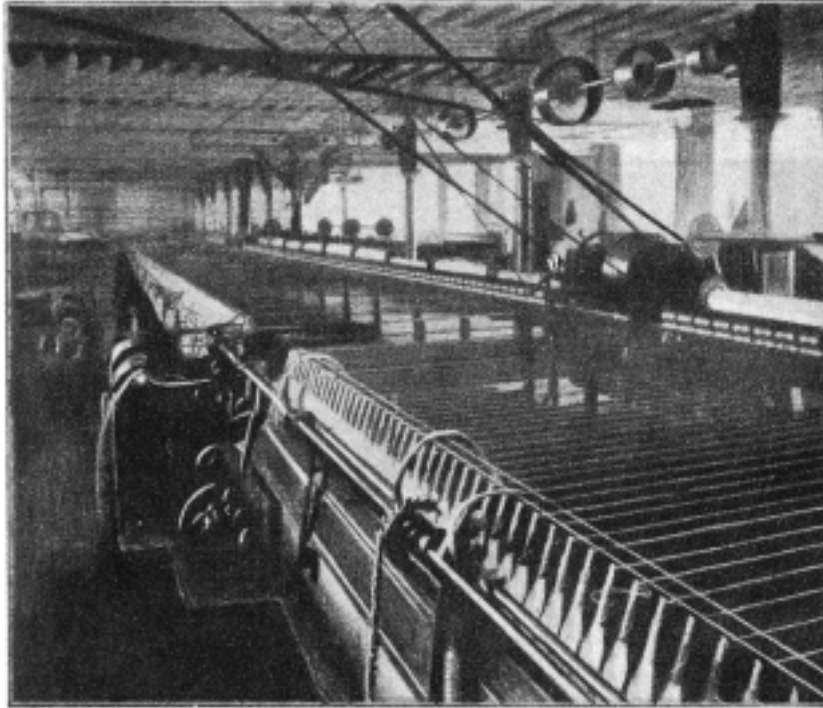


FIG. 1A.—SHOWING THE MULE-CARRIAGE ALMOST AT THE EXTREMITY OF ITS TRAVERSE.

ciples which must be observed if the typical woollen thread is to be produced. In the first place, as "spindle-draft" is a necessary condition there is a limit to the length of fibre which can be successfully treated. Broadly speaking, long-fibred material "binds"

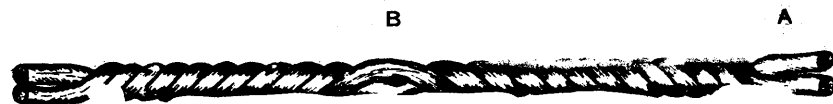


FIG. 2.—ILLUSTRATING "FALSE TWIST."

too easily, thus resisting "spindle draft" even with a very small insertion of "drafting twist," while short-fibred material can be wondrously well controlled, so much so that there is a popular saying that anything with two ends to it can be successfully spun

on the woollen mule. But while fully realising these obvious conditions and limitations, it is desirable to go even deeper into the subject and see if any justification can be found for the strictures passed by the late Charles Vickerman upon the spinning of the modern woollen yarn.

This at once takes us back to the condensing, and here we shall find the key to the mystery, which up to the present has baffled most workers on the problem.

Those who can go back some fifty years in the woollen industry will remember the controversy with reference to the supplanting of the old "piecening carder" by the comparatively modern "con-

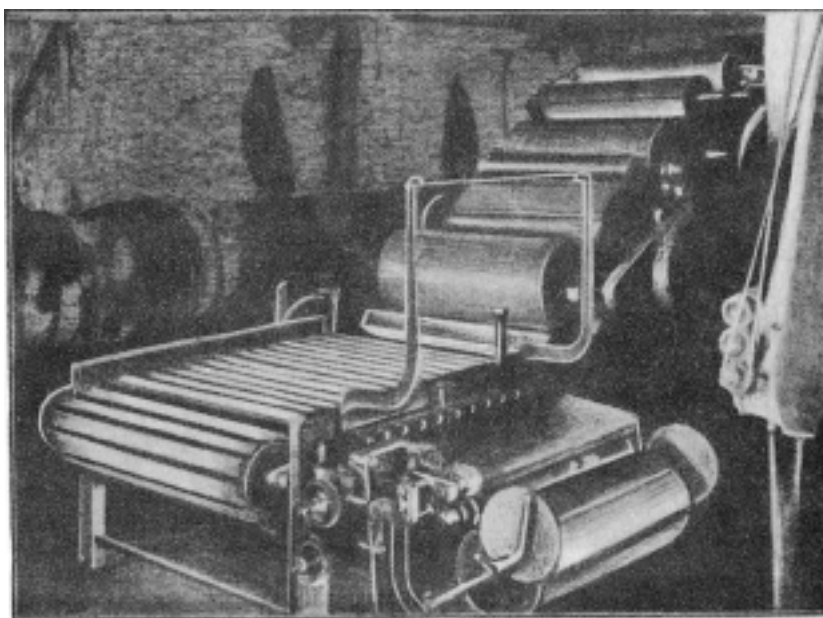
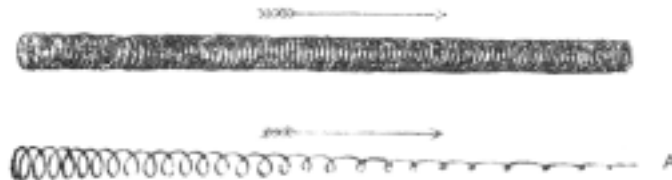


FIG. 3.—THE OLD PIECENING CARDER OR CONDENSER. (Note the divisions across the Doffer.)

denser." Here is the key to the Vickerman mystery. In stripping from the doffer in the old "piecening carder" (see Fig. 3) any continuity of the fibres due to the direction of carding was broken by the spaces *across* (not round) the last doffer so that as the slivers were doffed the fibres would be arranged approximately concentrically, *not longitudinally*, in the sliver. The joining together of these slivers—each the same length as the card width—was, of course, a problem, but this achieved, the woollen spinner could produce a wonderful yarn, for each fibre, being concentrically placed in the sliver, would be drawn out in the form of a spiral by the spindle

drafting which followed (see Figs. 4 and 4A), so that by a sufficiency of this spindle drafting the fibres would gradually be drawn more or less longitudinally in the thread, thereby giving it the necessary strength, but at



FIGS. 4 AND 4A.—ILLUSTRATING THE ARRANGEMENT OF FIBRES IN THE CONDENSED SLIVER FROM THE OLD PIECING CARDER, AND THE EFFECTS OF DRAFTING.

the same time each fibre would take the form of a spiral—not of a straight line. Bearing this point in mind, it will be obvious why Mr. Vickerman went so strongly for the writer of this paper

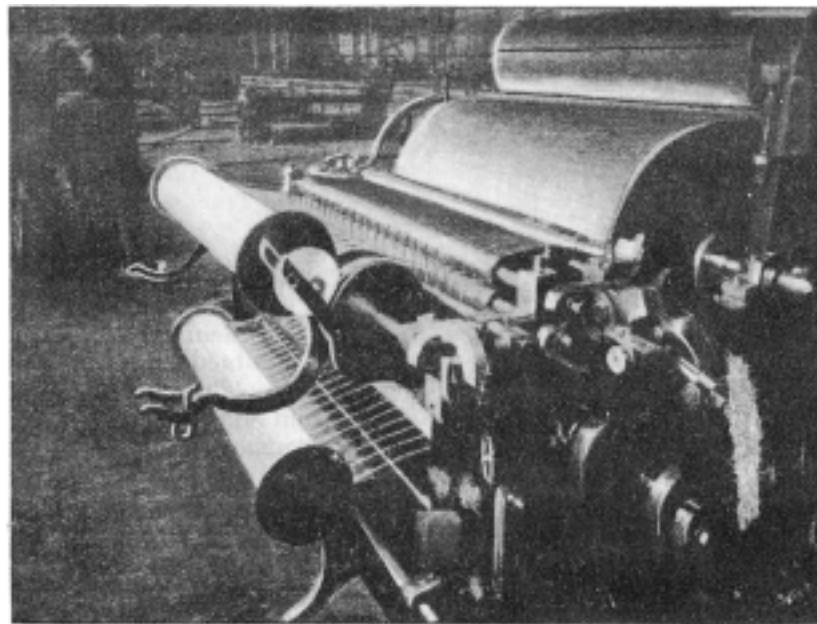


FIG. 5.—SINGLE DOFFER CONDENSER. (Note the divisions round the Doffer.)

when he ventured to urge that by condensing to a low count on the modern condenser (Fig. 5) and roving and drafting to a fine count on the mule a really typical woollen thread might be produced. That the thread so produced is sufficient for all reasonable requirements is proved by the passing of the old "piecening carders"

and the universal adoption of the modern ring condenser; but that the same woollen thread can be thereby produced the writer is now at one with Mr. Vickerman in combating.

So far as our present purpose is concerned, however, this matter is only of interest as showing the curious fibre arrangement which should obtain in the true woollen thread. We now understand exactly what is required from any frame spinner, and are in a position to judge to what extent these requirements are met.

Of the many frames constructed to spin woollen yarns, that made by Celestin Martin is perhaps the only one which, up to the present, has made headway in practice. Messrs. Platt Bros.' recently-introduced frame, however, includes points which should specially recommend it to the woollen spinner, and consequently it is given special consideration here.

PLATT'S PATENT WOOLLEN RING SPINNING FRAME.

Any machine may well be studied by carefully considering—

- (a) The principles involved in its construction;
- (b) The clothing of these principles; and further
- (c) By comparing it with machines designed with a similar purpose in view.

As members of the Institute are afforded every opportunity of watching this machine in operation, and can then ask questions as to the details involved, it is proposed here to deal very broadly with the above points.

(a) *The Principles Involved in its Construction.*—While the original idea of the machine is continuity of action, thus ensuring greater output, it is so designed that an intermittent delivery of the sliver may be introduced at will. This undoubtedly increases the spinning range of the frame, as the longer wools require this intermittent action. It naturally follows from this that each frame must have a controlling mechanism or headstock (but very much simpler than the mule), and this, of course, excludes the idea of fixing the machine on to the condenser, as one headstock may be made to control hundreds of spindles instead of the 80 or 120 which would be required if it were simply fixed on to the condenser. Again, an intermittent action of the frame could not well be introduced along with the continuous delivery from the doffer of the condenser. It is still conceivable that some simple form of spinning apparatus directly attached to the condenser may prove satisfactory, and the above remarks must in no sense be taken as a discouragement to those inventors who are working with this object in view.

The main drafting action of the machine is effected by two pairs of drafting rollers, as in the many other machines of the type referred to, but the *pièce-de-resistance* of the machine is the

"twister tube." This not only inserts the necessary false "drafting twist," but, by means of two "lugs," gives the necessary "flips" or "tugs" during the "spindle-drafting," thus imitating the action of the yarn slipping over the top of the spindle in the mule at every revolution (see Figs. 6 and 7). The tube is also so designed at its lower extremity that it presents the sliver with its false twist directly into the nip of the draft rollers, *i.e.*, the drafting-twist is from *a* to *b*, as shown in Fig. 2.

The drafting rollers deliver the untwisted sliver to an ordinary ring and traveller attachment whereby the necessary final twist is inserted and the yarn wound on to suitable bobbins or cops.

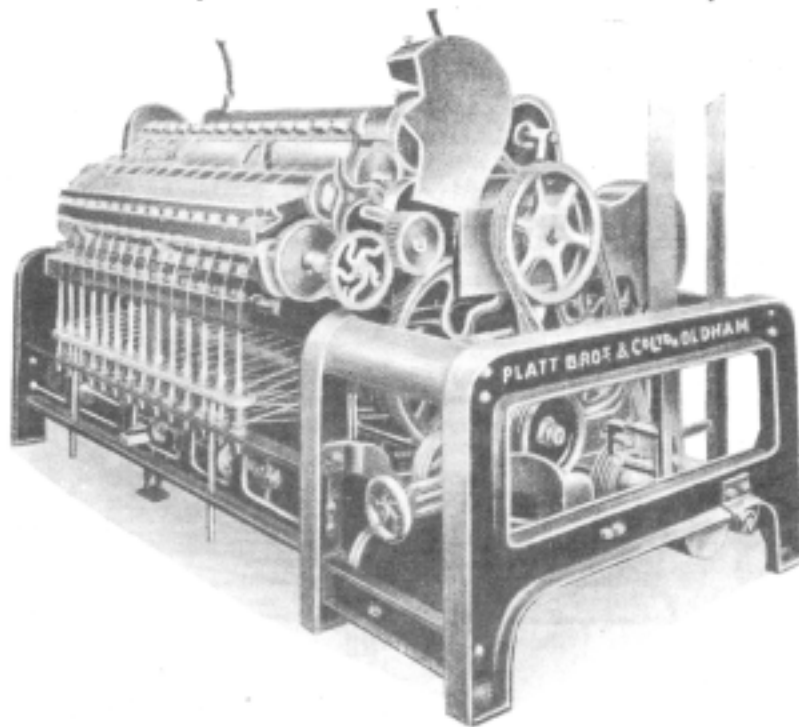


FIG. 6.—PLATT'S PATENT WOOLLEN RING SPINNING FRAME.

It will thus be evident that the main principles of mule spinning are observed, more particularly the two fundamental ones of spindle draft and the "flips" or "tugs" referred to. Whether the fibre arrangement ensured by the two-fold drafting described is interfered with by the following ring-twisting and winding-up is a matter which can only be decided by actual experience with the yarns produced, but we can at least say that there will be here no greater difference than the difference which was introduced by the change from the old "piecening carder" to the more modern condenser.

It is obvious that the continuous action of the machines must result in greater production and it is interesting to note that this continuous action of the ring attachment in no wise interferes with an intermittent delivery during the drafting operation, such as is necessary for dealing with the longer wools.

(b) *The Clothing of the Principles.*—Messrs. Platt Bros.' name is sufficient so far as the general build of the frame is concerned, but there are many matters involved which have required very careful consideration. For example, the distance between back

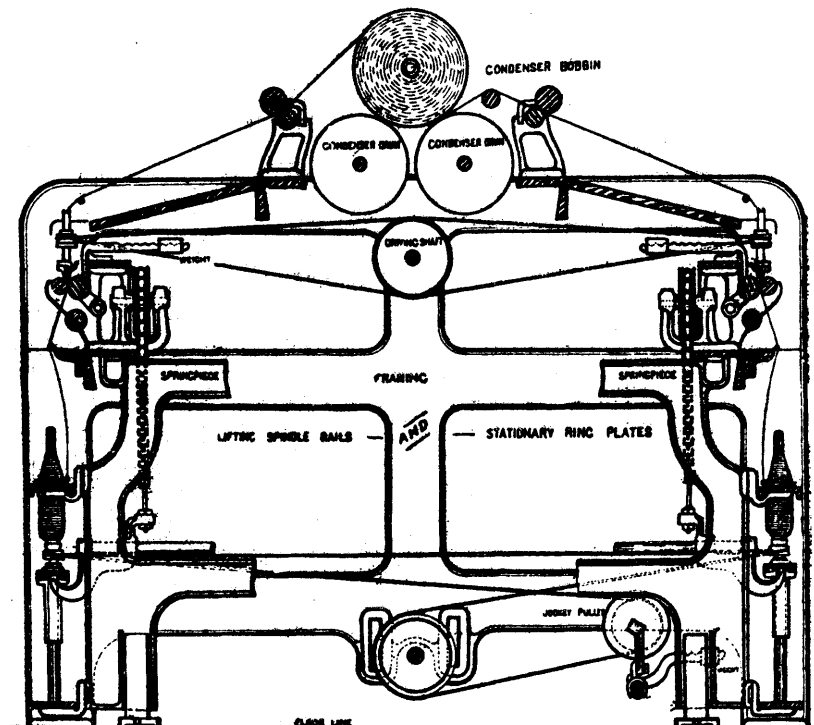


FIG. 7.—PLATT'S PATENT WOOLLEN RING SPINNING FRAME.

and front drafting rollers and between drafting rollers and ring rail, the position and inclination of the twister tube, arrangements for waste collection and for piecing up, and the critical question of fixed or moving ring rail and conversely moving or fixed spindle rail; these and many other matters have had to be faced and solved by experiment. Again, such matters as the pitch of the spindles and the build of the frame have not been deemed unimportant in view of the fact that the yield of material area for area as compared with the woollen mule has had to be taken into account.

(c) *Comparison with the Mule.*—Through the kindness of Mr. George Garnett, of Apperley Bridge, the writer is enabled to supply the following comparative statements:—

Per Spindle.	Mule.	Frame.
Initial cost	10/6	30/-
Space occupied.. .. .	2·5 sq. ft.	2 sq. ft.
Power consumed.. .. .	·005 H.P.	·023 H.P.
Running cost	Less.	More
Wages per week	6d.	1·2d.
Lbs. per week	1½	1½

These results are obtained from throwing out mules and putting in frames, but where arrangements can be made to more satisfactorily house the frames and to run economically, the above expenses are considerably reduced and at least double the advantages obtained.

The question of quality of result now arises. This is difficult to estimate, as there are usually so many blends running in a woollen mill that it would be strange if some of these might not be spun to advantage on the frame.

The following lists, referring to two distinct blends, may here be usefully considered:—

BLEND NO. 1.

	Frame.	Mule.
Count spun to	26 sk. (Yorks.)	30 sk. (Yorks.)
Turns per 1 in.	17·05	12·5
Strength in ozs.	10·6	8 1
Elongation in inches	2·51	2·03

BLEND NO. 2.

	Frame.	Mule.
Count spun to	27 sk. (Yorks.)	25 sk. (Yorks.)
Turns per 1 in.	15	12·75
Strength in ozs.	7·75	8·6
Elongation in inches	2·44	2·16

These two examples, however, do not give really reliable comparative results between the frame and the mule, as differences were introduced which are not here taken into account. Blend No. 3 supplies the necessary comparison, the materials here being identical:—

BLEND NO. 3.

	Frame.	Mule.
Count spun to	26·8 sk. (Yorks.)	25·1 sk. (Yorks.)
Turns per 1 in.	14	12·6
Strength in ozs.	9·9	9·1
Elongation in inches	2·29	1·74

The chief lessons to be learnt from the above results are:—

1. That to effect a satisfactory spin on the frame it appears necessary to insert rather more twist than need be inserted in mule spinning.
2. That the frame yields a yarn as strong or stronger than the mule.
3. That the frame yarn is more elastic.

That there is little difference in regularity of the two yarns is shown by the accompanying photo-micrographs, Figs. 8 and 8A. These micrographs further suggest that the supposed fullness of mule-spun yarn is a myth, and that frame-spun yarns may be quite as full and give as much "cover" in the resultant fabric.



FIG. 8.—FRAME-SPUN YARN
(BLEND 3).

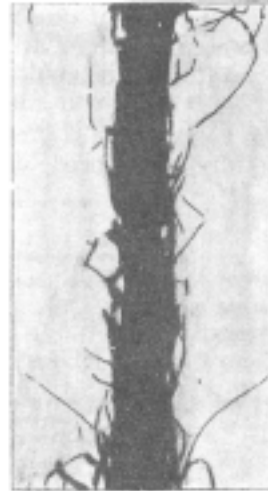


FIG. 8A.—MULE-SPUN YARN
(BLEND 3).

So far as the actual working of typical blends is concerned, there is little to choose between the two methods. In all cases in dealing with the blends in question it has been found most satisfactory to condense to about half the count required. In the case of lower blends to be spun out fine, however, it is found that the mule has the advantage. If a thread which must be "burst" in the resultant fabric is required, then the necessary extra twist in frame spinning may be a most marked disadvantage.

As will be expected from the greater thread speed, there is slightly more waste in frame spinning as compared with mule spinning.

The fabrics produced from the frame-spun yarns are in every respect satisfactory. The following is an exact comparative example:—

CLOTHS FROM BLEND NO. 3.

	Frame Spun Yarn.	Mule Spun Yarn.
Width in loom	34 in.	34 in.
Width in grey state	31½ in.	31½ in.
Width in finished state	30¼ in.	30 in.
Length in loom	20 yds.	20 yds.
Length in grey state	15½ "	17 "
Length in finished state	15¼ "	16½ "
Weight in grey state	7¼ lbs.	7¼ lbs.
Weight in finished state	6¾ "	6¾ "
Warp, strength in lbs.	65·6	59·9
Warp, elongation in inches	1·73	1·69
Weft, strength in lbs.	59·7	50·6
Weft, elongation in inches	1·85	1·69

These results, as stated here, are somewhat surprising, but not more so than one's surprise on handling the two cloths. Without previous knowledge the cloth made from the frame-spun yarn would certainly be selected as the cloth made from the mule-spun yarn and *vice versa*.

Final Conclusions.—It is evident from these results that no firm need fear putting in these frames so far as actual spinning is concerned. They will successfully deal with a large variety of blends, and in many cases space for space and cost for cost, as compared with the mule, will prove a sound economic investment. It is equally obvious, however, that there is still certain work which is most economically treated on the mule, and which it would be unfair and unwise to attempt to spin on the frame. Where there is a fair spinning margin the frame may usually be employed to marked advantage, but where this margin does not exist it is better to keep to the mule. Again, where there is a fair margin in handle and appearance of the resultant fabric, frame yarns may be successfully employed, but when soft-spun yarn and a markedly burst thread in the fabric is required the mule yarn again comes to the front.

One other useful point to note is that when space is limited, power unlimited, and production everything, then there is a distinct advantage in adopting the frame rather than the mule. Finally, for those firms who require a waste spinner, one can conceive of nothing handier than the frame in question.

MULE-SPUN WORSTED YARNS.

Had the time at my disposal been greater I might well have gone deeply into the question of French drawing and worsted mule spinning more particularly in the light of what we have already been considering. For if it be true that the man who knows only

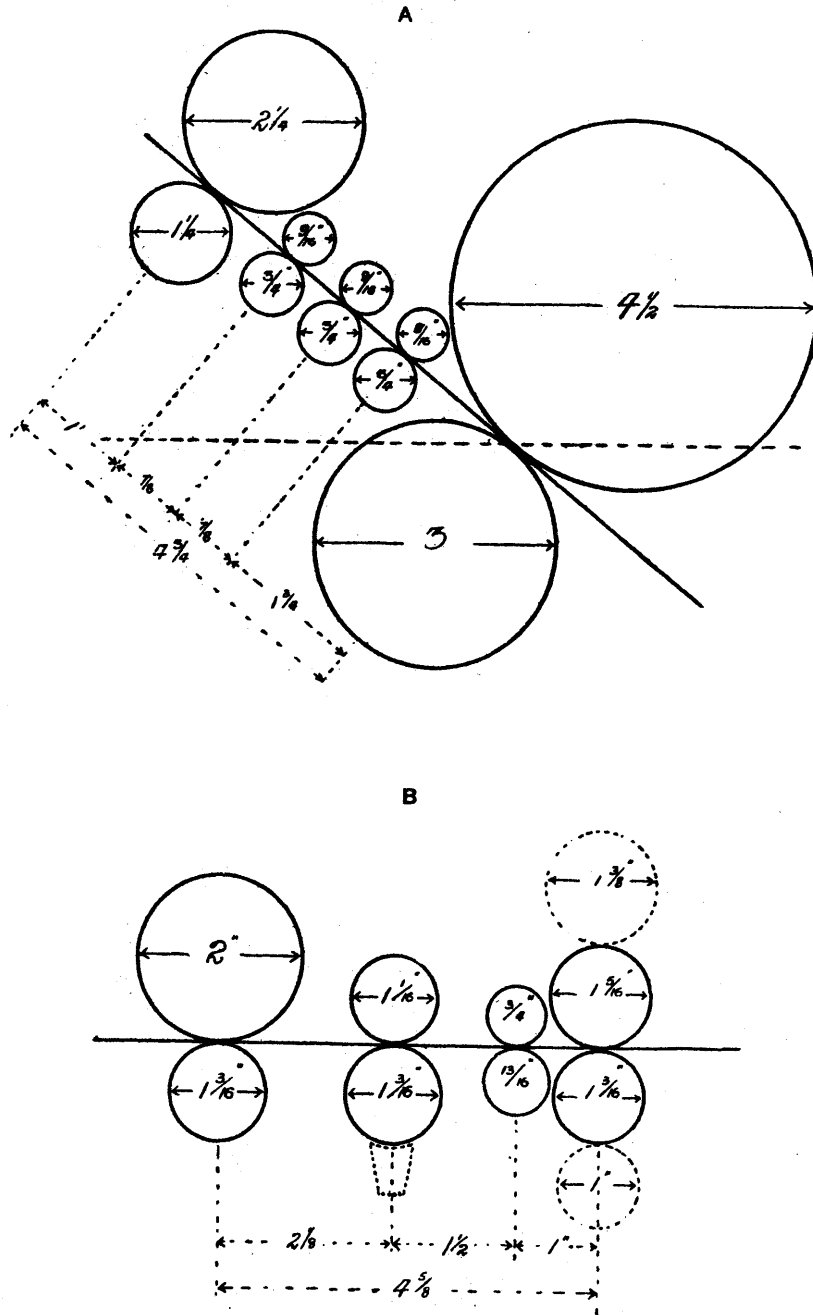


FIG. 9.—A.—CAP FRAME DRAFTING ROLLERS. B. MULE FRAME DRAFTING ROLLERS.

one language knows none, it is equally true that the man who understands only one type of drawing and spinning is hardly half a spinner. In other words, the comparative method is supreme.

And there is wonderful value in considering French drawing and cone drawing, worsted mule spinning, woollen mule spinning, and flyer and cap spinning. Compare, for example, the drafting rollers in the worsted mule and in the cap frame (see Fig. 9). This takes one back at once to the very matter we have been considering, viz., the method of preparation of the material previous to spinning; and, again, the value of very close consideration and realisation of the fundamental principles involved is in evidence.

Let the worsted spinner carefully consider, for example, the value of French drawing, but at the same time realise that for cap or ring spinning he must employ not only "roller and carrier control," but also "twist control," and he is led at once to the completion of the French drawing operations by cone roving to be followed by cap or ring frame spinning, and if we have learnt anything from our careful consideration of frame *versus* mule spinning, it is that the possibilities of the frame are much greater than have been taken for granted up to the present.

One of the great advantages of such an equipment as that recently installed at Bradford is that it is now possible to make these comparative studies on a practical scale, and should the subject be deemed of sufficient merit to warrant the further attention of the Institute, at some subsequent meeting I shall be glad to place before the members some of the interesting comparative results we are working out.

DISCUSSION.

MR. G. H. WILSON (Hawick) said that it would have been interesting if they had been able to see the same yarn spun the same size, and the figures given for that.

PROFESSOR BARKER said that manufacturers had found that the frame, on the whole, was suited for a certain class of work and the mule for another class of work. The result was that it was often difficult to get exactly the same conditions, but in No. 3 blend there was only a difference of one count, and that might be due to elasticity of yarn. He advised them to take No. 3 as the basis of comparison.

Another member said, suppose they were spinning to the utmost limit of their capacity, one extra count might make a considerable difference.

PROFESSOR BARKER thought the mule would spin out to the limit better than the frame.

LORD ROTHERHAM said he understood Professor Barker to say that in woollen yarn there was greater elasticity in the frame-spun yarn than in the mule-spun yarn. He would rather question

that. In the woollen or cotton trade mule yarn was considered, as a rule, to be rather more elastic than the frame yarn.

PROFESSOR BARKER said that was a very interesting point. When he was writing the paper he certainly expected to find that the frame yarn would be less elastic than the mule yarn, but for the present they must confine themselves to this, that they found the frame yarn was more elastic than the mule. That, of course, was spun on the woollen system. So far as worsted was concerned, and cotton also, he should quite expect to find that Lord Rotherham's view was correct.

MR. FRY asked if the elasticity was not largely accounted for by the very much greater amount of twist that was put into these fine yarns.

PROFESSOR BARKER said that was so to a certain extent. At the same time there was distinct evidence from what had been noticed in the mill that there was, in addition, more elasticity in that yarn, quite irrespective of the comparison with the mule. He hoped, later on, to be able to add to his paper tests of precisely similar yarns in the same twist.

MR. FRY said that was the only way they could get accurate comparison.

MR. C. J. WILSON said this question was very interesting to them 40 years ago. The same arguments were brought forward, but after a short experience those who made a change had to go back to the mule, which was better for their class of trade.

MR. CARTER (Belfast) said that frames of the sort described had been on the market for a considerable time. He thought that Mr. Martin's ring frame approached more nearly than any of these tube frames to the spinning of the mule. The principle was to lift the present drawing roller rapidly—sixty or more times a minute—let the twist run up into the undrawn portion of the thread, and when the present roller came down it gave a draught after the twist had run into the thin portion of the thread, leaving the thick portion as in the mule. Even that arrangement, when tried in Yorkshire, did not seem to be a great success. The yarn, although approaching pretty nearly to the mule spun, did not give the same characteristics. It was more of the nature of a warp yarn than of a weft yarn.

PROFESSOR BARKER, in reply to Mr. Wilson and Mr. Carter, said that the Celestin Martin frame was used to a considerable extent to-day on the Continent, but the present frame was a distinct improvement, and the principles were certainly more carefully thought out and adhered to in that frame than in any of the others. It was very interesting to hear what Mr. Wilson had said on the attempts that were made forty years ago. Sometimes one little thing made all the difference in such complex matters. He asked them to give Platt's frame most careful consideration. It was in the exhibition at Hawick, and was worthy of being looked at.