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NEW TECHNOLOGY IN OPEN-END SPINNING[1/]

by

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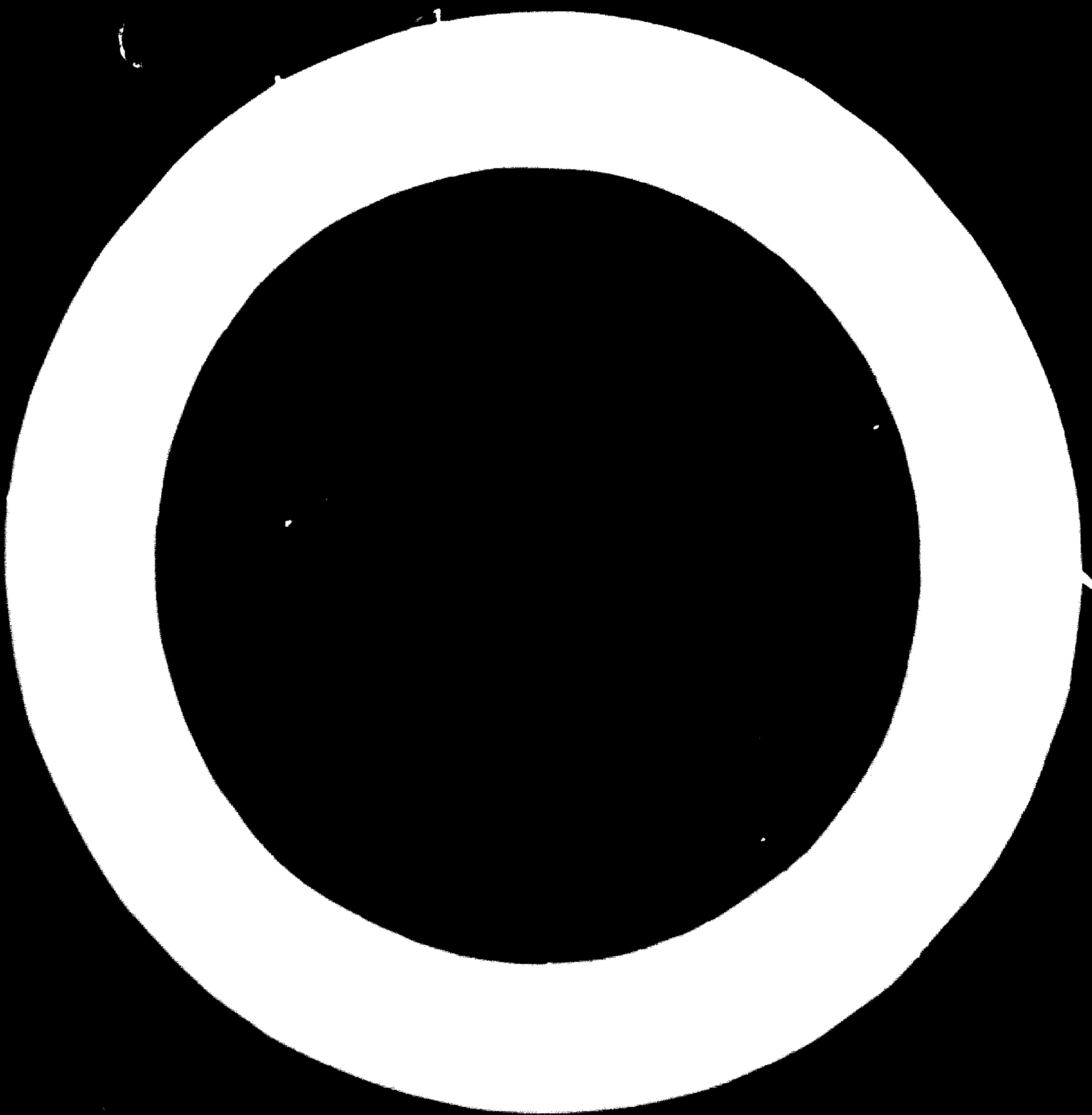

Contents

New Technology in Open-end spinning

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New Technology in Open-end Spinning

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1. Preface

With respect to the history of the Open-end spinning, we can go back to U.S.P. 6647714 of W. A. Pillip, England, at the beginning of this century. At that time, the first flow of patent applications of Open-end spinning could be seen, however, it soon declined; in the 1930's, about 30 years later, we could see the great flow of patent applications of Berthelsen-Patent and others which became the base of the rotor type Open-end spinning machine. However, it was too early for the industry to accept them. In the latter years of the 1930's, about 20 years later, the industrial condition consisting of the dead lock of the ring spinning machine and the demand for high efficiency, etc. and the objective condition of the progress of related technology came together, and interest on the side of the industry became high in the Open-end spinning.

In such circumstances, the BD-200 Open-end spinning machine appeared in 1966, and it became real at last. In our company, about 10 years ago, we paid much attention to the Open-end spinning machine as an epoch-making spinning system after a long period of research and study, and we came to the conclusion that Czech BD-200 is the best among the present Open-end spinning machines. We co-operated with Messrs. Toyoda Automatic Loom Works, Ltd. and in 1967 introduced the technology thereof, and have made great efforts in order to produce the machine domestically. As a result, it is our pleasure to be able to produce BD-200 Open-end spinning machine in mass production domestically for the first time in the world. Generally speaking, theory and reality differ and hardly meet, however, for your information, we want to introduce various experiences as follows, firstly we can make theory and reality meet after a long operation and have got much experience, secondly we can produce spun yarns of good quality and excellent products which cannot be produced with the conventional ring spun yarns, etc.

2. The Present Status of Open-end Spinning in Japan

At present, in Japan, many BD-200 Open-end spinning machines have been introduced to the leading spinning companies, firstly about 250 sets to our company, and to Kanebo, Unitika, Nisshin Spinning, Fuji Spinning, Toyo Spinning and so forth, about 700 sets in total are commercially operated. Another type of Open-end spinning machines, MS-400 and MS-500 are test-operated mainly in Toray and in other companies; the number of machines amounts to about 50 sets in total. The original BD-200 was deemed very excellent with regard to spinning of cotton yarns, however, it is rather difficult to spin man-made yarns with this machine. We have finally succeeded in widening the field of spun yarns by developing the rotor, the combing wire and twist transmission mechanism for man-made fibers as well as suitable man-made fibers for BD-200.

The production items and the breakdown in production ratio of Open-end spun yarns are shown below, and we can judge that this information roughly shows the present situation of the Open-end yarn production in Japan. Namely, the actual production quantity in pounds which was made during the past six months for Open-end spun yarns (hereinafter called BD yarns) in our company amounts to about 21 million lbs, and its ratio by material is about 60 % of cotton, about 20 % of pure man-made fibers and about 20 % of man-made fibers and cotton blend.

The range of the yarn count is 6 S through 36 S for cotton yarns, 12 S through 30 S for pure viscose staple yarns, 1/31 through 1/64 for pure acrylic yarns, and 12 S through 32 S for polyester and cotton blended yarns and 24 S through 34 S for acrylic and cotton blended yarns.

We are still developing special spinning oils for polyester fibers with regard to commercial production of pure polyester yarns.

3. <u>Some Experiences Regarding Rotor Type Open-end Spinning</u>

About four years have already passed since we started commercial production of BD yarns by the Open-end spinning machines BD-200. Since we have obtained several dozens of patents and much know-how through various experiences during these four years, we would like to introduce some subjects as follows out of this experience which will be thought very useful and profitable in installing these machines.

(1) The form of the opening device

In BD-200, fibers combed by the combing wire are peeled off from the surface of the combing wire by centrifugal force generated by the high speed revolutions of the combing roller, and the difference in the aerial pressure on the surface of the combing roller which is made by the difference in the speed between the surface speed of the combing roller and the speed of suction air by the revolutions of the rotor. Fibers which are air-drafted and straightened out by suction air are then fed to the rotor. In case fibers clog on the teeth of the combing wire and continue to revolve with the combing wire, it causes the trouble of neps and slubs. And in case the opening ability of the combing wire is not sufficient, it also causes the trouble of slubs, on the other hand, if the opening ability of the combing wire is too strong, it causes the trouble of cut fibers which eventually decrease the yarn strength. Therefore, the form of the opening device should satisfy the following points in action; Neither should it give any damage to fibers, nor hook them so heavily, rather it should open them completely one by one, make them detach easily from the combing wire and transport them steadily to the rotor.

Accordingly, we should decide the form of the opening device in consideration of the form of the teeth, the working angle, the back side angle, the depth of the teeth, the number of points (the pitch in longitudinal and lateral directions), the coefficient of friction of the edge of the working angle, the form of the channel edge, the distance between the combing wire and the casing, the number of revolutions of the combing roller, the diameter of the combing roller, the location of the air inlet, the gravity of suction air, etc. From the above-mentioned viewpoint, we have studied the opening device, so we would like to disclose some results of it.

Firstly, we have confirmed that it is preferable to open the air inlet tangentially to the point of fiber detachment, especially for man-made fibers.

Moreover, even if the air inlet is not situated at this ideal location, we have also found that, if we make an air inlet which is opened between the plucking point and the fiber detaching point and through which air is sucked, we can easily detach fibers from the combing roller by the difference in the aerial pressure between the surface speed of the roller and the speed of air flow. On the contrary, we confirmed that we cannot expect complete spinning because of insufficient peeling-off action of fibers from the combing roller, if the air inlet is closed in order not to introduce air.

Some models of Open-end spinning machines have no apparent air inlet, but have only a cleaning device. Actually, air is sucked from the cleaning device, so it seems to us that this device carries out the cleaning action as well as the air sucking action which is necessary for peeling off fibers. The cleaning device may indeed be able to remove larger foreign matters such as seed dusts and leaf dusts, however, it cannot take away very small foreign matters completely which deposit in the rotor and mainly cause periodical slubs, which cause trouble in application and decrease the yarn strength. Moreover, this device brings us the disturbance in fiber orientation and eventually a lot of neps as well as the decrease of the yarn strength, so it is better to remove the foreign matters in the fore-spinning processes from the viewpoints of the yarn properties and control of the machines, when we merely think of removing the foreign matters. (This subject will be mentioned later.)

(2) Twist transmission mechanism

A yarn is twisted by the revolutions of the rotor in the roter type Open-end spinning machines, but the twist should be transmitted to the fiber collecting part in order to spin yarns consecutively.

The yarn is spun by revolving itself around the navel part in accordance with the revolutions of the rotor, at the same time rolling around the yarn axis. If we make this rolling around the yarn axis more positively, a twist increases much more between the navel part and the fiber collecting part and the yarn is spun easily.

According to the development on the twist transmission mechanism in which the yarn rolls itself around the yarn axis at the navel part, we have succeeded in spinning of 40 S class medium count yarns of various materials, including man-made fibers which have a great torsional rigidity as well as spinning of yarns which have almost as low a twist coefficient as ring yarn for the end-use of knitted fabrics on which we require a soft touch.

(3) The form of the rotor

Since we introduced the technology of BD-200, we have studied again the form of the rotor. From the viewpoints of yarn qualities, number of ends down, operation of the machine and economical points, we found that the type of self-fan of BD-200 shows less difference in performance among each unit, is very simple and the most excellent system for commercial production. However, we also found that, on the original rotor of BD-200, cut fibers, leaf dusts, seed dusts, spinning oils, fallouts of polymer, etc., after long operation, are transported by exhaust current to the sinus part which is located at the center of the rotor, and the foreign matters which are depositing on the sinus part and frequently piling up fall on the surface of fiber bundle by centrifugal force of the rotor and consequently cause slubs and ends down.

We have reached the idea to make the bottom of the rotor flat to avoid the deposit at the central part of the rotor and to send the foreign matters which are separated during spinning to the part of the fiber bundle by centrifugal force for twisting them into the yarn. Thus, we have solved the problem and have been able to prevent ends down which are increasing in accordance with time of operation.

(4) The characteristics of man-made fibers for Open-end spinning

The spinnability and yarn qualities of man-made fibers are considerably affected by the fiber properties and spinning oils. The factors which influence the spinnability and the yarn qualities have many contradictory points, so it is better to determine the spinning conditions according to the greatest common measure of the various factors. The larger factors influencing the spinnability are opening ability, transferring property and twist transmitting property. With respect to opening ability, we should consider Young's modulus, denier, fiber length, static frictional coefficient between fibers, dynamic frictional coefficient between fiber and metal and crimp characteristics. Concerning twist transmitting property, we should consider static frictional coefficient between fibers, rigidity of fiber, denier, fiber length, crimp characteristics, etc. For the purpose of getting a great yarn strength it is desirable that the tenacity of fiber is strong, the denier of fiber is fine, the number of crimps of fiber is small, the frictional coefficient between fibers is large and the fiber length is, to some extent, long.

(5) Increasing the number of revolutions of the rotor

Many Open-end spinning machines which had a large number of revolutions of rotor were exhibited at ITMA in 1971 for the purpose of merely demonstrating the effect of operation, however, we firmly believe that we will surely have a lot of trouble when 50 or 100 sets of the machine are used for about one year on a commercial basis without any actual achievements, even though the machines were operated satisfactorily at the show. We should fully evaluate a machine with regard to yarn qualities, endurance of the machine parts, consumed electricity, cost of the machine in order to judge whether or not the machine is suitable for commercial operation.

We can operate the present BD-200 made by Messrs. Toyoda Automatic Loom Works, Ltd. with 40,000 R/M of the rotor without any modifications, only by changing the motor of the machine. Some of the BD-200 have been operated in 40,000 R/M for a long time in our company, we found that endurance of the bearings of which we had been anxious is very long provided that we take good care of them, and the present BD-200 made by Messrs Toyoda Automatic Loom Works, Ltd. can be used without any hesitation on a commercial basis in 40,000 R/M only by changing the motor. Juduing from our experience of operation, to operate the machine in 30,000 R/M is the least troublesome and the best way at present in Japan where the cost of electricity is high; and we try to spin yarns of good qualities of low grade cotton with a few ends down while placing a few workers only, which is different from the situation in the U.S.A., etc. In order to determine the optimum number of revolutions of the rotor, we should consider the end-use of the yarns, kind of the cotton used and the labour situation. Therefore, the optimum number of revolutions of the rotor may differ according to the respective situations in various countries.

(6) Desirable air-conditioning for rotor type Open-end spinning

In the process of the rotor type Open-end spinning machine, fibers are opened separately one by one and deposited in the rotor by means of high speed air flow, so fibers are apt to be processed under very dry conditions.

Accordingly, we should pay more attention to air-conditioning in this process than in the process of ring spinning with regard to twist transmission and yarn strength. The more the revolutions of the rotor increase, the stricter a control we should consider.

It is necessary for us to install air-conditioning equipments through which we can maintain 25° -- 30°C and 60 -- 70 % R.H. in the room.

Moreover, the rotor type Open-end spinning machine is sometimes called "air spinning machine", which makes us recall that hydrodynamical control is necessary for operation, so it is desirable to install exhaust equipments through which we can maintain an air exhaust quantity in 2 -- 3 l/sp.sec. in case of BD-200. Since the air should be clean, it is not favorable that air flows from fore-spinning rooms to the Open-end spinning machine room; an air circulation system specially utilized for the Open-end spinning machine room only is desirable.

(7) Desirable fore-spinning processes for rotor type Open-end spinning

As we mentioned before, a lot of BD-200 machines have been installed in many companies and a lot of BD yarns have been produced in Japan. However, there are several unpleasant cases of flowing out of BD yarns which show a lot of irregularity as do the products of such BD yarns in the market, to our regret, this situation eventually incurs unfavorable reputation of BD yarns and the products thereof.

Even if BD-200 made by Messrs. Toyoda Automatic Loom Works, Ltd. is used, we can only spin BD yarns of inferior qualities which will cause some trouble unless we carry out exact control on fed slivers and the rotor type Open-end spinning machine.

Accordingly, we should control each unit of the rotor type Open-end spinning machine completely, at the same time, we should feed slivers which are suitable for the machine.

In the rotor type Open-end spinning machine, it is unnecessary for us to pay closer attention to the influence of unspinnable short fibers which are included in slivers than in ring spinning machines because of doubling action in the rotor, however, we should take foreign matters into greater account in the rotor type Open-end spinning machine than in the ring spinning machine.

Namely, it is because the foreign matters deposit, by centrifugal force generated by high speed revolutions of the rotor, on the surface of the fiber bundle which is collected along the maximum inner diameter of the rotor and cause slubs, ends down and decrease the yarn strength in the rotor type Open-end spinning machine.

Therefore, proper opening and removing of dust particles in fore-spinning processes, especially in blowing and drawing processes, are indispensable, thus, improvement of opening and removing abilities in a taker-in part and crashing rollers attached to a calender part of a carding machine are necessary at least.

(8) Desirable development on the products of BD yarns

The tensile strength of BD yarns is still slightly lower than that of ring yarns, which comes from the difference in yarn structure. So it is hardly possible for us to improve the tensile strength of BD yarns to the same level of ring yarns. However, BD yarns have several features, such as evenness, good dyeability, strong abrasion resistance and excellent bulkiness, so we can produce excellent woven fabrics as well as knitted fabrics if finishing which does not eliminate these features is applied properly.

Should BD yarns be handled merely for replacing the role of ring yarns, the weak points of BD yarns appear during processing and on the products, and we finally get unexpected evaluation.

Accordingly, it is necessary for us to pay close attention to the proper use of all the features of BD yarns as much as possible while we are developing BD yarns. With regard to BD yarns, a system, which is conventionally adopted for the purpose of selling ring yarns, where yarns are merely sold is not preferable, but rather there should be a control system in which we can spin the yarns in accordance with the products and maintain strict control systematically from the yarns to the final products.

That is to say, we firmly believe that we cannot succeed in business under easy-going ways, such as merely purchasing machines, spinning yarns and selling yarns, which are mainly adapted for ring yarns, because there is much competitive business for developing the products of BD yarns. We should grasp the substance of BD yarns and develop the products which are suitable for the yarns. We should consider a system in which the products are continuously and systematically developed from raw materials to final products. Man-made fiber producers adopt such a system for the purpose of carrying out their business profitably.

4. The Properties of BD Yarns

There are several differences in quality between BD yarns and ring yarns even though they are spun from the same cotton, because the two spinning systems differ substantially in drafting, doubling, twisting, etc.

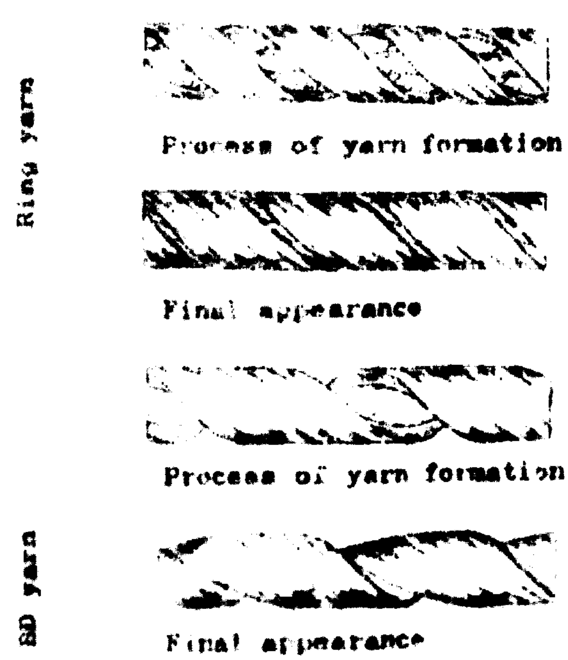
Accordingly, we would like to explain the properties of BD yarns produced commercially in our company as follows, mainly with regard to twist characteristics, strength and evenness of the yarns which will be discussed in Chapter 5 through 7 from the viewpoints of operation, processability and properties of the products.

(1) Twist characteristics of BD yarns

Ring yarns are composed of a soft inner core consisting of fibers twisted only slightly and an outer layer consisting of spiral fibers subjected to high tension. The strength of ring yarns derives from the fact that the fibers forming the yarn core are pressed tightly by wrapping of the outer fiber layer having a larger helical angle. The fibers involved in the surface wrapping layer of ring yarns are smaller in percentage than in BD yarns, so ring yarns show high values of tensile strength. On the other hand, because of outer fiber layer having a smooth surface and a

Fig. 1 Structural models of BD yarn and ring yarn

Structural comparison of the yarns



cylindrical shape, the outer fiber layer is easily broken by friction with outer matters and the core is exposed. This is the reason why ring yarns show a rather low performance in abrasion resistance. From the viewpoints of dyeing and sizing processes, penetration of dyestuffs and sizing agents is bad because the fibers in the soft core are being compressed heavily by the outer layer. BD yarns are composed of a single helical structure. The fibers are distributed from the inner core to the outer layer and are twisted uniformly, eventually the fibers in the inner core receive less compression. This brings not only bulkiness but also good penetration of dyestuffs and sizing agents, on the other hand, it causes a negative factor to yarn strength. Some helical corrugations deriving from the single helical structure are found on the surface of BD yarns, so the peaks of the corrugated helical surface first come into frictional contact with outer matter so that we can avoid mass damage of all fibers on the surface of the yarn. This is the reason why BD yarns show good property in abrasion resistance. Namely, as you can see in Fig. 1, even if the twist coefficient of ring yarns is the same as that of BD yarns, we have quite a different result in handling of the yarns, because of the difference in twist formation.

(2) Yarn strength of BD yarns

Fig. 2a Curve of twist characteristics of BD yarn (Cotton 20 S)

We can get BD yarns having enough strength for practical uses without raising the cost of raw cotton if we use the suitable raw cotton and the right fore-spinning processes and choose the right number of twists. Generally speaking, the strength of BD yarns is 10-25 % lower than that of ring yarns. The rate of yarn strength decline varies with yarn counts and materials to be spun. With 10 S there is hardly any difference in the rate between ring yarns and BD yarns, however, there is a considerable difference between the two in case of fine count yarns and the yarns which are fully or partially composed of man-made fibers exceeding 40 mm in fiber length.

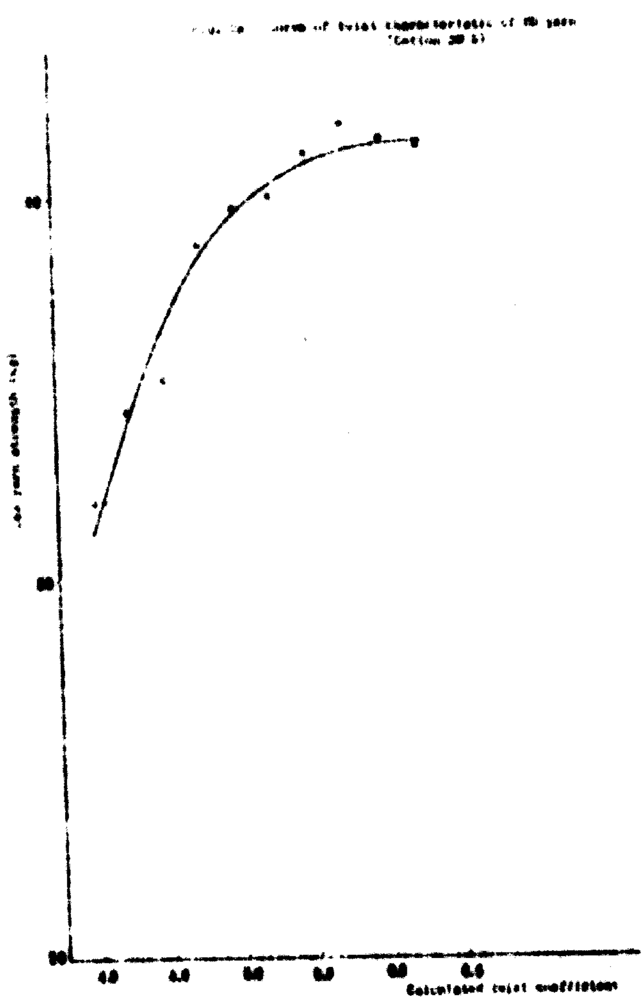


Fig. 2c Curve of index characteristic of [illegible] yarn ([illegible])

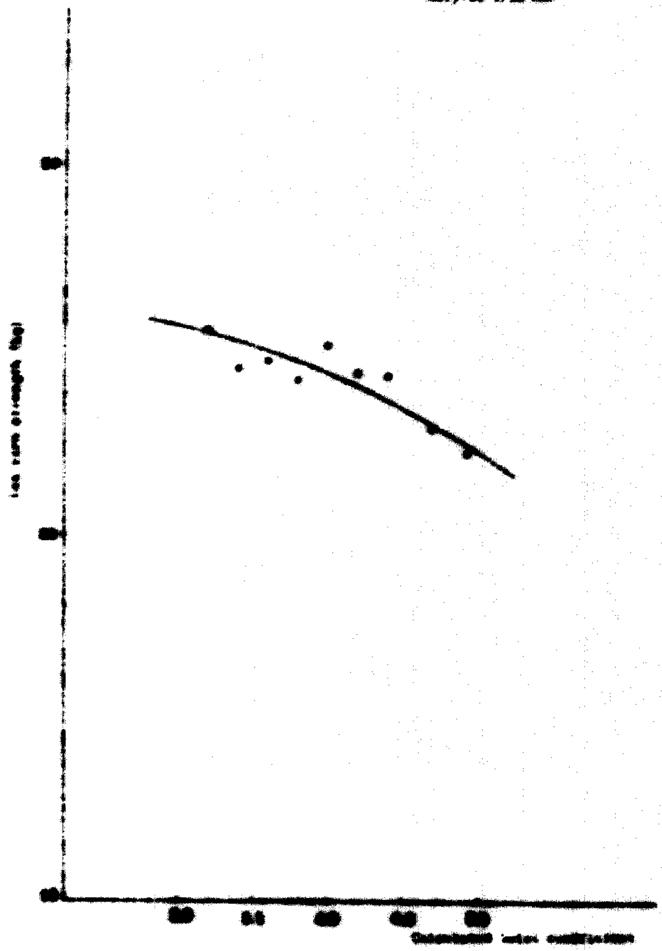
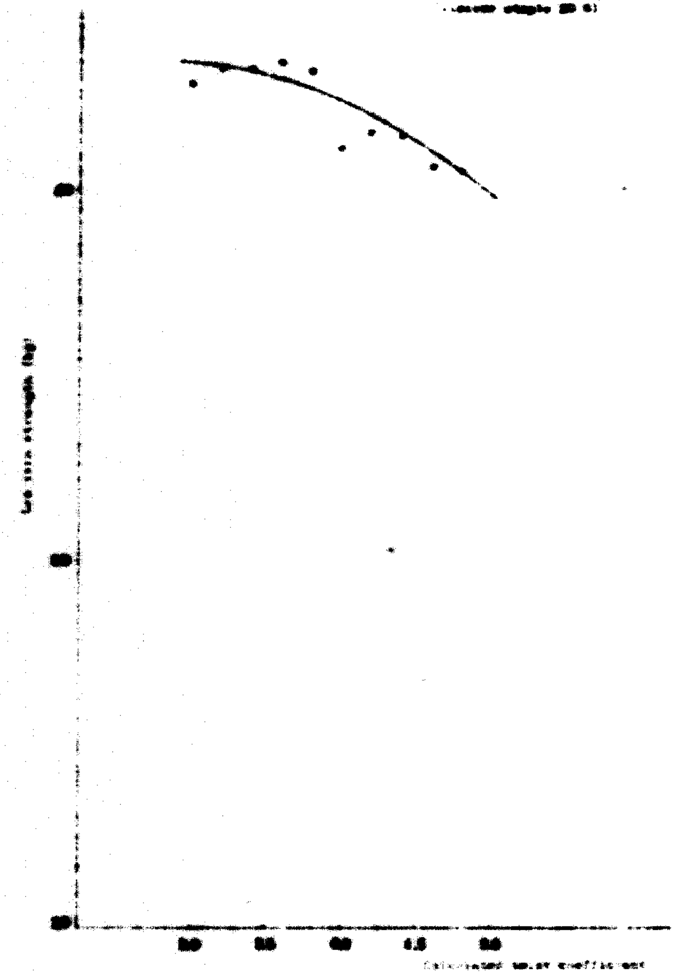
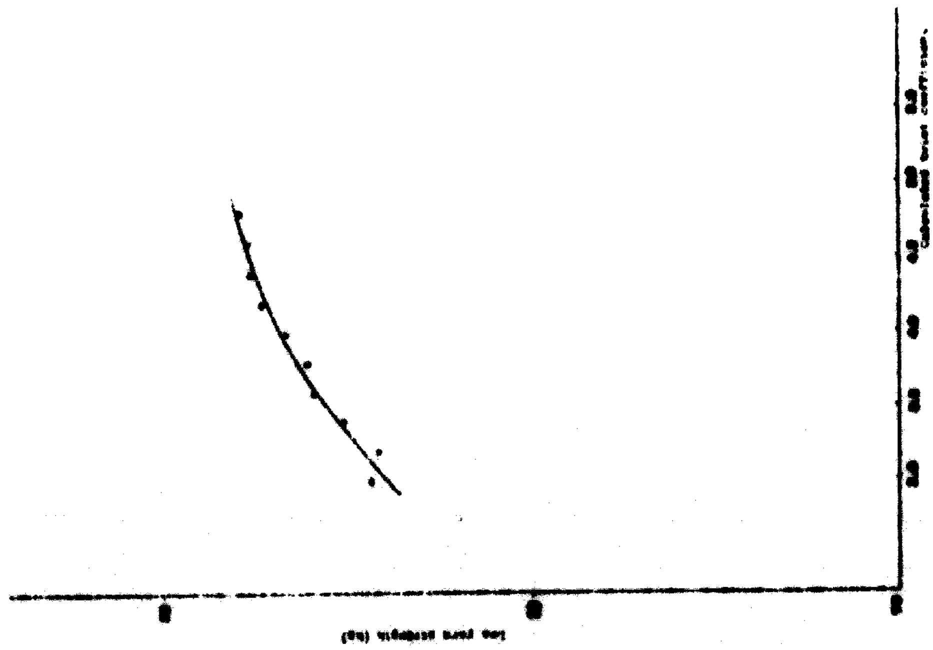
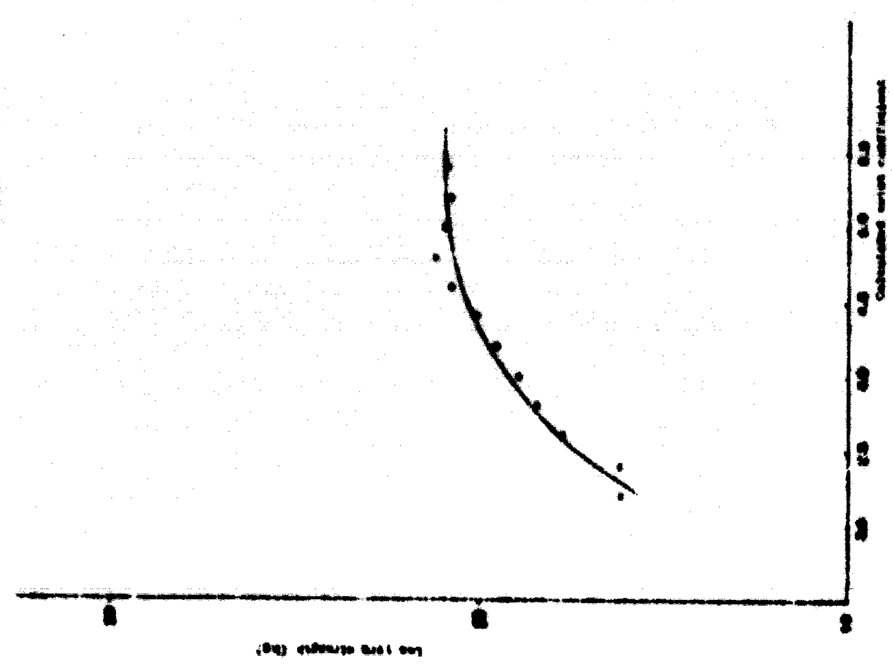


Fig. 2b Curve of index characteristics of [illegible] yarn ([illegible])







We show examples of properties of BD cotton yarns in Table 1a and examples of properties of BD man-made and its blended yarns in Table 1b.

(3) Twist coefficient and yarn strength of BD yarns

According to the difference in the coefficient of twists between ring yarns and BD yarns, the maximum point of strength of BD yarns shifts to a higher twist coefficient in comparison with that of ring yarns. Fig. 2a through Fig. 2e show the relations between twist coefficient and lea yarn strength of typical kinds of cotton, man-made and cotton man-made blended yarns. In spinning, we decide twist coefficient in consideration of yarn strength, spinning conditions and productivity.

(4) Evenness and residual slubs of BD yarns

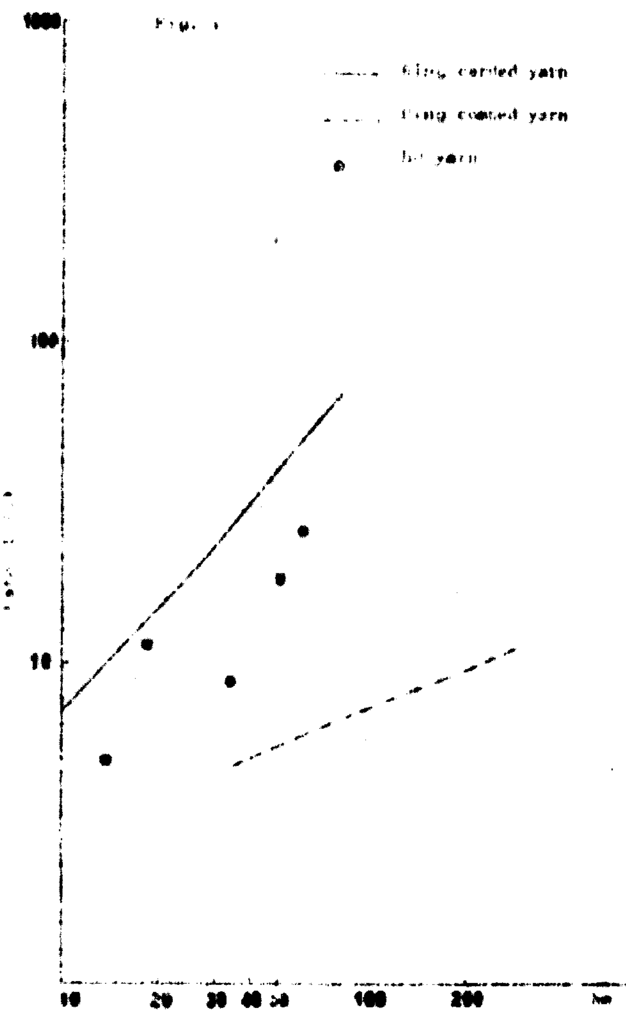
Many people have already reported that the evenness of BD yarns is excellent, which is also verified on the yarns produced in large quantities in our company. Fig. 3 shows the relation between yarn count and Uster U %, Fig. 4a shows the relation between yarn count and number of neps, Fig. 4b shows the relation between yarn count and number of thin yarn parts and Fig. 4c shows the relation between yarn count and number of thick yarn parts.

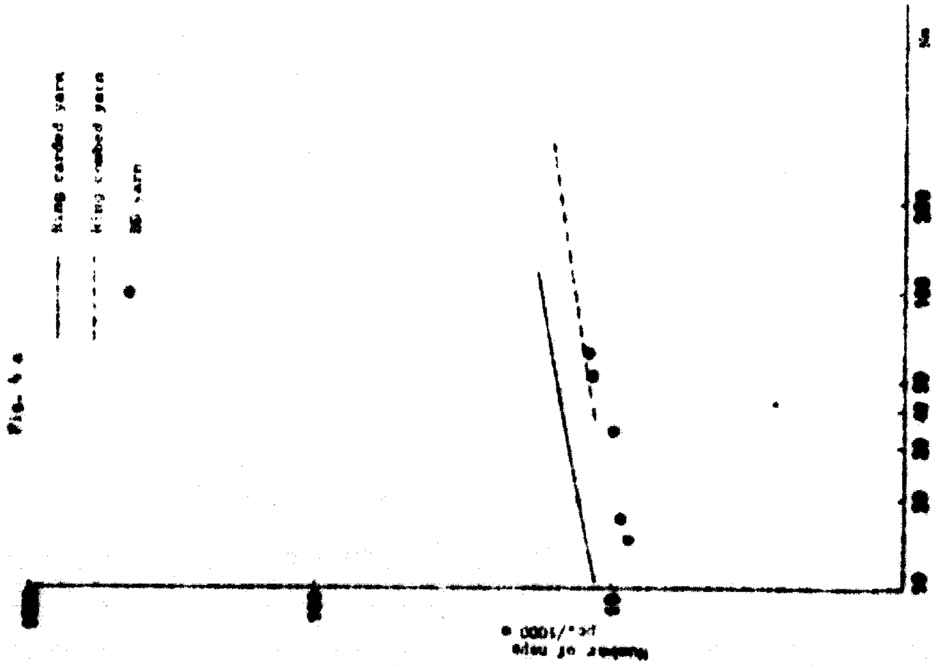
As you can acknowledge from these figures, the U %, number of neps, number of thin yarn parts and number of thick yarn parts of BD yarns are much better than those of ring yarns and are nearly equal to those of ring combed yarns.

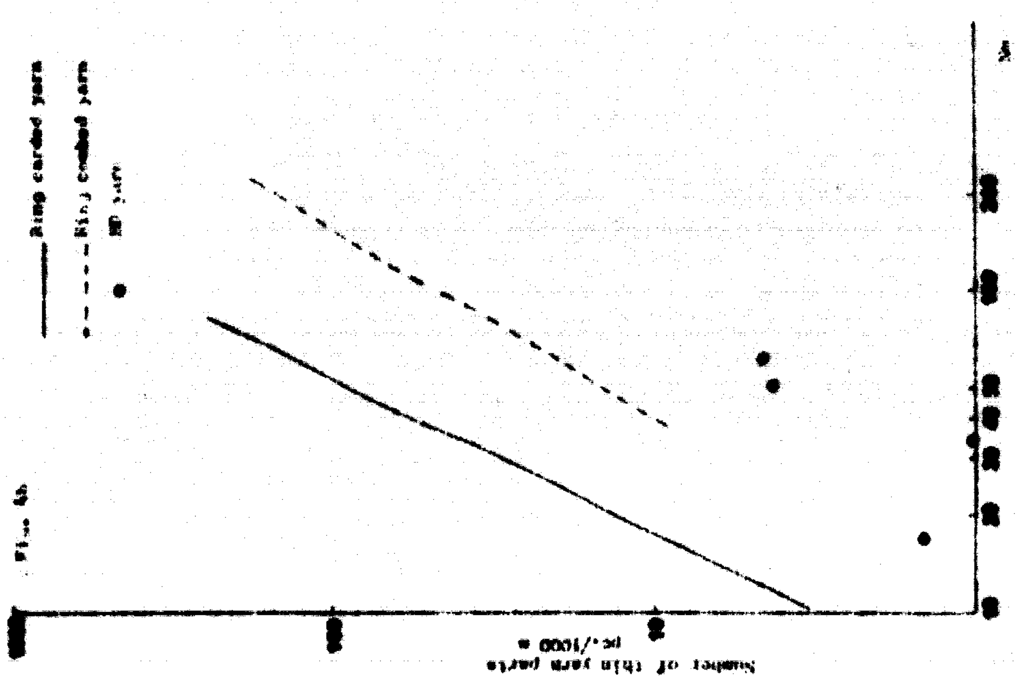
Fig. 5 shows the comparison of yarn appearance on a black board in a picture, we can easily understand that the evenness of BD yarns is excellent.

Since BD yarns are spun by opening, doubling and twisting in the closed "Green Box", slubs produced by irregular drafting and fly are extremely small in quantity.

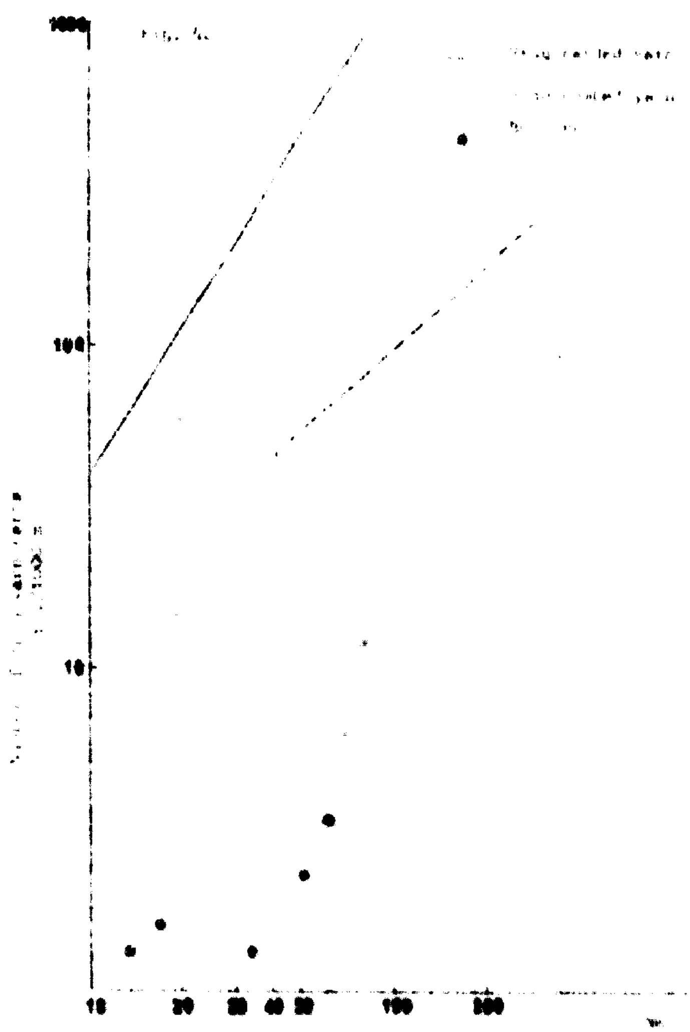
Fig. 3




Ring carded yarn
Ring combed yarn


Ring carded yarn
Ring combed yarn
Number of thin yarn parts
pc./1000 m

Therefore, the winding process for cleaning of the yarns is not necessary if yarn quality is not strictly demanded. We show the investigation result on the number of residual slubs of BD yarns and ring yarns by a slub catcher of the photo-electric system in Table 2, which makes us understand that the number of residual slubs of BD yarns is extremely small.



5. Operational Efficiency of BD Yarns

Operational efficiency of BD yarns is excellent in comparison with that of ring yarns. We believe this is due to fewer defects of the yarns, such as loose twists, fine ends, slubs, etc., which cause yarn breakage, than those of ring yarns, and due to the excellency in abrasion resistance. Namely, the fact that BD yarns have low average strength does not become an obstacle in operation, but, on the contrary, the fact that the strength distribution of BD yarns has a narrower range than that of ring yarns gives us a great advantage to the operation.

(1) Warping process

(a) As the form of package of BD yarns differs from that of ring yarns, creels are enlarged and cause a disadvantageous factor, but down-time involved in package-changing is shorter because of large package of BD yarns.

(b) As there are fewer defects of BD yarns and as there are no knots in spools, we have less yarn breakage during warping in comparison with ring yarns, thus warping efficiency is advanced. Table 3 shows the number of yarn breaks during warping of 20 S cotton BD yarns and ring yarns by the causes, and it is apparent that the number of yarn breaks of BD yarns largely decreases compared with that of ring yarns.

(2) Weaving process

Yarn breakage of BD yarns during weaving is less in comparison with that of ring yarns, and the weaving efficiency is excellent.

It is believed that the advantage of BD yarns becomes more apparent in case automatic and high-speed weaving looms are used. Table 4 shows the excellence of abrasion resistance of BD yarns to reed wires. Table 5 is the comparison of the yarn breakage during weaving.

BD yarns have strong abrasion resistance, less fluff and fly to be wound in and no knots. Together with these points, the number of yarn breaks during weaving largely decreases in comparison with that of ring yarns.

(3) Knitting process

With regard to the knittability of BD yarns, we cannot expect such a great advantage of BD yarns in the conventional processes of knitting as in case of weaving processes. We think it is because of a high frictional coefficient and bending modulus which can be traced back to the twist construction of BD yarn.

Consequently, we should give smoothness and softness to the yarns by means of waxing and oiling and strictly control the tension of knitting machines.

By means of setting automatic yarn feeders to knitting machines in order to reduce the tension variation, together with sufficient minimum strength, in spite of low average strength, less fluff, no knots and excellent evenness of the yarns, we can knit excellent products.

6. The Properties in Finishing of BD Yarns and the Products of BD Yarns

The properties in finishing of BD yarns do not differ so much from those of ring yarns except for dyeability and sizing property.

(1) Dyeing

The difference of dyeability between BD yarns and ring yarns is caused by the arrangement of fibers based on the difference of twist construction, in other words, the difference in air content, so that we can obtain brilliant colors because of good penetration and good holding ability of water.

As BD yarns absorb dyestuffs rapidly at the initial stage of dyeing, it is not desirable to dye both BD yarns and ring yarns in the same dyeing bath.

(2) Sizing

Because of the same reason as mentioned above, BD yarns have good absorbency in sizing materials, we should adjust the concentration of sizing materials 10-20 % less than the conventional concentration in order to secure the same quantity of applied sizing materials.

(3) Raising

By adding some consideration to the process we can get almost the same raising characteristic on BD yarns as on ring yarns though there is a difference of twist construction between them.

(4) Steam-setting

By steam-setting at about 90° C, we can perfectly prevent BD spun cotton yarns from any kind of trouble which is caused by the difference in twist characteristic during hank dyeing and knitting.

(5) Scouring and bleaching

Desizing, scouring and bleaching on woven fabrics of BD yarns can be performed in the same condition as on woven fabrics of conventional ring yarns. Table 6 shows one of the results of scouring, bleaching and finishing in our mill for your reference.

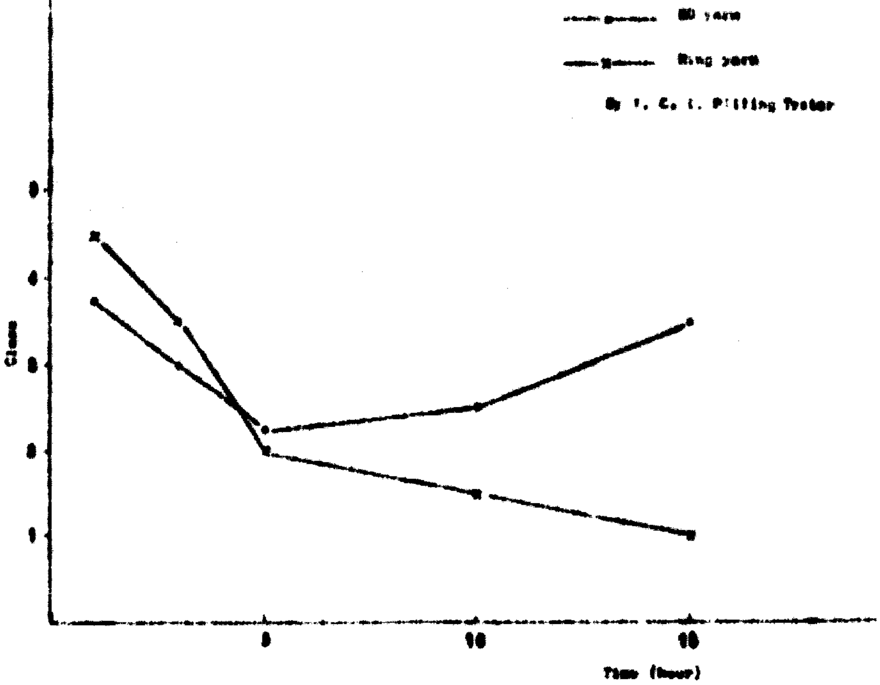
(6) Finishing

When reactant type resins are used, the woven fabrics of BD yarns generally have excellent crease resistance. With regard to resin concentration, the same effect can be attained for woven fabrics of BD yarns even if the resin concentration is about 10-20 % less than that for woven fabrics of ring yarns. Table 7 shows the results of finishing processes.

(7) After washing

Concerning hardening tendency of touch and shrinkage by washing, there is no big difference between the products of BD yarns and those of ring yarns.

Fig. 6 Comparison of pilling tendency



(8) Pilling

Occurrence of pilling is, to a certain degree, unavoidable in case of knitting products of synthetic fibers, however, there is an apparent difference between the products of ring yarns and those of BD yarns. With regard to the products of BD yarns, pilling is easily raised but disappears soon. For this phenomenon we assume the following to be the reason. There are some floating fibers on the surface which do not participate in the construction and they are apt to flock together and cause pilling, but are taken off very easily.

In case of acrylic Jersey, resin finishing is usually applied in order to improve anti-pilling. Fig. 6 shows the comparison of pilling.

7. The Properties of the Products of BD Yarns

(1) General description

(a) Strength of the products made of BD yarns is almost in proportion to that of BD yarns. Considering the required strength for the products, there is no trouble so far as 36's class is concerned, however, there are still some points to be solved regarding the products made of fine yarns.

(b) Generally, the products have a good appearance, thickness, suitable bulkiness and agreeable harshness, but we had better increase the amount of softness depending on the kinds of products.

(c) As twist construction and orientation degree of fibers of BD yarns are different from those of ring yarns, some of the products have the tendency of cloudy surface depending on the kinds of woven fabrics.

(d) It has a good dyeability and can be dyed in brilliant colors.

(e) In case of blended yarns, blending of fibers composing BD yarns is so good that we can gain a special effect on one side dyeing of blend fabrics by blending more than two kinds of fibers with different dyeability.

(f) We can get very brilliant printed fabrics, and we are going to explain in detail every kind of product of BD yarns which has these characteristics.

(2) Woven fabrics

A. Sheeting

The surface of the cloth is good, it has a feeling of bulkiness, and there is no problem of strength.

B. Flannel

Raising is good, and there is no problem of strength.

C. Bed sheets

In case of dobby fabrics, there is no difference in appearance between BD yarns and ring yarns, they have agreeable coarseness, and both good absorbency of humidity [illegible] make the products rank very high.

D. Terry cloth

The products of BD yarns are well piled-up and have a good appearance. Particularly pile woven fabrics of paralleled yarns which are after-processed give us an even twist to every pile and effective result.

E. Leno cloth

Products of BD yarns have a good appearance and the texture of the cloth is better than that made of ring yarns.

F. Canvas

In case of coarse yarn of this class, there is hardly any difference of strength between BD yarns and ring yarns, so that canvas can be used as a water-proof cloth for covers for trucks and tents.

G. Poplin

Products of BD yarns have a good appearance as a base cloth for printing as well as piece-dyed goods and are particularly suitable for poplin of high density. Table 8 compares the fabric properties of products.

H. Casual wear

Ring two-folded yarns are conventionally used for casual wear. however, in case of BD yarns, single yarns are sufficient for casual wear, and it has got a good reputation by soft-touch-finishing by emery.

Table 9 shows the fabric properties of BD polyester/cotton yarns.

I. Velveteen and corduroy

Due to the improvement of twisting and processing methods of BD yarns, the advantage of BD yarns has become apparent.

(3) Knitted fabrics

A. Underwear (Rib, Interlock)

The products of BD yarns have an excellent general appearance and clear appearance in texture and have nearly the same appearance as the products of combed yarns of ring spinning. The BD yarns have a strong harshness so that soft BD yarns by a special twisting method are used when soft touch is needed. Moreover, the appropriate soft finishing is done as occasion demands.

B. Outerwear

Touch of BD yarn products is excellent. We are making efforts to develop our products from the fields where outerwear is consumed in large quantities, namely from the field of jersey for children and infants, the field of underwear which replaces underwear of conventional high-bulked yarns and the field of circular knitted sweaters, etc. to the field of yarn dyed jacquard and jersey. Table 10 gives a comparison of acrylic-knitted fabric properties.

8. Spinning Conditions of Open-end Spinning Machines BD-200

Our company has put a lot of spun yarns and products on the market, which are dealt with in detail in Chapters 4 - 7. And until we were able to spin the above-mentioned yarns by the BD-200 Open-end spinning machine, a certain amount of know-how was accumulated, however, we would like to explain elsewhere the detailed spinning condition, quality control and standard of maintenance.

As it will be explained in Chapter 9, when the BD-200 Open-end spinning machines were installed in our company, the special mill from fore-spinning to rewinding was not constructed. We only carried out the replacement of the ring spinning machine by the Open-end spinning machine and certain reconstruction work on finish-drawing machine and air conditioning equipment, etc. We continue to use partly conventional equipment of both fore- and back-spinning so that we are spinning and controlling on fore-spinning processes according to the conventional ring spinning method.

Concerning the Open-end spinning machine, we are spinning in the conditions illustrated in Table 11.

9. Economic Survey of Open-end Spinning Machines BD-200

The economy of Open-end spinning was already introduced in various parts but there is hardly any economically calculated explanation based upon the actual operation data. Fortunately in our company, we already have the actual results of commercial operation of 290 sets of Open-end spinning machines, and the actual results based upon these experiences will be shown later.

The production cost differs according to the conditions, and the calculation shown here is the result based upon the assumptions as follows:

Assumptions:

(1) Spun yarn: Cotton 20 S

(2) Production capacity: BD-200 100 frames

(3)	Method of equipment:	Ring spinning machines are replaced by BD-200 machines, and reconstruction of both fore- [illegible] and air conditioning equipment is carried [illegible] the [illegible] scale.
(4)	Spinning condition:	According to the spinning condition described in Chapter 8.
(5)	Year of depreciation of machine:	Main machines 10 years
(6)	Ratio of annual wage increase:	13.5 - 14.0 %
(7)	Cost of electric power:	¥ 4.20/KWH
(8)	Ratio of spool rewinding:	30 %
(9)	Method of operation of BD-200:	3 shifts, 24 hours operation
(10)	Number of ends down of BD-200:	2.5/200 sp.-hr

(1) Placing of workers and arrangement of equipment

Table 12 shows the placement of workers and Table 13 shows the placement of workers required for standard equipments of both BD and ring spinning systems.

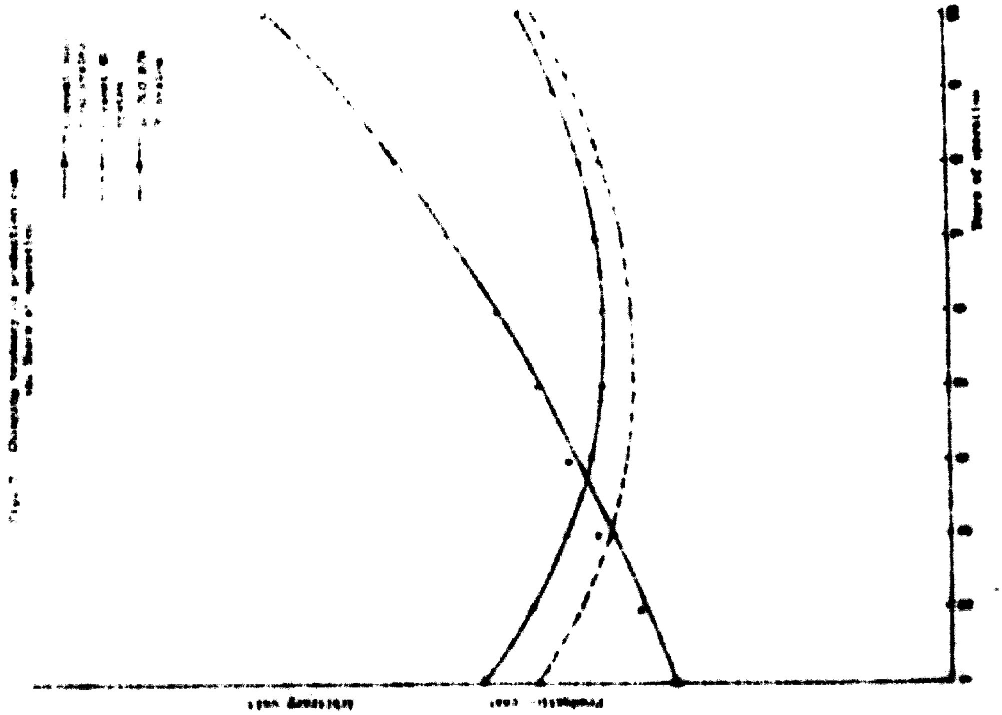
(2) Production cost

Fig. 7 shows the tendency of production cost which changes as the year goes by in both systems, BD and ring spinning systems. (The year should be counted from the time of installation of BD-200).

The solid line marked with "o" shows the production cost for the manufacture of one bale of cotton 20 S in case of a number of workers of 1.47. And the solid line marked with "x" shows the cost in the case of the present ring spinning system.

We firmly believe that Open-end spinning will gain advantage over the ring spinning system in four years after installation of the machine under the present ratio of wage increase in Japan, even if, in consideration of safety, the number of revolutions of the rotor is lowered to less than 30,000 R/M.

And the dotted line shows an expected cost under the spinning condition in mass production of 40,000 R/M of the rotor.



10. Lay-out of a Newly Established Mill of Open-end Spinning System

The installation for the purpose of replacing the ring spinning machine which is adopted in our company was explained in the above Chapter 9, and next we want to introduce one example of a lay-out of a newly established mill which is designed on the premises of using the BD system.

The assumptions are as follows.

(1) Cotton 20 S

(2) BD-200 99 sets (output per day 142.32 x 99)

(3) Winders for rewinding and a steam-setter are installed in the weaving and knitting departments

(4) Air conditioning equipment should not be installed in the mixing and blowing processes

(5) Conditions of air conditioning

A. Degree of temperature and humidity

Outdoors (summer)	t = 33° C	t' = 27° C
Indoors (summer)		
fore-spinning	t = 29° C	ø = 55 %
spinning	t = 28° C	ø = 60 %

B. Water temperature 20° C (summer)

C. Illumination $10\ w/m^2$

D. Calorification of human body

150 Kcal/1 person.H.

Moreover, Fig. 8 shows a lay-out of a newly established mill of Open-end spinning system. Table 14a shows the capacity of the main machine, Table 14b shows the number of machines and equipment and electricity for the equipment, Table 14c show the power equipment and the necessary quantity of consumed steam, water and air.

11. Conclusions

About four years have passed since the Czech BD-200 Open-end spinning machine was introduced. Although there have been a lot of discussions about the quality and profitability during this period, the fact that BD-200 became real proves that industry expects much from the Open-end spinning machine.

The productivity of the present BD-200 frame is about twice that of the ring spinning frame while the price of the BD-200 frame is higher than that of the ring spinning frame. Consequently, at the initial stage of the installation there will be an economic dis-advantage in consideration of depreciation of the machine. However, considering the wage increase in each year, the production cost will be lower than that of the ring spinning frame after about four years of operation. Moreover, we have faced a hard labor situation that the number of young laborers is decreasing year by year. Judging from the above reasons, we firmly believe that the age of Open-end spinning will be realized much sooner than we expected. Moreover, the fact that the number of workers is less than half of that of the conventional ring spinning frame will never make the spinning industry a declining one.

In the countries with lower wages, mill managing using the ring spinning frame will still be profitable. However, in the countries with high wages like the U.S.A. and Europe, if people operate the Open-end spinning machine just as it is done in Japan, we can firmly believe that the progress of Open-end spinning will be much faster in these countries than in Japan. Not many years have passed since the utilization of Open-end spinning was realized, and there are many points to be innovated. However, they will be innovated together with the progress of related technology and the spinning range will be enlarged, and the number of revolutions of the rotor will make rapid progress.

Bearing in mind that there is no end in the field of technology, we co-operate with Messrs. Toyoda Automatic Loom Works, Ltd. and are making great efforts to improve the Open-end spinning, and at the same time to develop the products made of Open-end yarns and we try to develop our mill industry.

Table 1a Examples of properties of BD Cotton yarns

Item / Yarn count	10 S	20 S	30 S
Weight (Grain/120 Yds)	99.17	49.32	31.70
Weight variations (%)	1.9	0.8	1.6
Dried weight (Grain/120 Yds)	93.38	46.50	29.84
Moisture percentage (%)	6.20	6.06	6.21
Lea strength (kg)	87.17	41.90	23.43
Lea strength of corrected counts (kg)	85.19	41.11	24.12
Lea elongation (%)	7.36	7.09	6.72
Single yarn strength (g)	671.00	328.10	190.30
Single yarn strength of corrected counts (g)	661.63	321.89	196.12
Single yarn strength variations (%)	8.1	10.5	8.1
Single yarn elongation (%)	7.75	7.44	6.51
Number of twists (T/inch)	14.40	21.60	26.80
Twist variation (%)	2.4	2.4	2.5
Uster U (%)	9.31	10.63	12.27
Number of ends down (200 sp. hr)	2.76	2.50	3.91

Table 1b Examples of properties of BD man-made and its blended yarns

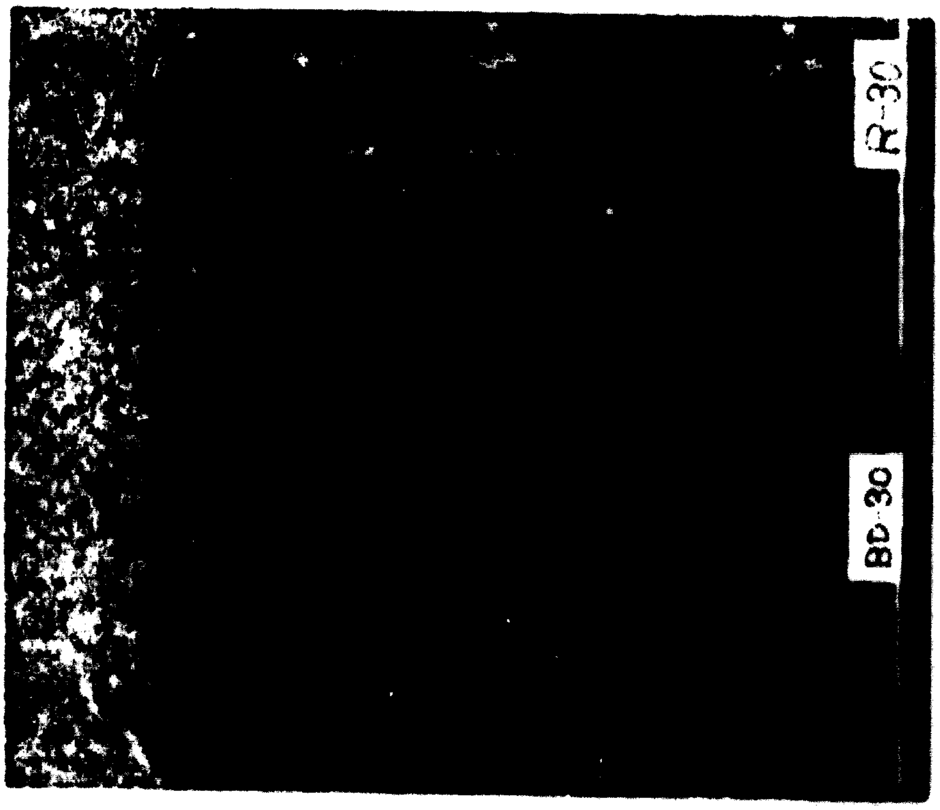
Item / Yarn count	Acrylic 1/31 Nm	Acrylic 1/52 Nm	Viscose staple 20 S	Polyester 65%/ Cotton 35% 32S	Cotton 70%/ Acrylic 30% 32 S
Weight (Grain/120 Yds)	54.53	32.54	51.02	31.38	31.62
Weight variations (%)	2.3	1.8	1.2	1.6	2.0
Dried weight (Grain/120 Yds)	53.76	32.13	45.47	30.47	30.19
Moisture percentage (%)	1.43	1.27	12.21	2.99	4.73
Lea strength (kg)	44.77	24.46	43.56	28.07	20.46
Lea strength of corrected counts (kg)	44.59	24.30	43.15	27.30	19.89
Lea elongation (%)	18.75	17.16	11.72	8.35	6.61
Single yarn strength (g)	352.58	197.60	321.00	239.30	161.10
Single yarn strength of corrected count (g)	351.14	196.30	317.96	232.70	156.62
Single yarn strength variations(%)	5.3	10.3	6.2	6.0	7.0
Single yarn elongation (%)	20.03	18.37	12.84	9.01	6.46
Number of twists (T/inch)	16.83	21.36	13.16	20.11	22.64
Twist variations (%)	6.9	5.5	1.5	7.1	5.0
Uster U (%)	10.26	11.76	11.62	11.74	11.15
Number of ends down (200 sp. hr)	1.21	1.75	1.53	3.87	3.60

Table 2 Comparison of slub between BD yarn and ring yarn

Note: BD yarn on spool
Ring yarn on bobbin

Count		Thickness % \ Length (cm)	Number of slubs in yarn pc./100,000 m 0.1	1	2	4
Cotton 20 S	Ring yarn (carded)	400	0.84	3.70	0.84	0.50
		250	4.04	7.23	1.01	0.16
		150	60.45	22.05	4.04	0.50
		100	1103.87	184.34	22.39	1.17
	BD yarn	400	0	0	0	0
		250	2.06	0	0	0
		150	14.42	1.03	0	0
		100	106.09	3.09	0	0
Cotton 30 S	Ring yarn (carded)	400				
		250				
		150				
		100				
	Ring yarn (combed)	400	2.08	1.04	3.12	2.08
		250	2.08	3.12	0	0
		150	16.64	10.40	3.12	0
		100	108.16	5.20	0	0
	BD yarn	400	0	0.92	0	0
		250	0	0.92	0.92	0
		150	9.2	0.92	0	0
		100	87.4	1.84	0	0.92

Fig. 5 Comparison of yarn appearance on a black board between BD yarns and ring yarns



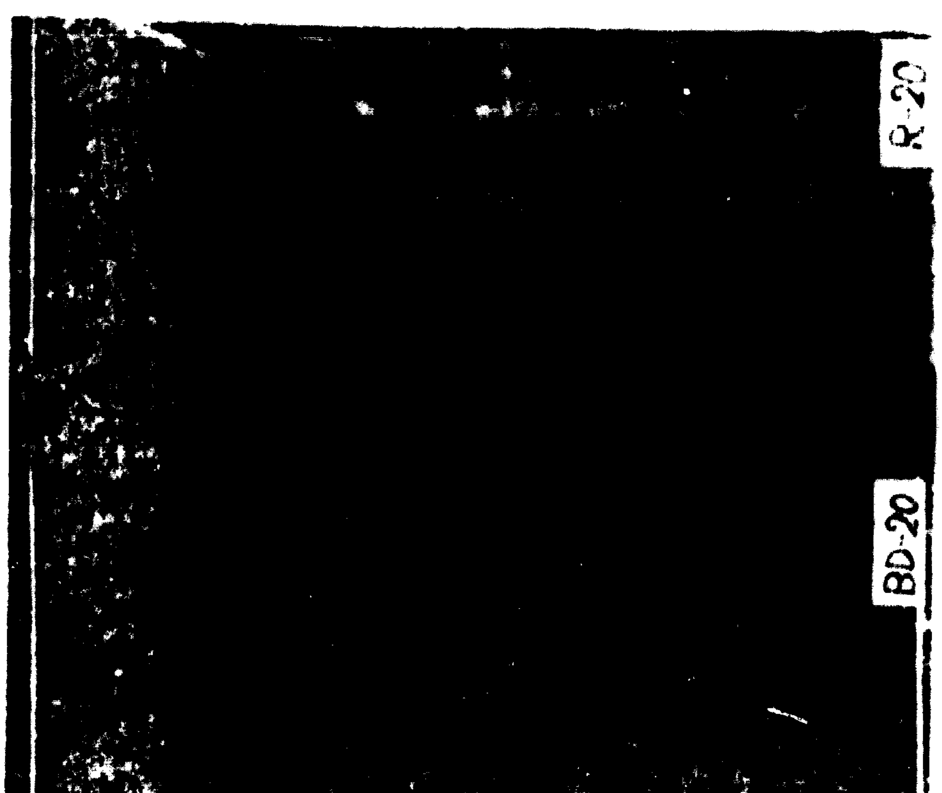


Table 3 Number of yarn breaks during warping

(Cotton 20 S per 5,000,000 Yds)

Cause of yarn breaks	Yarn	BD yarn	Ring yarn
Spool defect	Breaks on spool	1.68	1.77
	Ribbon-wind	0.84	0.22
	Other causes	0.63	2.21
Yarn defect	Slubs	1.89	3.98
	Loose twists	0.84	1.99
	Other causes	3.15	4.64
	Total	9.03	14.81

Table 4 Strength of abrasion resistance to reed wire (20 S)

Yarn	Abrading times until breaking
BD yarn	1120
Ring yarn	345

Table 5 Number of yarn breaks during weaving process (per loom per hour)

product	Sheeting				Shirting			
	Warp		Weft		Warp		Weft	
Causes of yarn breaks	BD 20 S	Ring 20 S	BD 20 S	Ring 20 S	BD 30 S	Ring 30 S	BD 30 S	Ring 30 S
Loose twist	0.017	0.050	0.023	0.040	0.023	0.043	0.017	0.037
Yarn irregularity	0.003	0.026	0.010	0.020	0.013	0.033	0.033	0.050
With fly waste	0.003	0.010	0	0.007	0.017	0.026	0.003	0.013
Slubs	0.007	0.057	0.017	0.033	0.023	0.063	0.023	0.053
Slipping out of yarns	0.033	0.017	0.010	0.017	0.023	0.050	0.033	0.053
Slipping out of knots	0	0.017	0	0.007	0.003	0.033	0	0.010
Other causes	0.047	0.057	0.033	0.017	0.060	0.053	0.053	0.040
Total	0.110	0.234	0.093	0.141	0.162	0.301	0.165	0.256

Table 6 Examples of fabric properties after scouring and bleaching

Item	Gray fabric BD 20 S x BD 20 S / 100 x 50		Bleached and mercerized fabric	
	48" x 100 Yds		44" x 102 Yds	
	Warp	Weft	Warp	Weft
Strength (lb)	84.9	46.8	88.8	49.4
Elongation (%)	26.7	11.1	16.6	20.5
Shrinkage after washing (%)	13.29	4.94	5.8	0.4

Note: Tensile testing . . . . . . Grab method
Shrinkage after washing . . Sanforized method

Table 7 Fabric properties after resin finishing

Gray fabric
BD 20 S x BD 20 S / 100 x 50

Resin	Conc. Item	Tensile strength W + F	Tearing strength W + F	Crease recovery (degree) W + F
Glyoxal	2.5 %	91.2	1600	136
	4.0	77.6	1285	167
	6.0	73.4	1170	274
Ethylene urea	2.5	113.6	1870	186
	4.0	103.0	1585	214
	6.0	76.6	1290	257

Table 8 Comparison of fabric properties

Product	Yarn	Construction	Thickness (m/m)	Tensile strength(kg) Warp	Tensile strength(kg) Weft	Tearing strength(g) Warp	Tearing strength(g) Weft	Bending abrasion (time) Warp	Bending abrasion (time) Weft	Flat abrasion (time)
Sheeting	BD	20 x 20	0.35	49.5	48.3	766	724	148	139	11
(Size-finished)	Ring	62 x 60	0.34	53.1	52.8	836	878	198	193	9
G poplin	BD	20 x 20	0.48	89.6	35.4	1812	850			
(Unfinished)	Ring	110 x 50	0.48	90.6	40.6	1870	1074			
Shirting	BD	30 x 30	0.34	29.3	28.4	478	488			
(Finished)	Ring	61 x 63	0.33	30.9	28.8	574	570			
Canvas	BD	10/2 x 10/2	0.68	90.8	81.0	3750	3330			1730
(Water-proof)	Ring	45 x 36	0.67	87.0	84.0	4130	3430			1360

Table 9 Fabric properties of BD Polyester/Cotton yarn

(For casualwear)

Item / Yarn	Polyester 65 %/Cotton 35 % 16 S
Construction	16 S x 16 S
Weight g/m^2	240
Tensile strength W (kg)	130
F	54
Elongation W (%)	24
F	25
Tearing strength W (g)	3600
F	2250
Crease recovery W (degree)	125
F	150
W. & W.	4 - 5

Table 10 Comparison of acrylic knitted fabric properties

Item / Yarn		BD Yarn	Ring Yarn
Yarn count Nm		1/52	1/52
Construction		Three step butt interlock (20 G)	the same
		Heat set finishing	the same
Thickness (m/m)		1.06	1.04
Density	W	34.2	36.0
	C	35.6	34.4
Weight (g/m²)		249	283
Tearing strength (g)	W.D.	4630	5490
	C.D.	4620	5510
Bursting strength (kg)		8.8	11.3
Flat abrasion (Time)		354	334
Shrinkage after washing (%)	W.D.	3.4	3.4
	C.D.	- 1.3	- 5.0

Table 11 Spinning conditions of Cotton yarn by Open-end spinning machine BD-200

Yarn Count Ne / Item	8 S	10 S	12 S	14 S	16 S	20 S	30 S	36 S
Weight (Grain/120 Yds)	123.27	98.62	82.18	70.43	61.62	49.30	32.87	27.40
Number of revolutions of rotor (R/M)	30.000 ... 40.000	30.000 ... 40.000	30.000 ... 40.000	30.000 ... 40.000	30.000 ... 40.000	30.000 ... 40.000	30.000 ... 40.000	30.000 ... 40.000
Number of revolutions of combing roller (R/M)	7.500 ... 8.500	7.500 ... 8.500	7.500 ... 8.500	7.500 ... 8.500	6.500 ... 7.500	6.500 ... 7.500	6.500 ... 7.500	6.500 ... 7.500
Twist coefficient $T/Ne^{\frac{1}{2}}$	4.2 ... 5.4	4.2 ... 5.4	4.2 ... 5.4	4.2 ... 5.4	4.2 ... 5.4	4.2 ... 5.4	4.2 ... 5.4	4.2 ... 5.4

Table 12 Table of placement of workers

Item \ System	BD System 2 Shifts	BD System 3 Shifts	Ring System 2 Shifts	Ring System 3 Shifts
Number of machines	100		105	
Number of spindles	20.000		40.320	
Number of bales per day	94.88	142.32	94.71	142.07
Necessary workers (direct)	126	178	290	415
Necessary workers (indirect)	29	32	37	41
Total	155	210	327	456
Number of workers per bale	1.64	1.47	3.45	3.21
O.H.P. man,hour	3.17	2.67	6.69	5.82
P.M.H. lbs/man,hour	31.59	37.39	14.95	17.19

Table 13 Number of workers necessary for standard equipments on BD and ring spinning systems

	System	BD				Ring			
	Process	Number of machines	Number of operated machines per shift	Total number of workers for two shifts	Total number of workers for three shifts	Number of machines	Number of operated machines per shift	Total number of workers for two shifts	Total number of workers for three shifts
Direct parts	Mixing and opening	6	5	14	20	6	5	14	20
	Carding	117	113	15	21	152	147	18	25
	Drawing	12	11	12	21	9	8	11	15
	Roving					32	31	20	36
	Spinning	100	98.5	46	68	105	103	142	206
	Rewinding	6	5	21	38	14	13	64	94
	Auxiliaries			5	6			12	15
	For all processes			2	2			4	4
	Total			126	178			290	415
Indirect parts	Utilities			7	7			7	7
	Technical work			1	1			1	1
	Office work			6	6			6	6
	Personal work			15	18			23	27
	Total			29	32			37	41
	Grand total			155	210			327	456

Grand total

Table 14a Specifications of main machines

Machine	Yarn Count Ne	Number of doublings	Draft	Processing speed (m/min)	Calculated output (g/hr)	Efficiency (%)	Actual output (g/hr)	Necessary output (kg/hr)	Loss (%)	Number of calculated units	Number of machines	Number of units on a machine	Total number of units
Karousel opener							240			5	6	1	6
Card "Cristal-lina" 24" x 48" cans	0.12				25	96	24	1096	3.5	45.7	48	1	48
Drawframe DO/2 20" x 45" cans	0.14	8	9.33	240	60.8	85	51.6	1089	0.6	21.1	12	2	24
Finisher Drawframe	0.165	8	9.43	300	64.5	85	54.8	1083	0.6	19.8	12	2	24
Open-end spinning frame "BD-200"	20		121		55.03	97.57	153.7	1047	3.48	19503	99	200	19800

Table 14b Number of equipped machines and electricity for equipment

Name of machine	Number of machines	Electricity for equipment HP	Total electricity for equipment HP(Kw)	Quantity of compressed air per machine Nm^3/min	Total quantity of compressed air per machine Nm^3/min
Karousel opener	6	20.0	(90.0) 120.0		
Waste opener	3	3.75	(8.5) 11.25		
Mono cylinder cleaner	6	3.0	(13.5) 18.0		
Aeromix	3	16.5	(37.1) 49.5		
E R M Cleaner	6	10.0	(45.0) 60.0		
		Sub total	(194.1)		
Flockfeeder incl. fan	6	13.5	(60.7) 81.0		
Card "Cristallina"	48	7.75	(279.0) 372.0	0.7	33.6
Drawframe DO/2	12	7.5	(67.5) 90.0	0.1	1.2
Finisher Drawframe	12	8.5	(76.5) 102.0		
		Sub total	(483.7)		
Open-end spinning frame BD-200	99	28.0	(2069.1) 2772.0		
		Sub total	(2069.1)		
Waste removal plant	1	75	(56.2) 75	31.0	31.0
Pneumatic conveyance	1	50.0	(37.5) 50.0	7.2	7.2
Compressor plant	2	15.0	(22.5) 30.0	72.0	144.0
		Sub total	(116.2)		
		Total	(2863.1)		

Table 14c Power equipments and necessary quantity of consumed steam and water

Item / Process	KW electricity for equipment: Machine	KW electricity for equipment: Air-conditioning	Electric light KW	Consumed quantity of water T/min	Consumed quantity of steam T/min	Quantity of ai- kg/min
Mixing and opening	194.1					
Fore-spinning	483.7	141.4				Circulating air 2800 Fresh air 700
Spinning	2069.1	434				Circulating air 7840 Fresh air 1960
Refrigerator		953.4				
Total	2863.1	(1000RT) 1528.8		Circulating water 35.5	2.6	Circulating air 10640 Fresh air 2660
	4391.9		53.1	Charged water 1.0		
	4445					
Note				18° C	3 kg/cm^2 (g)	

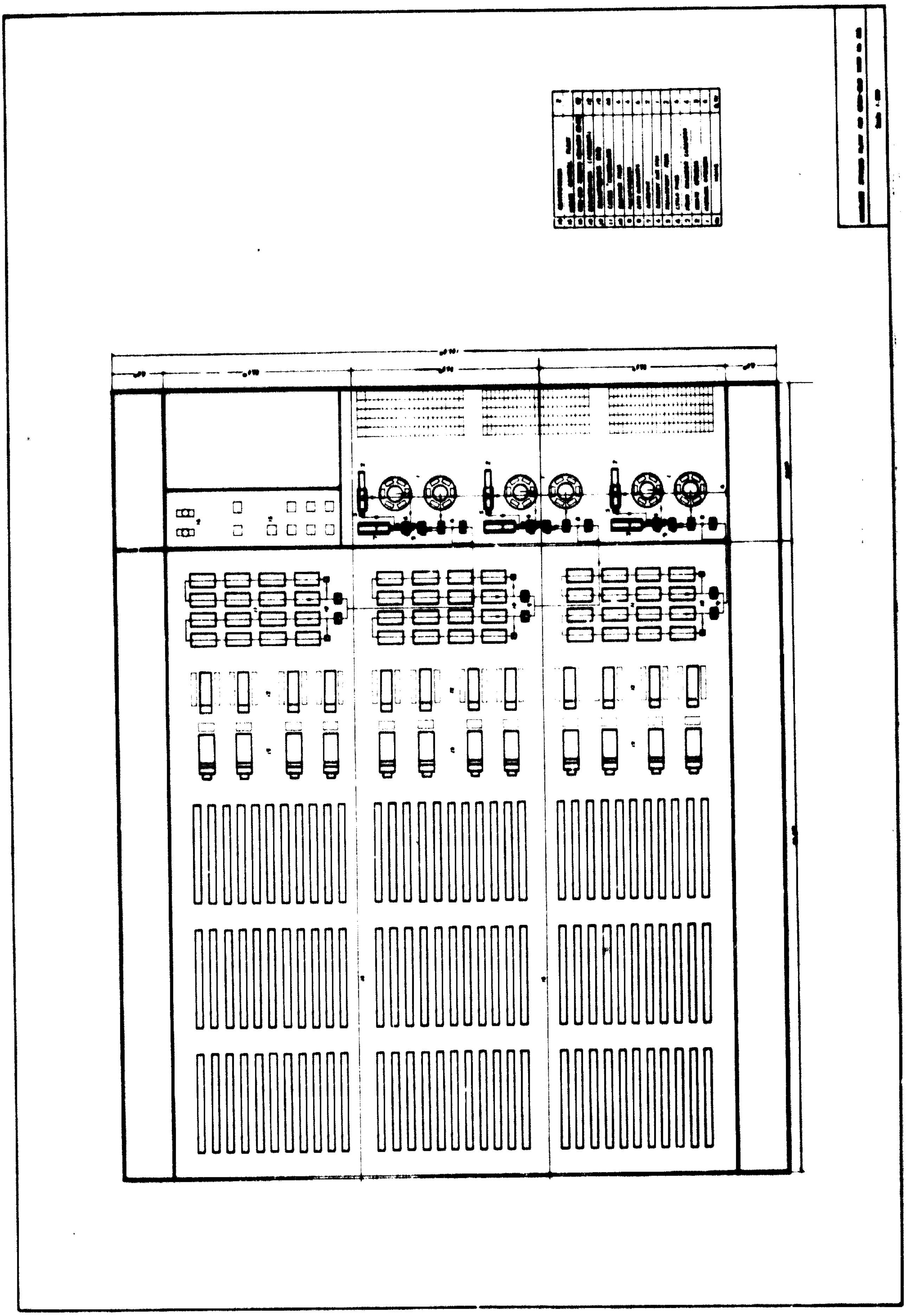


Fig. 1 Structural models of BD yarn and ring yarn

Structural comparison of the yarns

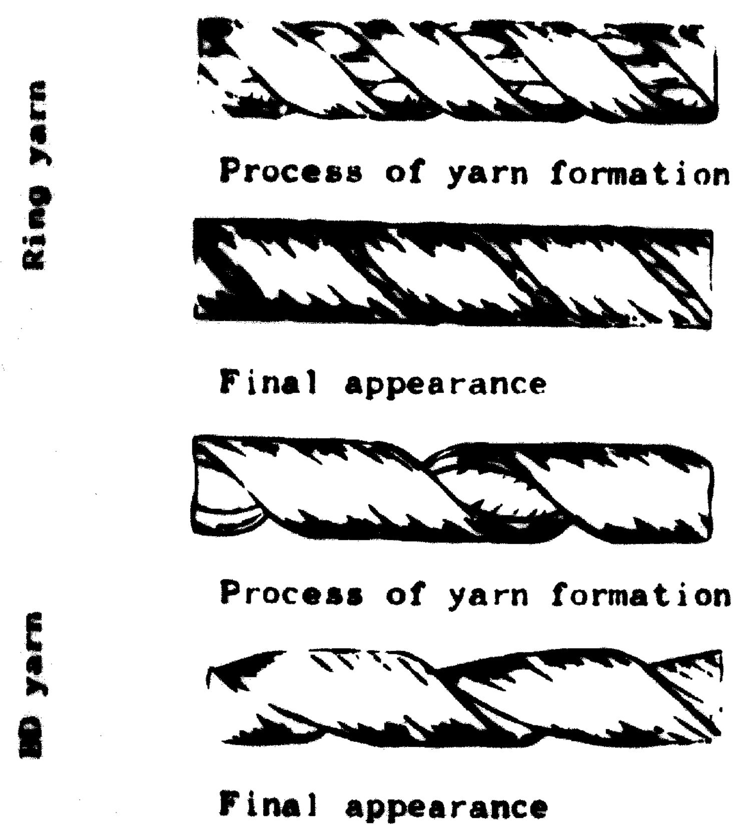


Fig. 8a Curve of twist characteristic of 30 yarn
(Cotton 30 S)

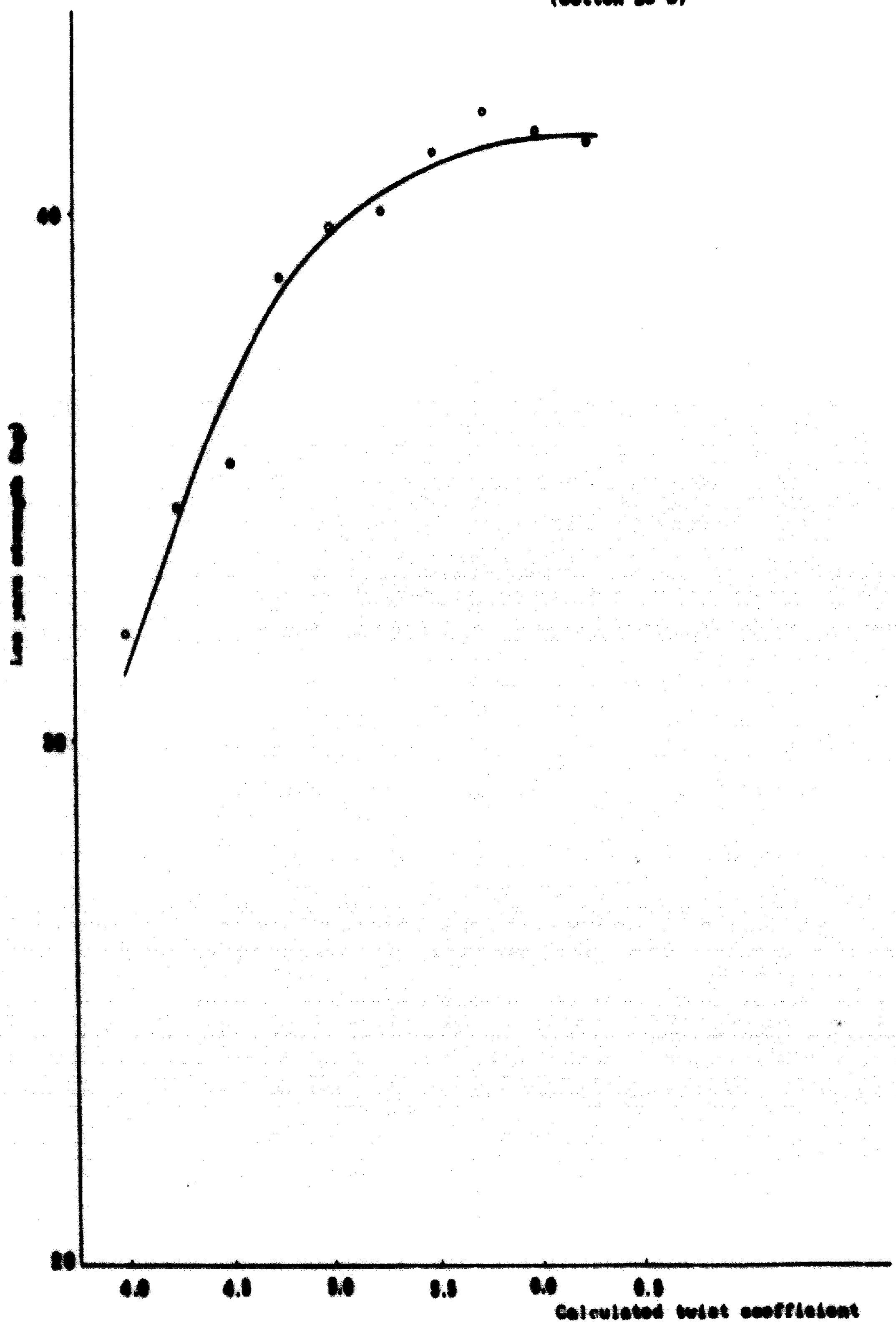


Fig. 8b Curve of twist characteristic of BD yarn
(Viscose staple BD 8)

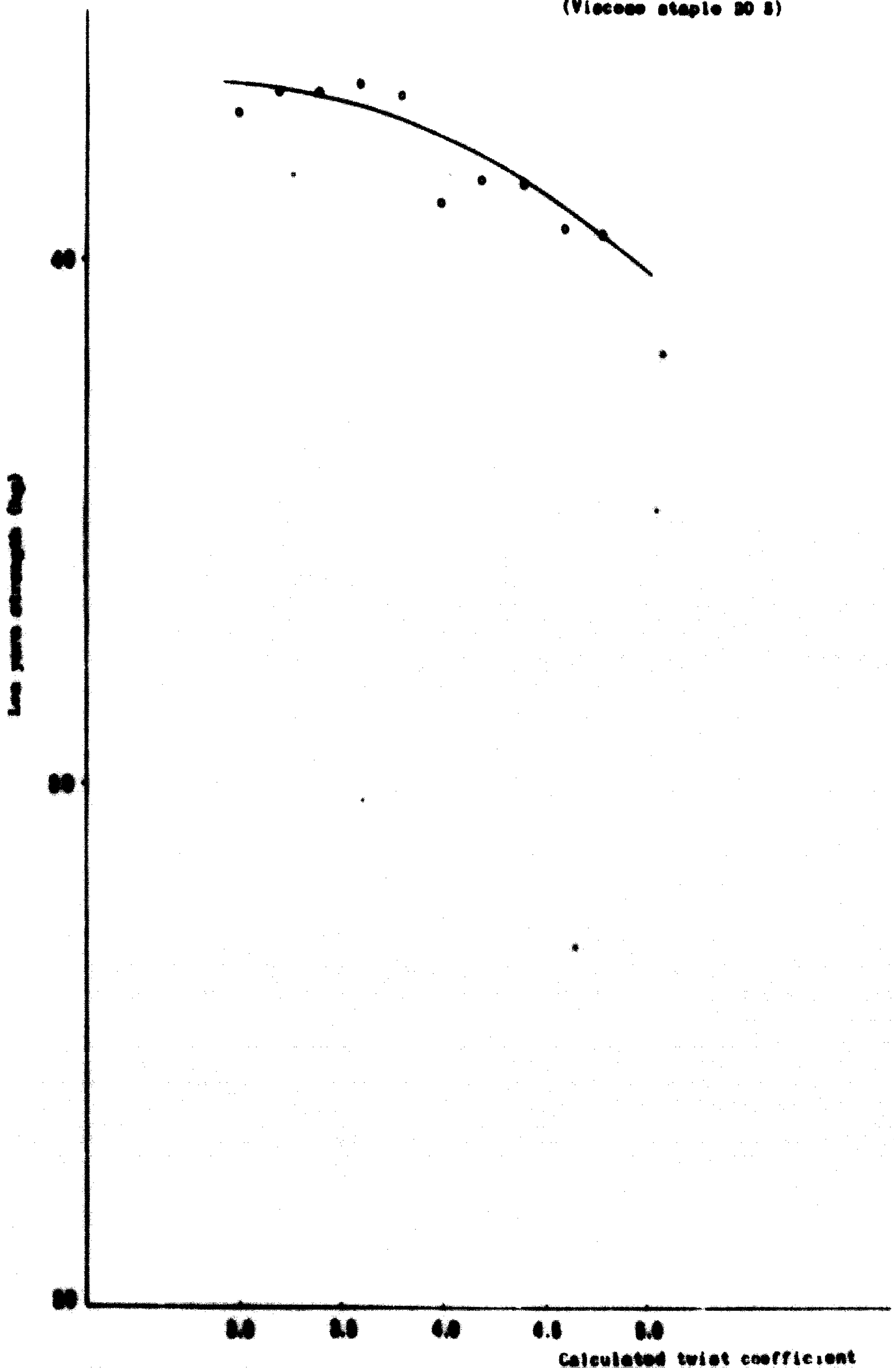


Fig. 2c Curve of twist characteristic of HD yarn
(Acrylic 1/52 Nm)

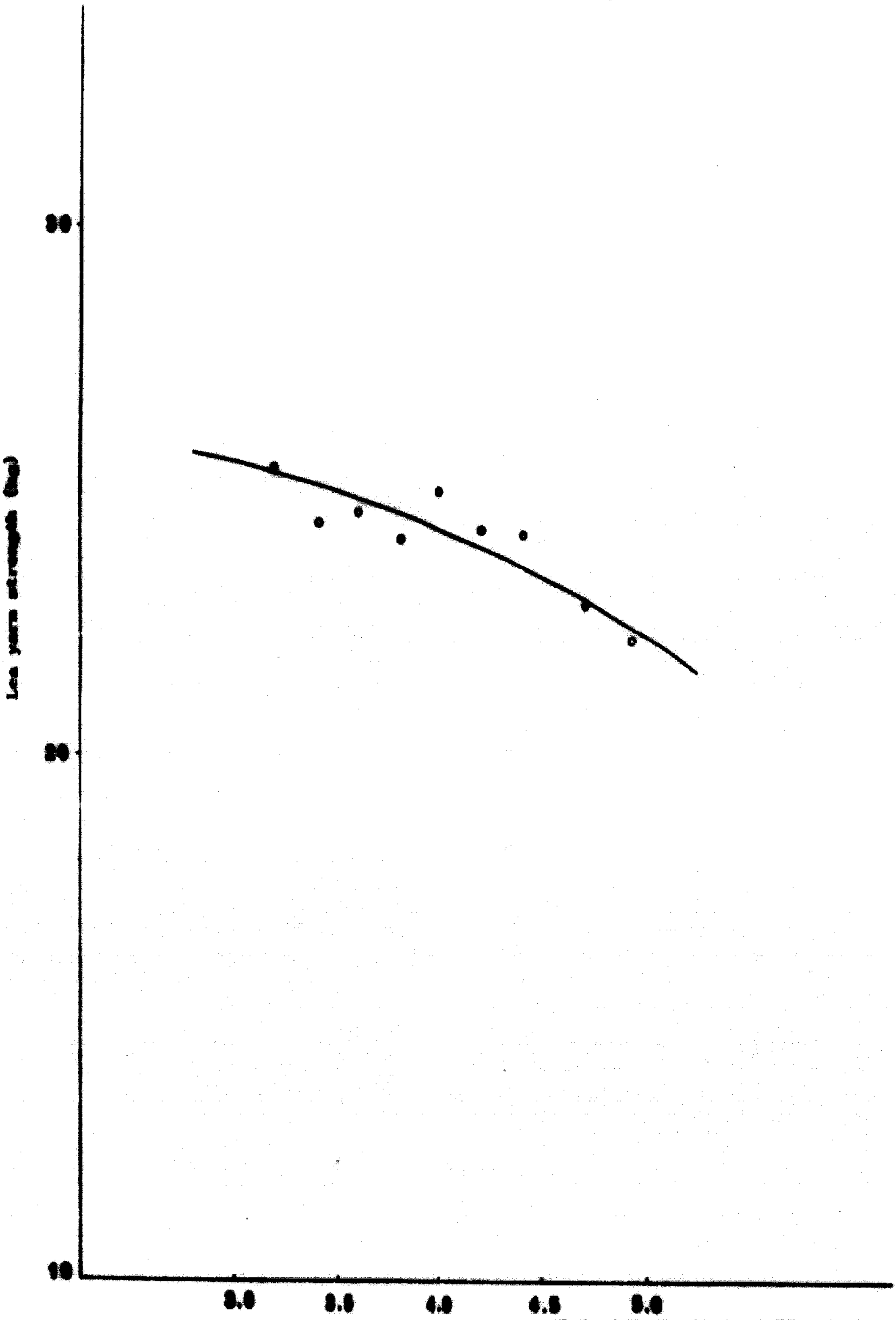


Fig. 24 Curve of twist characteristic of BD yarn
(Cotton 50 %/Polyester 50 % 32 S)

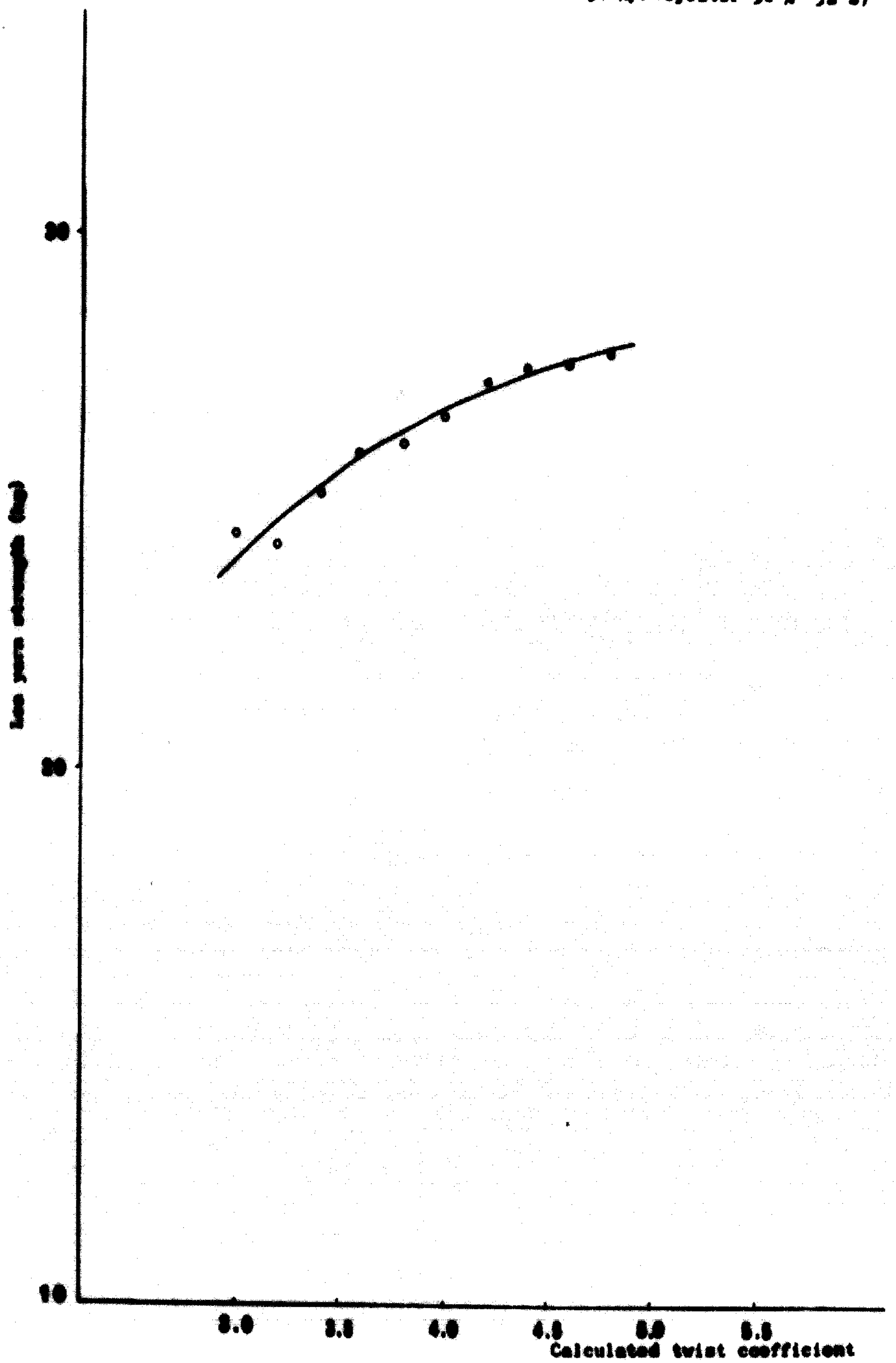


Fig. 2e Curve of twist characteristic of BD yarn
(Cotton 70 %/Acrylic 30 % 32 S)

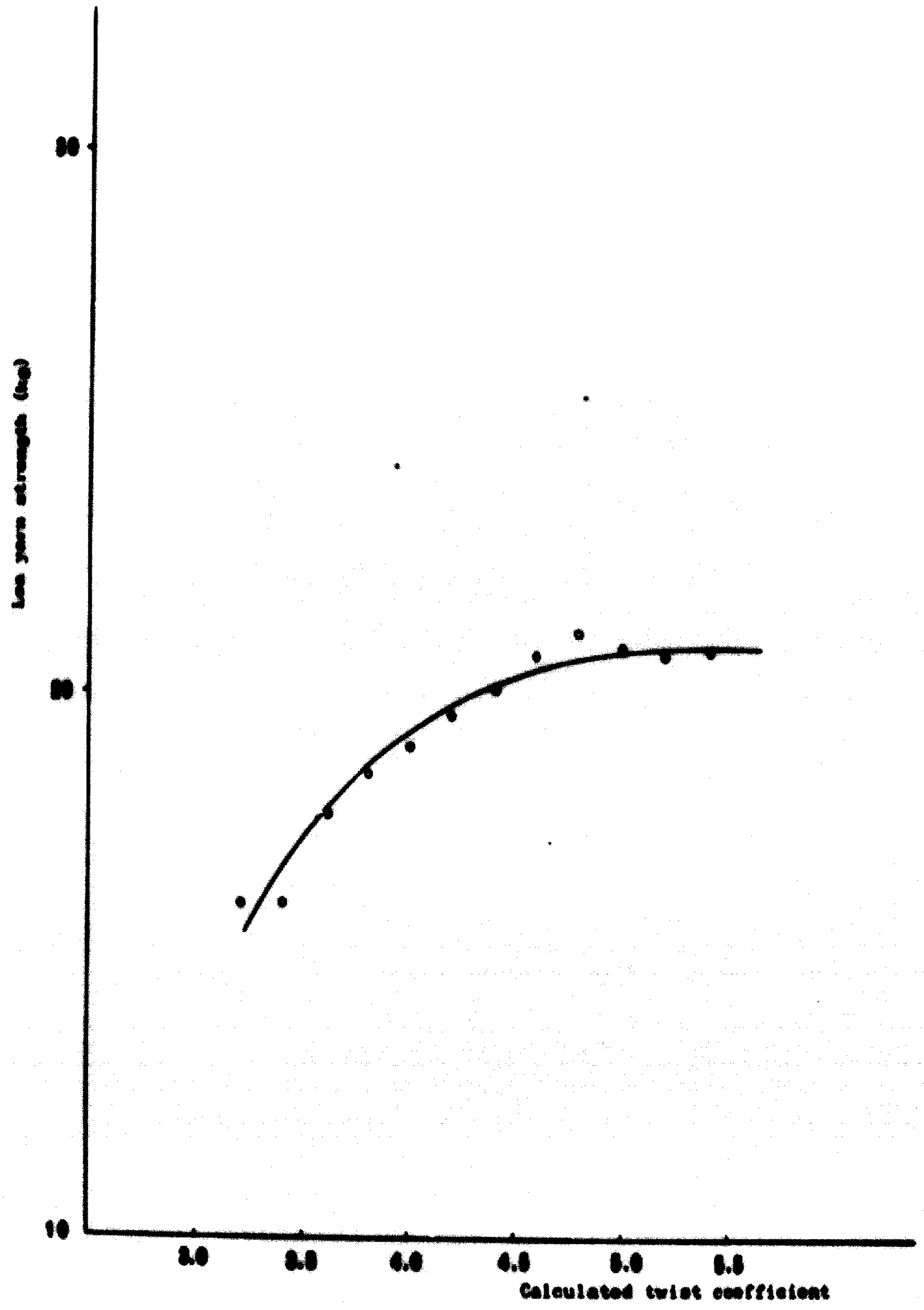


Fig. 3

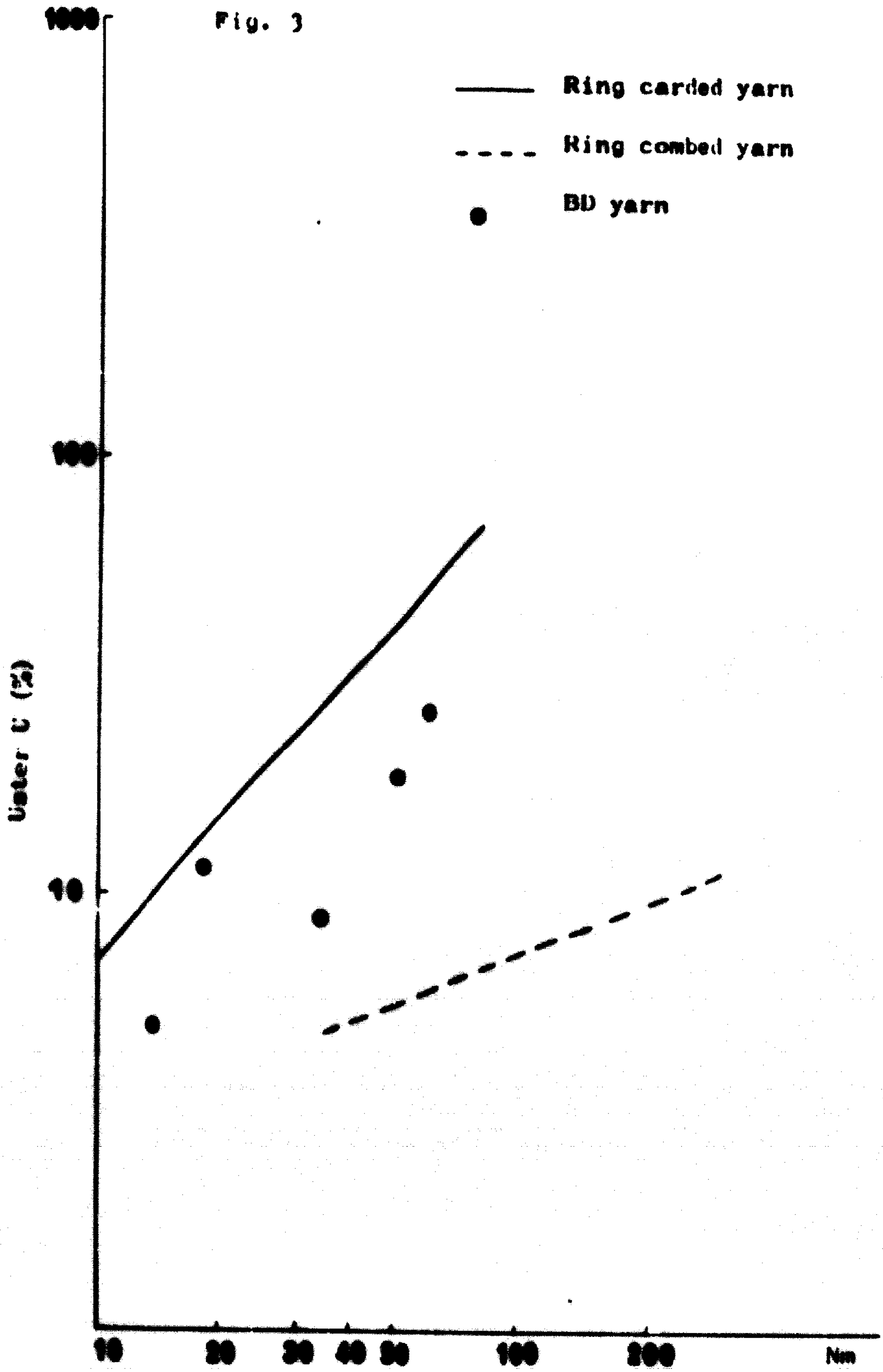
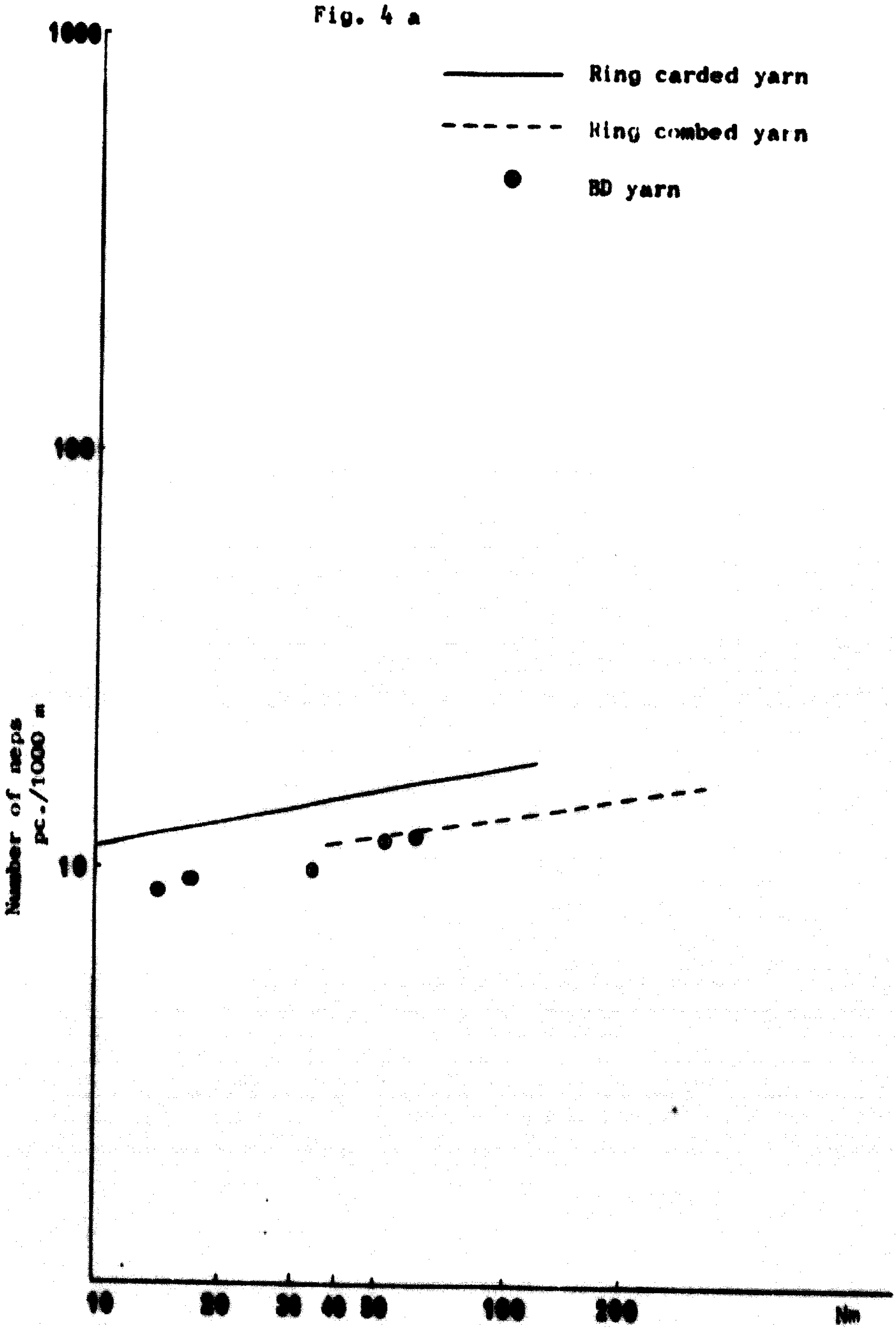

Ring carded yarn
Ring combed yarn
BD yarn
1000
100
10
Uster U (%)
10
20
30
40
50
100
200
Nm

Fig. 4 a


1000
100
10
Number of neps
pc./1000 m
Ring carded yarn
Ring combed yarn
BD yarn
10
20
30
40
50
100
200
Nm

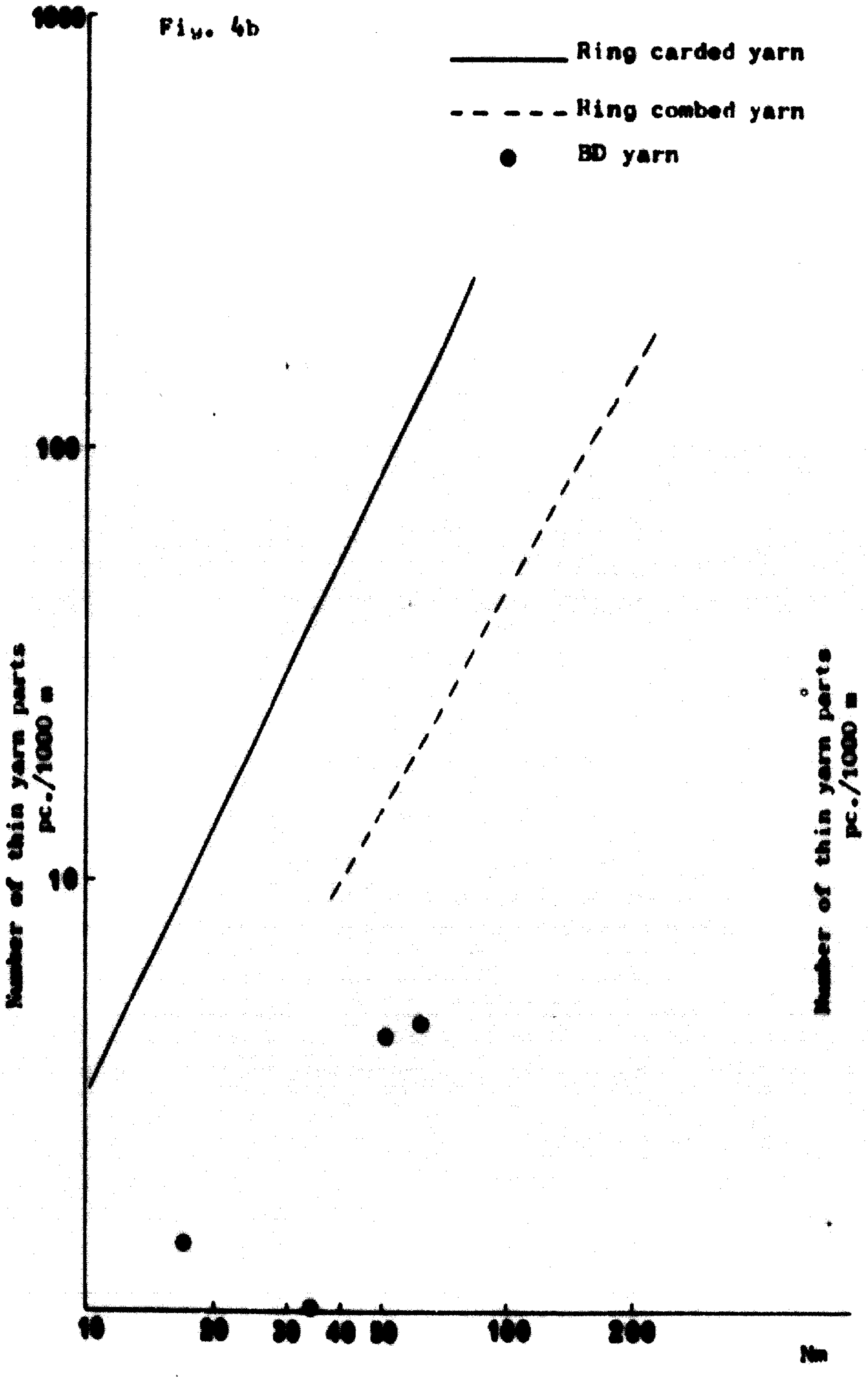


Fig. 4b
Ring carded yarn
Ring combed yarn
BD yarn
1000
100
10
Number of thin yarn parts pc./1000 m
10
20
30
40
50
100
200
Nm
Number of thin yarn parts pc./1000 m

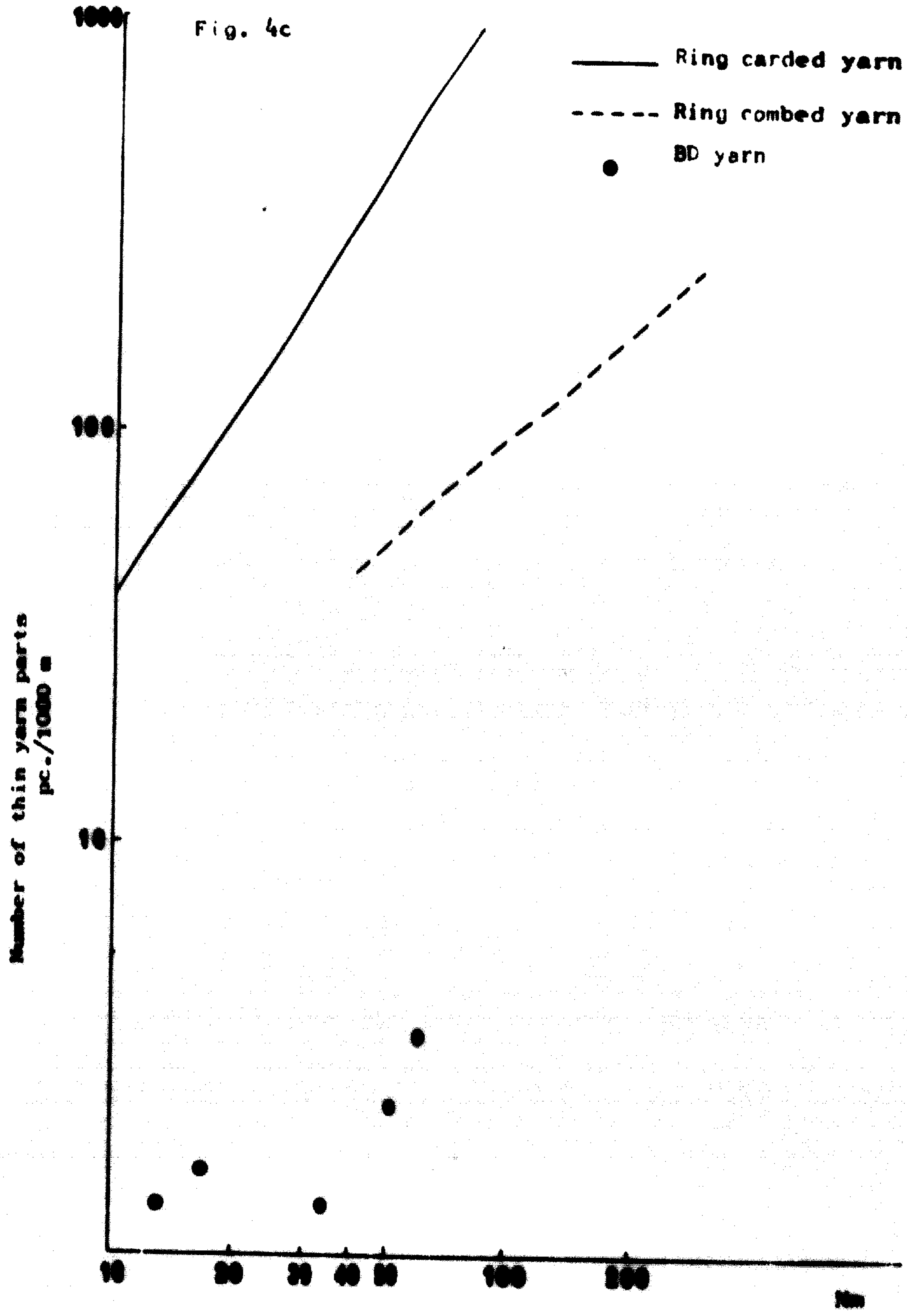

1000
100
10
Fig. 4c
Ring carded yarn
Ring combed yarn
BD yarn
Number of thin yarn parts
pc./1000 m
10
20
30
40
50
100
200
Nm

Fig. 6 Comparison of pilling tendency

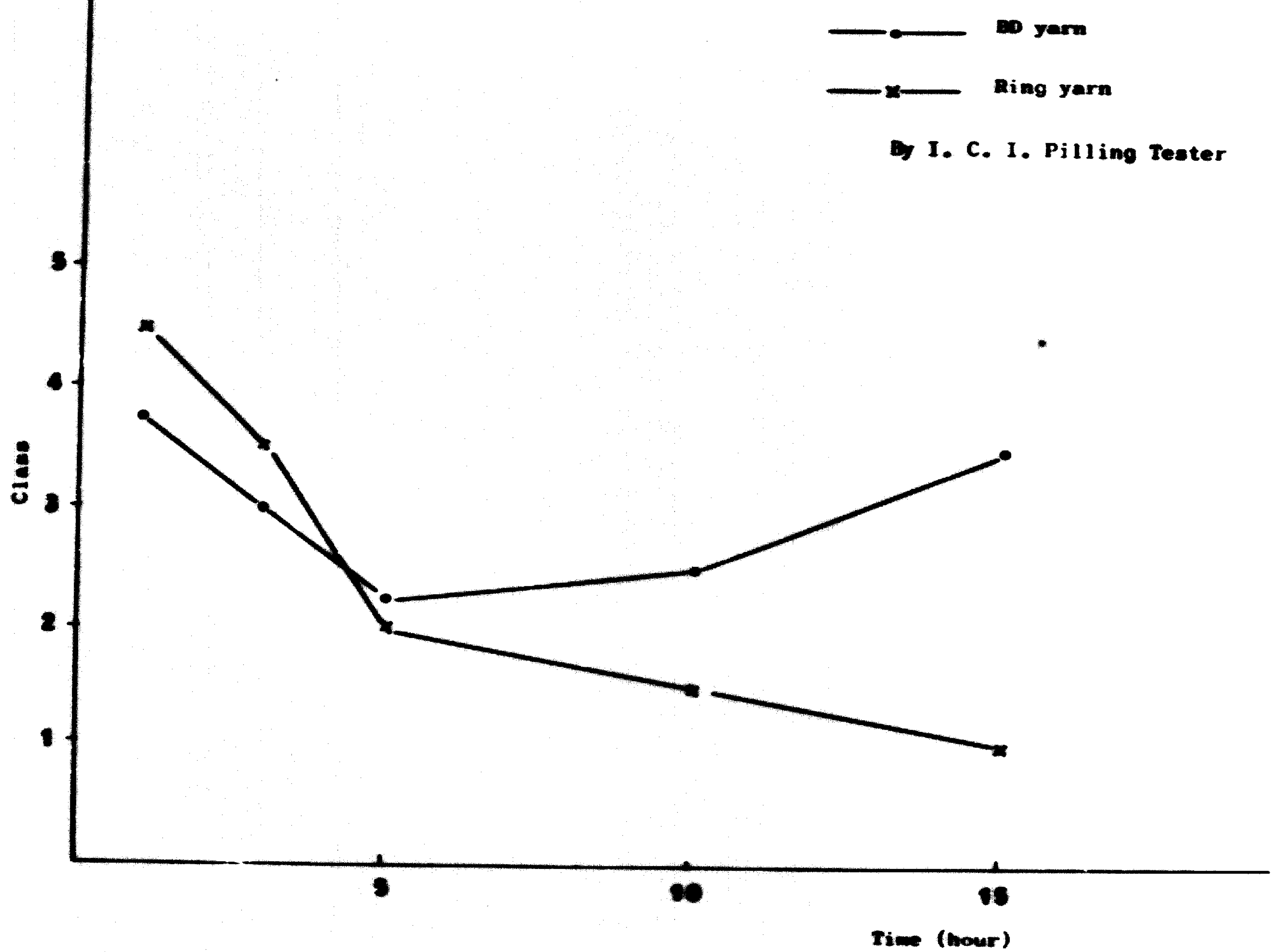
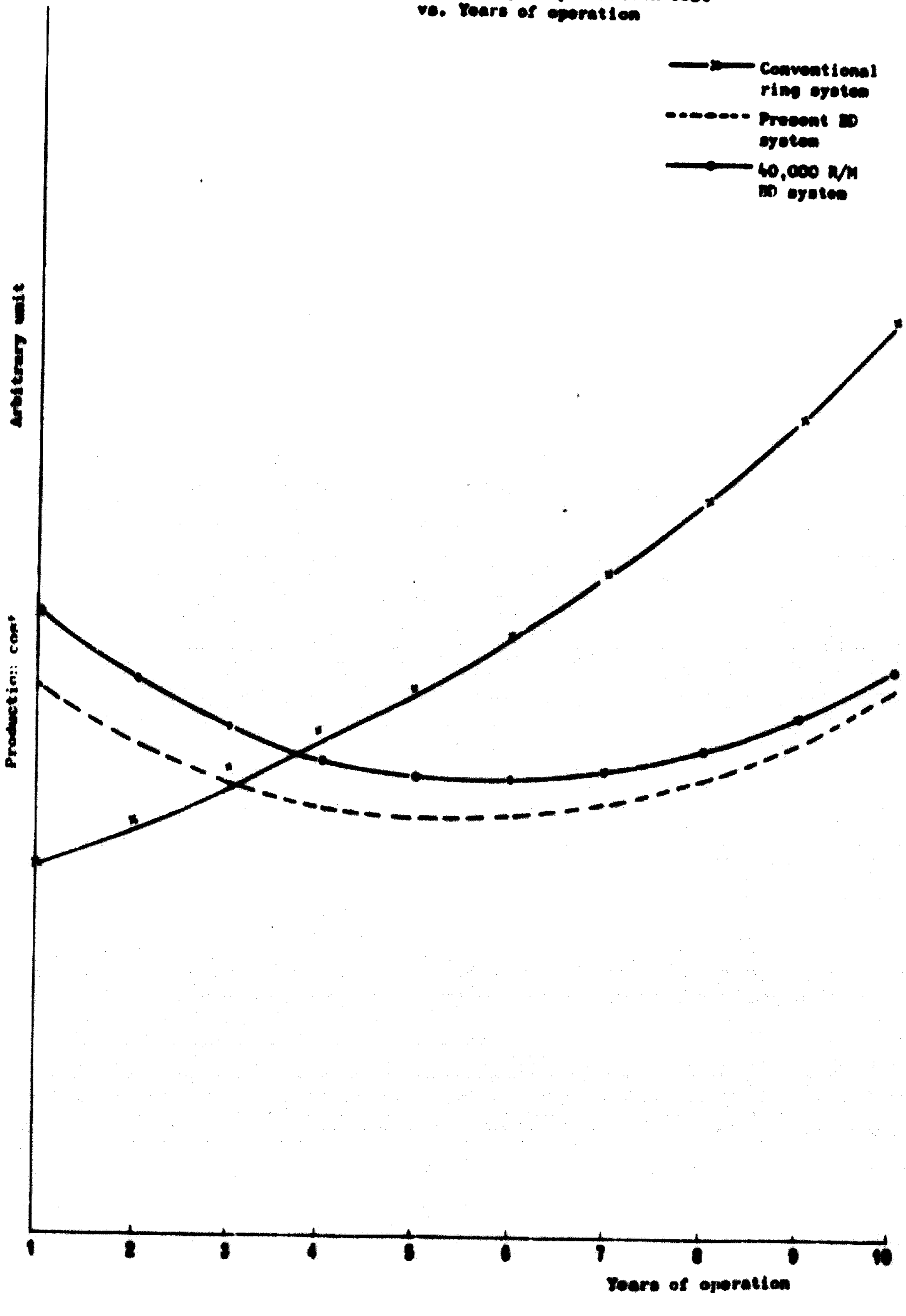
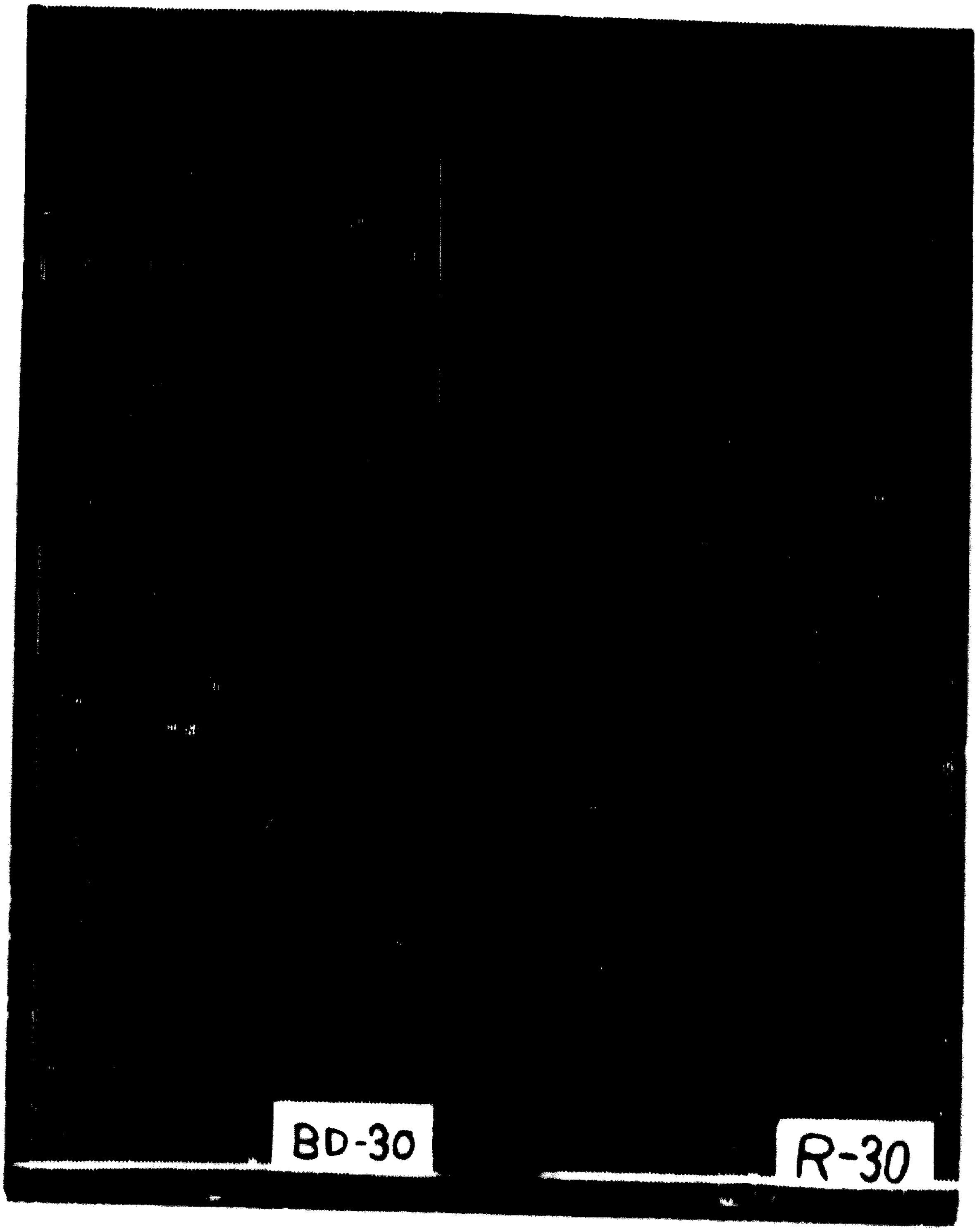
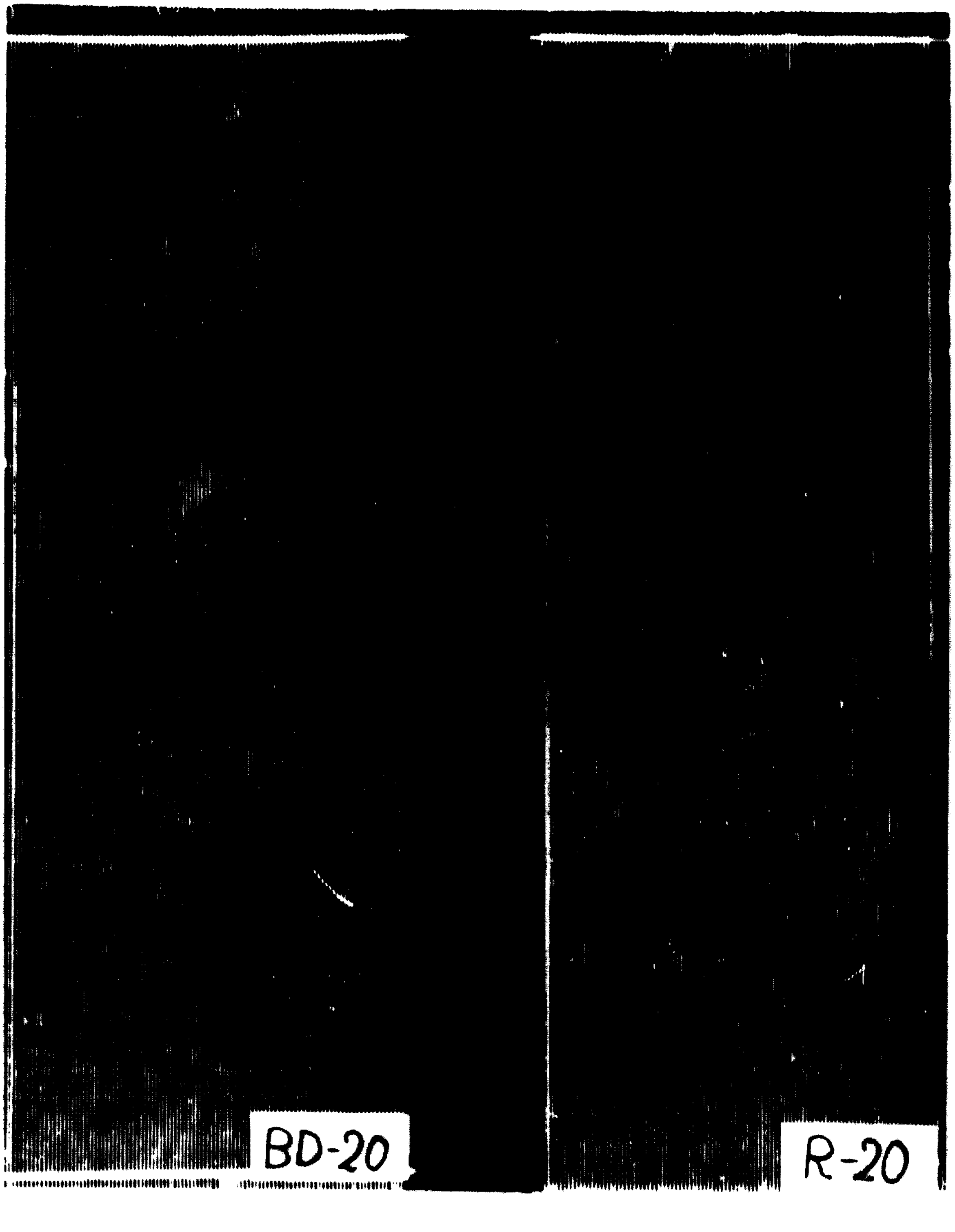


Fig. 7 Changing tendency of production cost vs. Years of operation




BD-30
R-30


BD-20
R-20

17. 6. 74