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**INDIAN CENTRAL COTTON COMMITTEE
TECHNOLOGICAL LABORATORY.**

COTTON RESEARCH IN INDIA

BEING

**AN ACCOUNT OF THE WORK DONE AT THE
INDIAN CENTRAL COTTON COMMITTEE
TECHNOLOGICAL LABORATORY,
1924-1935**

By

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WITH A FOREWORD

By

Diwan Bahadur Sir T. VIJAYARAGHAVACHARYA, K.B.E.

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*With the Compliments of
The Director
Technological Laboratory
Matunga Bombay*

FOREWORD.

INDIA is the second largest cotton growing country in the world. Out of a total *cultivated* area of about 300 million acres, no less than 25 million acres, or some 8 per cent. are sown under cotton, yielding a crop of about 6 million bales. Approximately half of it is consumed in India's 365 mills which employ 4,15,000 hands, the remainder is exported to foreign countries. Thus, whether we look to the agricultural, the trade or the industrial side, a large number of people in India earn their livelihood by work on cotton and their welfare depends entirely upon the condition of the crop and the prosperity of the cotton trade and industry. Cotton is easily the foremost organised industry in India.

Cotton is one of those crops which needs continual attention. Left to itself it deteriorates in quality owing to the mixing of seeds in the fields and the gineries which gives rise to undesirable hybrids. Moreover, it is not only highly susceptible to climate and environment but also falls an easy prey to a host of pests and diseases. The cotton breeders have to be, therefore, untiring in their efforts to evolve improved varieties, which, in a given area, could resist the onslaught of pests and diseases, give a higher yield and ginning out-turn or should mark an improvement in staple over the already established cotton. But the work of the cotton breeder is restricted to the fields; he has no means of assuring himself that the variety evolved by him will ultimately prove acceptable to the spinner. There is thus a very clear need for an institution where the fibre-properties and the spinning performance of cottons can be accurately determined. An institution of this type forms an indispensable link in the chain of cotton cultivation and consumption.

The Indian Central Cotton Committee was one of the first bodies to recognise the need of having a technological laboratory of its own where tests could be made on improved varieties and research could be undertaken on cotton. The Technological Laboratory has now worked in collaboration with the Provincial Agricultural Departments for over 10 years. It has, besides, carried out a number of investigations on problems which are of direct importance to the cotton breeder, the merchant or the millowner. These investigations cover a wide range of subjects as will be seen from a perusal of this brochure and in this respect alone the Laboratory will bear comparison with any other similar institution. The results obtained at the Laboratory have been described in numerous bulletins, leaflets and circulars, but it was felt by the Committee that if a compact and connected account of the activities of the Laboratory since its inception were written up, it would give the public, both the scientific workers and the laymen, an idea of the nature of work which is being done here and the type of problems which have been investigated in the past 10 years.

I take pride to myself that Dr. Nazir Ahmad was one of my "discoveries." Very soon after I became President of the Indian Central Cotton Committee under an amendment of the Indian Cotton Cess Act made in 1929, it was brought

to my notice that the newly created appointment of Assistant Director though advertised in the Indian Press could not be filled as no suitable applicants were forthcoming in India. I suggested that I should be allowed to write round a personal letter to the Indian Universities and as a result there was a useful letter from Dr. Meghnath Saha suggesting some names, Dr. Nazir Ahmad's being one of them. The Selection Committee appointed for the purpose chose him as the most suitable of the candidates who were interviewed. He took over his duties at Matunga in March 1930. Quite unexpectedly our first Director, Dr. Turner, had to leave us in December of the same year to take up an appointment in Manchester and the Committee appointed Dr. Nazir Ahmad to succeed him. In view of the shortness of time he had been in Matunga this was somewhat in the nature of an experiment, but the remarks of successive Technological Research Sub-Committees show what an unqualified success it has been.

There is no finality in scientific research and any "live" institution is bound to grow and expand. Under Dr. Nazir Ahmad, as under Dr. Turner, the Technological Laboratory at Matunga has progressed in new directions and is being called upon to deal with a variety of new problems.

I trust that this brochure will interest the public in the work carried on so unobtrusively in Matunga.

T. VIJAYARAGHAVACHARYA.

SIMLA, 28th September 1935.

PREFACE.

THE cultivation of cotton and its use for the manufacture of textiles goes back to pre-historic times in India. This fact has been established beyond doubt by the recent excavations at Mohenjo-Daro, when certain household articles were unearthed, which had remained buried underground for the last 5,000 years. These were wrapped in tiny fragments of a material which, on careful examination under the microscope, was found to be made from cotton. From those ancient times the cotton industry in India developed slowly but steadily, until in the middle ages the fame of her fabrics, which were then unrivalled in fineness of texture or beauty of design, spread far and wide. These halcyon days were followed by a period of decay, when the hand spinning and hand loom industries declined owing to the rapid development of power machinery in the West and the quality of cotton suffered deterioration owing to the lack of scientific control.

With the organisation of the agricultural departments, however, a new leaf was turned, and steps were taken to improve the quality of the cotton crop. During the past fifteen years these efforts have been co-ordinated under the aegis of the Indian Central Cotton Committee, which has financed numerous schemes for this purpose. In this work the Technological Laboratory of the Indian Central Cotton Committee has played an integral and important part by making the requisite tests on the new strains and improved varieties evolved by the cotton breeders and undertaking investigations on the fibre-properties and the spinning qualities of Indian cottons. It is now nearly twelve years since the Laboratory began to function, and it was felt that the time was ripe for taking a stock of the work done in the past. Most of the investigations carried out at the Laboratory have already been described in Technological Bulletins, but it was thought that a connected account in one volume would enable those sections of the public, who are interested in the production, marketing or consumption of cotton, to form a correct perspective of the ground that has already been covered, and to elicit valuable suggestions for lines of development in the future. It need hardly be said that such suggestions would receive the most careful consideration of the Indian Central Cotton Committee.

The success of an institution depends to a very great extent upon those who are at the helm of its affairs and upon those who are selected to conduct its work. The Technological Laboratory has been fortunate in both respects. The principal office-bearers of the Committee have been distinguished men with wide knowledge of administrative and public affairs and their direction of the Laboratory's work has been to its great and lasting advantage. Space does not permit me to recount the names of all, but special mention must be made of Diwan Bahadur Sir T. Vijayaraghavacharya, K.B.E., and Sir Pursho-tandas Thakurdas, Kt., who were respectively President and Vice-President of the Committee when this brochure was under preparation, and who by their sympathetic interest made it possible for the Laboratory to expand in a

steady manner. Mr. B. C. Burt, C.I.E., who has now taken over from Sir T. Vijayaraghavacharya, has been associated with the Laboratory from its inception and the Laboratory owes him a deep debt of gratitude for his valuable help and fruitful suggestions. As regards the staff, the Laboratory was fortunate in having as its first Director, Dr. A. J. Turner who not only laid the foundations of its work truly and well, but established its reputation among the cotton research centres of the world. All the work described in Technological Bulletins upto No. 17 (Series A), No. 13 (Series B) and Technological Circulars upto No. 36 was done under his guidance. As the work of the Laboratory grew, the contribution of the Spinning Section became increasingly important, and I must take this opportunity to acknowledge the untiring zeal and the valuable assistance of the present Spinning Master, Mr. R. P. Richardson. The duties of the other sections of the Laboratory have also steadily increased in a corresponding measure and I have pleasure in appreciating the work of Mr. Hari Rao Navkal, who has all along been in charge of the Fibre Testing Section, and Mr. V. Venkataraman who was until recently in charge of the Yarn Testing Section. On the research side Messrs. D. L. Sen, R. S. Koshal, A. N. Gulati and C. Nanjundayya have made valuable contributions. Limitations of space do not permit me to mention by name the testing and clerical staff of the Laboratory, who have performed their arduous duties in a spirit of loyal co-operation. Apart from its own staff, the Laboratory has been favoured with assistance and useful suggestions from public bodies like the East India Cotton Association, Bombay, the Millowners' Associations of Bombay and Ahmedabad, etc. In this connection I must offer my special thanks to Major W. Ellis Jones who for many years very kindly undertook to value the samples of cotton sent to the Laboratory for tests.

December, 1935.

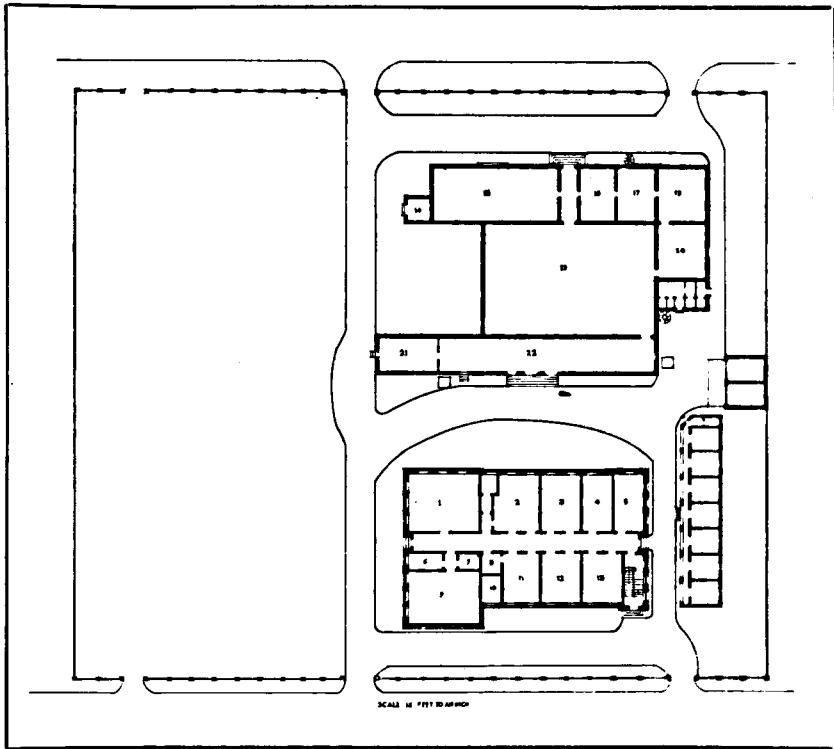
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PLAN OF THE TECHNOLOGICAL LABORATORY.



RESEARCH LABORATORY.

- | | |
|------------------------|--------------------------|
| 1. Physics Laboratory. | 7. Dark Room. |
| 2. Director's Room. | 8. Record Room. |
| 3. Library. | 9. Chemistry Laboratory. |
| 4. Research Room. | 10. Combustion Room. |
| 5. Workshop. | 11. General Office. |
| 6. Balance Room. | 12. Microscopy Room. |
| | 13. Colloids Room. |

SPINNING LABORATORY.

- | | |
|------------------------|--------------------------|
| 14. Boiler House. | 18. Spare Room. |
| 15. Yarn Testing Room. | 19. Spinning Room. |
| 16. Office. | 20. Gin Room. |
| 17. Store Room. | 21. Cotton Samples Room. |
| | 22. Blow Room. |

I.—HISTORY AND OBJECTS OF THE INDIAN CENTRAL COTTON COMMITTEE TECHNOLOGICAL LABORATORY.

The objects for which the Technological Laboratory of the Indian Central Cotton Committee was instituted are set out clearly in the suggestions regarding the appointment of a Technologist made by the Indian Cotton Committee in Section 262, p. 162 of their Report, 1919. According to this report the duties which would devolve upon the Technologist are as follows :—

**History
and Objects.**

(i) He should help the Agricultural Departments to arrive at a correct judgment of the value of any new varieties of cotton produced.

(ii) He should also undertake other lines of research relating to cotton; such, for example, as an investigation into the differences between the fibres of American and Indian yarns.

(iii) He should also be able to value different varieties of cotton in such a manner as to bring out clearly the real value of staple and of definite increases in its length.

The Indian Central Cotton Committee adopted these recommendations regarding the need for such a Laboratory and immediately funds became available by the application of the Cotton Cess Act of 1923, it authorised the building of a spinning laboratory in Bombay. The work was begun in September 1923 and in August 1924 the first spinning tests were performed. Dr. A. J. Turner had in the meantime been appointed Director of the Laboratory, and he took up his duties in Bombay in January 1924. Plans were shortly afterwards prepared for building a research laboratory for carrying out research on cotton fibre and, on the 3rd December 1924, His Excellency the Viceroy, the Earl of Reading, signalled the importance of the aims and objects of the Committee by formally opening the spinning laboratory and laying the foundation stone of the research laboratory. The building operations for the latter were begun on the 1st September 1924 and it was actually occupied on the 28th September 1925. Pending the construction of this laboratory, the scientific work was carried on in a room in the Victoria Jubilee Technical Institute kindly placed at the disposal of the Committee by the Trustees of the Institute. The total cost of the land, building and equipment of the spinning and the research laboratories came to about 5 lakhs of rupees.

The first problem which the Laboratory was called upon to tackle was the possible danger of the introduction of the cotton boll-weevil in India through the agency of the American bales imported in the country. The problem was to

find a suitable practical method for the fumigation of American bales imported into India, the conditions of fumigation being such that all live boll-weevils on or near the surface of the cotton bale should be killed. The problem was successfully solved and an account of the investigation was published in a Memoir of the Department of Agriculture in India, Vol. X, No. V:—"The use of hydrocyanic acid gas for the fumigation of American cotton on import into India: Experiments on its lethal power for the Mexican Boll-weevil (*Anthonomus grandis*) and for the Grain-weevil (*Sitophilus oryzae*); on the extent to which it is absorbed by cotton and jute respectively; and on a practical method for satisfactory fumigation on a large scale." The outcome of the solution of this problem was the issue of a notification by the Government of India requiring all American cottons consigned for India on or after 1st December 1925 to be imported through the Port of Bombay and there to be fumigated in a prescribed manner. Detailed instructions based upon the results of this investigation for the fumigation of American cottons were prepared and for some time in the beginning the fumigation was actually supervised first by members of the staff of the Laboratory. The work was handed over later on to the Fumigation staff who are attached to the Laboratory and do the routine tests when no fumigation is to be done.

The work of the Laboratory was organised on an adequate basis for carrying out fibre and spinning tests on Indian cottons. For this purpose the Laboratory was equipped, on the one hand, with suitable fibre and yarn testing instruments and, on the other, with blow-room and spinning machinery. In order that the results of the Laboratory tests may be accepted with confidence by the practical men, this machinery is identical, in most respects to that used in the mills, and comprises, besides several ring frames, a self-acting mule and a combing machine. The two main objects of the work of the Technological Laboratory are (1) to test new strains and improved varieties for the agricultural departments and (2) to study the relationships between the measurable characteristics of cotton fibre and its spinning value. The need for the first type of work arose in the following way. Until a cotton breeder could send his improved varieties to a technological laboratory for authoritative report as regards their fibre-properties and spinning value, he had to work up till he could grow a bale or two for a mill test before he could decide whether or not the variety under trial would be acceptable to the spinner. This would severely curtail his activities as, in most cases, the resources and the area at his disposal are extremely limited and he would be obliged to divide these between a very small number of varieties to grow them in sufficient quantities for a mill test. Again, if the mill report on any of these varieties should eventually turn out to be unfavourable, then all the time and the labour spent in evolving the particular variety would be wasted. Furthermore, the conditions as regards speeds, settings, twists, drafts, humidity, etc., which exercise an important influence on the spinning performance of a cotton, vary from mill to mill and may even be different in the same mill on two different occasions. Thus, the reports supplied to the cotton breeders by a mill may not be strictly comparable and the chances of two cotton breeders being able to compare the performance of their respective varieties are rendered even more remote if

these varieties had been tested at two different mills. On the other hand, the conditions can be standardised for different types of cottons in a technological laboratory and these standard conditions can be reproduced at will. Furthermore, the spinning tests can be carried out on small samples in the laboratory; making it possible for the cotton breeder to try a relatively large number of varieties. The unsatisfactory ones among them can be eliminated at an early stage of experimentation, thereby making room for more promising strains and effecting considerable saving in time, labour and money.

The second principal object of the work of the Technological Laboratory, namely, to study the relationships between the measurable fibre-properties of a cotton and its spinning performance, though closely related to the first is more fundamental. It has been stated above that a cotton breeder is anxious to have an authentic report on the spinning performance of his new varieties as early as possible and that the sooner this information is made available to him, the less is the wastage in time and money. Now, it takes him three to four years, beginning with a cross or a single plant selection, to grow a sufficient quantity for a laboratory test. During this period the strain must be grown year after year and its behaviour in the field and the properties of its fibres should be studied. If, at the end of it, the strain should give unsatisfactory spinning performance, then it must be scrapped and the work of evolving a new strain must be begun all over again. In actual practice a number of strains are tried at the same time, but this does not materially alter the issue. If, however, the spinning performance can be accurately expressed in terms of its measurable hair characteristics, then it is clear that the results of fibre tests on a handful of cotton, which would be available in the first year of its trial, would enable the breeder to decide whether to continue with it or discard it in favour of a more promising strain. Now, the fibre-properties of a cotton show considerable variability and in common with the spinning performance are highly susceptible to climatic and environmental factors. This rules out the possibility of deriving correct relationship formulæ from a few isolated observations taken here and there and indicates the necessity of applying statistical analysis, based upon a sufficiently large number of results obtained under known conditions, to this particular problem. Good progress has already been made at the Technological Laboratory in this direction and certain formulæ have been derived, which are especially applicable to Indian cottons and which enable one to predict in a majority of cases the spinning performance of a cotton from its fibre-properties (See p. 33). It should be mentioned here that such prediction formulæ are useful not only to the cotton breeder but also to the spinner as they would enable him to adjudge the spinning value of any commercial variety, which he may use in his mixings, from a knowledge of its fibre-properties which could be determined either in a small laboratory attached to the mill or at the Technological Laboratory. The results of the work along these lines would thus gradually replace the present-day subjective estimate of the performance of a cotton, which is liable to errors of personal judgment, by objective and impersonal data, which would become more definite and exact with a clearer conception of the part played by each hair characteristic in determining its spinning quality.

An important departure from the previous policy in connection with the spinning tests was made in 1929 when the Indian Central Cotton Committee at their meeting held in July passed a resolution requesting the Technological Research Sub-Committee to consider and devise means whereby the Laboratory tests could be made more useful to the trade and the industry without in any way reducing the usefulness to the Cotton Breeders and the Provincial Agricultural Departments. As a first step in this direction, an arrangement was made by which the Laboratory now undertakes spinning tests on representative Indian trade varieties, the samples being either selected by the East India Cotton Association or sent through the Millowners' Associations of Bombay and Ahmedabad.

Dr. A. J. Turner retired on the 6th December 1930 on being offered an appointment in Shirley Institute. Dr. Nazir Ahmad, who had held the post of Assistant Director since March 1930, was appointed Offg. Director and was later confirmed as Director in March 1931.

A moisture testing section of the Laboratory completely equipped with electrically heated conditioning ovens and other necessary apparatus was opened early in 1931 in the Cotton Exchange Building, Sewree, and tests on the moisture content of Indian cottons were commenced soon afterwards.

Another departure was made by the Committee when it considered the demand made by individual mills for testing ordinary mill samples and decided that such samples may be tested at the Laboratory on payment of a certain fee, provided these tests do not interfere with the normal routine and the work of the Laboratory.

In view of the importance of the spinning tests to the Agricultural officers and the trade, the aim of the Indian Central Cotton Committee had always been to maintain its spinning plant in an up-to-date condition. The equipment of the spinning room has been reinforced from time to time by the acquisition of new ring frames and a fine roving frame. Recently the Indian Central Cotton Committee sanctioned a scheme to overhaul the blow-room plant of the Laboratory. This step was highly desirable as during the last decade or so many improvements have been made in the design and construction of the blow-room machinery, as a result of which, its capacity to open and clean cotton has been greatly enhanced. Accordingly in the current year the blow-room plant was overhauled by installing a new horizontal cleaner, a new hopper feeder with three step cone pulleys, a new cage exhaust, new cyclones and improved dust trunks with vibrating grids. The machines are fitted with fast revolving cages and exhaust fans to eliminate dust and small impurities which are often so difficult to remove. Furthermore, the old hopper feeder has been provided with stronger, upright and even lattice and the old crighton opener with improved triangular grid bars and new set of blades. As cottons covering a very wide range, say some suitable for 6's while others for 100's, some containing barely 4 per cent. trash while others yielding 20 per cent. loss in the blow-room alone, etc., are being tested in the Laboratory, bye-passes have

been provided in the new plant so that in the case of clean cottons, one or more machines could be eliminated and the cotton given the treatment regarded correct for it.

The addition of these new machines necessitated the enlargement of the blow-room. Furthermore, since during these five years, two new ring frames, one fine roving frame and three experimental gins were installed, two new rooms had to be built contiguous to the spinning room to take some of this machinery and relieve the pressure on the spinning room.

Further, in view of the very large increase in the number of samples tested at the Laboratory from year to year the personnel and equipment of the Yarn Testing Room had grown steadily in such a manner as to result in overcrowding in this section of the Laboratory. Accordingly this room was also enlarged to meet the present-day needs. These new extensions of the Laboratory were formally opened in the presence of the office bearers of the Committee and a large number of mill agents and cotton merchants on the 29th May 1935.

II. FIBRE TESTS AND RESEARCH ON COTTON FIBRE AND YARN.

1. The Importance and Value of Fibre Tests.

The study of the fibre-properties of cotton, carried out with precision instruments in a Laboratory, is important in several ways. In the first place, it affords the most direct means of comparing the merits of two varieties of cotton which may differ in point of length, fineness, strength or regularity of staple, or in the variation of any of these properties with climatic and soil factors. The cotton merchants, as a result of long experience, have developed certain methods based on a hand-and-eye examination of the fibre, which enable them to estimate the quality of a cotton. These methods, however, being purely subjective, are not entirely free from errors of personal judgment, especially in such cases where a new variety, with which the merchant is not familiar, is involved. The laboratory methods, on the other hand, are objective, the personal element is eliminated to a very large extent and each property is accurately measured and expressed in terms of fundamental units.

Secondly, the results of the fibre tests are especially valuable to the cotton breeders in the early stages of their experimentation when selection has to be made, either in reference to one particular property, such as staple-length, or in respect of the general quality of the lint, from among a large number of new strains. These strains are subjected to the necessary fibre-tests and only those which approach most closely the standard set by the cotton breeder are retained for further propagation, while the others are discarded. In this manner, the field of selection is gradually narrowed down from year to year until a few strains, which have consistently shown superior fibre-properties, are cultivated on larger plots for spinning tests. In the absence of the guidance afforded by the results of fibre tests, it is possible that valuable strains may be lost for ever at an early stage. Furthermore, in evolving new strains by hybridisation, it is necessary that the breeder should have full knowledge of the fibre-properties of the parent strains which he wishes to cross, so that weak characters, such as low strength, low maturity, etc., may not detract from the merits of the offsprings.

The third useful purpose served by these tests is to provide data for the study of the relationships between the fibre-properties and the spinning quality of a cotton. Apart from the influence of the mechanical treatment to which a cotton is subjected, the characteristics of the yarns spun from it, which ultimately determine the quality of the finished product, are a function of the properties of its fibre. It is, therefore, important to know exactly the type of the relationships that hold between the yarn characteristics and the fibre-properties, so that attention may be concentrated upon those properties, which, for a specified object, are more important than the others, and the manner in which each of these properties is modified, if at all, by the treatment given to the cotton.



Research Laboratory.

The fourth object of undertaking fibre tests is to study the influence of various factors, such as the type and quantity of manure, amount of irrigation, position of boll on the plant, of lock in the boll and of seed in the lock, date of sowing, etc., on the quality of the lint. Many of these investigations have a direct economic value to the grower, others are primarily concerned with the nutritional problems of the plant and are thus of fundamental importance to the breeder.

In view of the above-mentioned manifold purposes served by the fibre tests, the Technological Laboratory has carried out these tests on numerous samples. These have included routine tests on agricultural and trade samples and special tests on samples in connection with the various investigations undertaken at the Laboratory. These will now be described under separate heads:—

2. Routine Tests.

(a) *Agricultural Samples.*

Cotton samples, which are sent to the Laboratory for spinning tests, are, in most cases, subjected to fibre tests as well. In addition, fibre tests are also carried out on small size samples, which are not available in sufficient quantities for the purpose of a spinning test. In the case of both types of samples, *i.e.*, large size and small size samples, the two fibre properties, which are ordinarily determined, are: (1) mean fibre-length and (2) fibre-weight per inch. The former corresponds to the staple length as estimated by a grader, while the latter is an accurate measure of the fineness of the hair. A mass of data, collected at the Technological Laboratory and elsewhere, has shown that of all the fibre-properties of cotton these two are most strongly correlated with its spinning quality. The fibre tests are, therefore, generally confined to the determination of these two properties; but in some cases, where the cotton breeder or the supplier of the samples is anxious to obtain additional information other properties are also determined. Among these the two properties, which come next in the order of importance, are the fibre-strength and the relative proportions of mature and immature hairs in a cotton. The percentage of immature hairs in a cotton is found to be intimately connected with the degree of neppiness of the yarns spun from it, and the cotton breeders are therefore anxious to concentrate their efforts on those strains which besides possessing a long and fine staple, are reasonably free from the defect of immaturity. All these fibre tests are carried out as routine work of the Laboratory on numerous large and small size samples and in one season as many as 68 samples have been received from a single farm. In addition to these routine tests the Technological Laboratory undertakes fibre tests on samples of cotton grown in connection with the field experiments which are performed with a view to obtaining information regarding the influence of various factors on the fibre-properties of a cotton. For instance, tests have been made to ascertain the effect of different amounts of irrigation applied at different intervals to a particular variety of cotton, the effect of

growing a cotton with different doses of farm yard and inorganic manures, the variation in the quality of a cotton with soil fertility, date of picking, ridge *versus* flat cultivation, etc., etc. The number of samples on which fibre tests as well as spinning tests have been made are given on page 46. In addition, the number of samples on which fibre tests alone have been carried out are shown in table 1 below.

(b) *Trade Samples.*

The samples falling under this category are received either from the cotton merchants, the mills or the trade organisations. These samples mostly belong to the well-known trade varieties on which information is required by the suppliers with respect to one or more fibre-properties. Thus, in seeking to establish standards of length for the African cottons, the East India Cotton Association requested the Laboratory to make tests for determination of length on samples of fair average quality of A. R. Kampala, A. R. Busoga and A. R. Jinja. For this purpose the East India Cotton Association supplied every month one sample each of these three cottons and the experiments were continued for nearly 3½ years when altogether 75 samples had been tested. The results were analysed for mean fibre-length, fibre-length irregularity and the variation of each of these properties from sample to sample. Again various mills and cotton merchants have frequently sent their samples to the Technological Laboratory with the object of gaining more exact information than can be supplied by their graders. Thus, samples drawn from different bales of the same lot have been received to find out whether or not the type is uniform in length, samples professed to belong to the same kapas lot, but ginned on different types of gins have been tested to determine the effect of ginning condition on the staple, etc.

As in the case of the other activities of the Laboratory, its work in connection with testing of small size samples has steadily increased in the course of time. This will be seen from the following table which gives the number of samples on which fibre tests have been made during the last 9 seasons :—

TABLE 1.—*Number of samples on which fibre tests have been made.*

1925—26	..	..	..	..	3
1926—27	..	..	..	..	18
1927—28	..	..	..	..	4
1928—29	..	..	..	..	45
1929—30	..	..	..	..	9
1930—31	..	..	..	..	37
1931—32	..	..	..	..	60
1932—33	..	..	..	..	119
1933—34	..	..	..	..	45

3. Cotton Fibre and Yarn Research.

In addition to carrying out these routine tests the Technological Laboratory has undertaken various investigations on the properties of cotton hair, their inter-relationships and their bearing upon the spinning quality of a cotton. These investigations have been classified under the following heads :—

1. Sampling.
2. Method—
 - (a) Fibre-properties.
 - (b) Yarn-characteristics.
3. Measurement of fibre properties.
4. Measurement of yarn characteristics.
5. Relationship between the fibre-properties and the spinning quality of a cotton.
6. Miscellaneous.

The work of the Laboratory under each of these heads will now be described.

(1) SAMPLING.

The fibre tests are performed on a handful of cotton taken for this purpose from a large sample. The cotton fibres even in a pure strain exhibit great variability in their properties ; in an impure strain or a mixture of two varieties the variability is further accentuated. It is, therefore, imperative to make sure that the small sample selected for the determination of any one single fibre-property should be truly representative of the bulk, so that the results obtained for the former can be regarded as being valid for the latter. Consequently, the problem of sampling is one of fundamental importance in cotton fibre research, and has been dealt with in the following two Technological Bulletins :—

Technological Bulletin, Series B, No. 6, "Studies in Sampling of Cotton for the Determination of fibre-properties: Part I, Introductory and Experimental; Part II, Frequency Curves for various fibre-properties; by R. S. Koshal, M.Sc. and A. James Turner, M.A., D.Sc." **Studies in Sampling:**

Technological Bulletin, Series B, No. 10, "Studies in the Sampling of Cotton for the Determination of fibre-properties", Part III, the Size and Reliability of a satisfactory sample by R. S. Koshal, M.Sc. and A. James Turner, M.A., D.Sc."

It is pointed out in the first bulletin that in the determination of any single fibre-property it is necessary to find answers to the following three questions :—

- (1) How to obtain a satisfactory sample ?
- (2) How many fibres constitute a satisfactory sample ?
- (3) What is the degree of reliability of the results obtained for any given number of tests ?

The obtaining of a satisfactory sample is a matter of practical manipulation in which the fibres constituting the large sample are mixed several times over and a small sample is selected which is completely representative of the bulk. The answers to the second and third questions, however, can only be formulated by the application of statistical methods. In order to do so it is necessary to obtain the values of a given property for a large number of fibres and plot these in a frequency distribution curve. In the investigation described in this bulletin the properties considered were fibre-length, fibre-width, number of convolutions, fibre-strength and fibre-rigidity. The tests were made on some 3,000 fibres of Surat 1027 A. L. F. and frequency polygons were drawn for each of these fibre-properties. Employing the method of moments, theoretical continuous frequency curves were drawn which gave the best fit with the frequency polygons and equations to these curves in terms of recognised statistics were obtained. It was found that the frequency distributions for fibre-length and convolutions are moderately symmetrical and nearly normal; for fibre-width, symmetrical and practically normal; for fibre-strength, moderately asymmetrical and for fibre-rigidity extremely asymmetrical. The results of fibre-strength which gave moderately asymmetrical distributions were considered in some detail, and it was shown that, as against the views held by other workers, the skewness in the case of fibre-strength should not be ascribed either to sampling or to fibre fracture in the ginning process but must be regarded as a definite physical feature. In support of this view it was shown that the frequency distribution of the results of 3,000 tests made on complete fibres is almost identical with that of 5,000 tests made on 1 cm. lengths, the values of skewness and co-efficient of variation being the same in both cases. Thus, no real improvement in the form of distribution would be obtained by testing whole fibres instead of 1 cm. lengths. The skewness of the frequency distribution of fibre-strength could be attributed to three possible causes, namely (1) the growth process of the plant aims at excess of weak fibres, (2) although the plant aims at normal distribution of fibre-strength, an excess of weak fibres is produced by the operation of certain inhibiting environmental factors, and (3) the excess of weak fibres is produced by mechanical damage in ginning. Each possibility was considered in the light of the experimental results and it was concluded that the skewness for fibre-strength should be ascribed either to a change in the external conditions of growth during the life history of the plant or to the interference of inhibiting factors with the development of the fibre. Similar considerations were applied to the results for fibre-rigidity tests which gave even greater asymmetrical distribution and it was concluded that the same causes which are responsible for the skewness of the fibre-strength contribute to the asymmetry of the fibre-rigidity distribution.

The treatment of the subject was continued in the second bulletin referred to above, in which the experimental data was analysed in order to assign the minimum number of tests which can be regarded as satisfactory for the determination of each of the above mentioned fibre properties. The chief method employed consisted in the comparison of the mean values of small samples with the mean value of the large sample, but, in order to obtain a large number

of small samples of a given size, the moving mean method was used. In addition, however, two other methods for determining the size of the representative sample were also employed. These were (1) a comparison of the dispersions of values of small and large samples, and (2) a comparison of the actual frequency distribution of small samples with the theoretical frequency distribution of a large sample. By employing these three methods the odds that the single mean of a sample of any given size would lie between certain assigned limits was ascertained. The following are the chief conclusions arrived at as a result of this analysis :

(1) The method of selecting individual fibres from a carefully prepared sliver in which the fibres have been thoroughly mixed shows a bias in favour of the longer fibres and is therefore inferior to the method of selecting small bunches of fibres from different parts of the sliver and testing every fibre in each bunch thus selected.

(2) In the case of fibre-length, fibre-width and convolutions, which give nearly symmetrical frequency distributions, the mean value and the probable error of a single observation are quite sufficient to indicate the composition of a sample.

(3) In the case of fibre-strength, and more particularly in the case of fibre-rigidity, for which the distribution is asymmetrical, caution must be exercised in the use of the mean values, as it is greatly affected by high individual values which are sometimes ten times as large as the arithmetic mean. For these two properties it is desirable to indicate the composition of a sample by the upper and lower quartiles in addition to the mean value.

(4) The degree of reliability of small samples is indicated in the following table which shows the total range expressed as a percentage of the mean, for which the odds are as indicated that the mean of a random sample will lie therein :

TABLE 2.—Range (% of Mean) for which the Odds are as shown that the Mean of a Random Sample will lie therein.

Fibre-property.	Odds.	Size of sample.				
		200	300	400	500	600
Fibre-length	20 : 1	18	16	13	11	9
Fibre-width	20 : 1	4	2.7	2	..	..
Convolutions	20 : 1	30	24	20	19	18
Fibre-strength	20 : 1	40	23	17	15	13
Fibre-rigidity	5 : 1	..	60	55	48	44

In the selection of a satisfactory sample the two considerations are (1) the degree of reliability of the results for the given sample and (2) the practical consideration of the difficulties of making a large number of tests. Bearing these two points in mind, the following minimum number of tests are regarded as giving sufficiently reliable results:—

TABLE 3.

Fibre-property.	No. of fibres for representative sample.	Total range (% of Mean) for which the odds are 20 to 1 that the Random Sample will lie therein.
Fibre-length	500	11
Fibre-width	300	2.7
Convolutions	500	19
Fibre-strength	500	15
Fibre-rigidity	500	48 (odds 5 : 1)

The results discussed in this investigation relate to 1027 A. L. F. only, but as this cotton has shown considerable variation in its individual test results, it may be inferred that the results obtained for any other cotton will be at least as reliable as those obtained for the same number of tests of the same property for Surat 1027 A.L.F.

(2) METHOD.

(i) *Fibre properties.*—Having ascertained the size of a satisfactory sample and the degree of reliability attached to the results of a given number of tests, the next step in the determination of the properties of cotton fibre and yarns is the comparison of the various methods of testing a property where more than one method is available. This is necessary in order to find out the particular method which gives the best results in respect of accuracy as well as economy in time and labour. This point has been investigated at the Technological Laboratory in relation to the determination of fibre-strength and yarn-strength. We shall now give the main results of these investigations :

Fibre-strength.—Several instruments are available for determining the strength of cotton fibres. These can be classified as belonging to one or the other of the following three types:—(a) hydrostatic type, (b) balance type, (c) pendulum type.

The hydrostatic type is represented by the O'Neill apparatus in which the fibre is pulled by a floating weight, which gradually sinks down as the liquid in the cylinder is drained off. The volume of the liquid which flows out between the beginning of the test and the fracture of the fibre is a measure of its strength.

The balance type is represented by Barratt's apparatus in which the fibre is suspended from one end of the beam of a balance, the other end terminating

in an iron rod, which passes through a solenoid. The attraction of the current for the rod provides the tension required for breaking the fibre. An ammeter in the circuit registers the current which is proportional to the breaking strength of the fibre.

The pendulum type is represented by Balls Magazine Hair Tester in which a compound pendulum is attached to a hook which is made to pull the fibre. The pendulum swings in V-cup bearings and its angular displacement, which is recorded by means of an electric spark, gives the measure of the tension required for breaking the fibre.

The tests were carried out on three cottons using all the three instruments and a third cotton with Barratt's apparatus and Balls Magazine Hair Tester. From an analysis of these results which are fully described in *Technological Bulletin Series B, No. 5, "A comparison of some methods of testing the breaking strength of single cotton fibres"* by Hari Rao Navkal, M. Sc. and K. R. Sen, M. Sc., the following conclusions were drawn :—

Fibre-Strength Testing Methods.

(1) The mean obtained by using Barratt's apparatus is higher than that obtained by the other two methods among which O'Neill's apparatus gives higher values than the Magazine Hair Tester.

(2) Replacing the water in O'Neill's apparatus by calcium chloride lowers the mean and renders it but little different from that obtained with Balls Magazine Hair Tester.

(3) At least part of the difference between the results obtained with the O'Neill's apparatus and the Magazine Tester is due to the greater speed at which the fibres are broken by the latter.

(4) The application of the formulæ given by Mann and Peirce to allow for the effect of speed on the breaking strength of fibre is not justified in the case of Indian cottons.

Errors of the three types of instruments are discussed in detail and it is concluded that whereas Barratt's apparatus gives much higher results than those obtained by the other two instruments, these agree fairly well if a large number of readings is taken and if calcium chloride solution is used in the O'Neill tester.

It is pointed out that the Magazine tester has the advantage of speed of working and the O'Neill tester economy in first cost.

(ii) *Yarn characteristics*—

(a) *Yarn strength*.—The method most commonly employed in the mills for estimating the strength of yarns is the lea test. In spite of possessing world-wide popularity this method suffers from several serious defects and in the technological laboratories it is not uncommon to supplement it with another method in which the strength of single yarns is

determined. The latter method, however, though free from these defects, is subject to large sampling errors and, therefore, requires a great deal of time in taking a large number of tests. Recently a third method has been introduced which measures the ballistic work of rupture of yarns. The standard Indian cottons, spun at the Laboratory, are subjected to all the three methods of determining yarn-strength, and the opportunity was, therefore, taken to compare the merits of the three methods. The experimental data referred to 22 cottons of 1926-30 seasons on which, in addition to the lea test and the single thread test, the ballistic tests were made in two series, one with the end of the lea free to move round the fixing rods and the other with the ends fixed. The results obtained and the chief conclusions drawn from this investigation are described in the following bulletin :—

**Yarn
Strength
Testing
Methods.**

Technological Bulletin, Series B, No. 12—“ A Study of Comparative Results for Lea, Single Thread and Ballistic Tests on Yarns Spun from Standard Indian Cottons.”—By A. James Turner, M.A., D.Sc., and V. Venkataraman, M.A.—In order to compare the results, the ratios of lea count-strength product to ballistic count-work product, lea count-strength product to single-thread count-strength product and single-thread count-work product to ballistic count-work product were calculated in each case. The various counts into which these cottons had been spun were divided into three classes, namely, very low counts, 6/10's; low counts, 12/18's; and medium counts, 20/40's. From a consideration of these results the following conclusions were drawn :—

(1) The ratio of lea count-strength product to ballistic count-work product varied from 0.32 for very low counts, to 0.51 for medium counts, when the lea ends in the ballistic tests were free to move; and from 0.41 for very low counts to 0.63 for medium counts when the ends were fixed. These values for the Indian cottons are found to be much lower than those found for non-Indian cottons by other workers. To some extent, these differences are due to the fact that the lower counts into which the Indian cottons are generally spun have considerably greater extension than the finer counts, resulting thereby in an increase in the work of rupture.

(2) The differences in extension, however, cannot fully account for the observed differences in the values of these ratios for various counts. It is clear from the results that the twist inserted in the yarn is also a factor of some importance in changing the value of this ratio as we proceed from the coarser to the finer counts.

(3) The lea strength is found to become less relatively to the single-thread strength as the counts become finer, the ratio values of the lea to the single-thread being 0.70, 0.67 and 0.64 for 20's, 30's, and 40's yarns respectively. These results show that the stronger leas gave higher lea single-thread ratio than the weaker leas.

(4) The ratio of the single-thread count-work product to the ballistic count-work product is also variable, but is distinctly higher when the lea ends are fixed in the ballistic test. Under these conditions it ranges from

0.87 for every low counts to 0.79 for medium counts. The variation of this ratio should also be ascribed to the effect of different twists in the yarns.

(5) When the ends are fixed in the ballistic test, the irregularity of the results is less for the ballistic than for the lea test. It is, however, greater for both than for the single-thread test when due allowance is made for the difference in the number of threads tested.

(6) The ballistic test is much more sensitive to changes of humidity than either the lea or the single thread test. This factor lessens, to some extent, its advantage of possessing greater regularity as compared with the lea test.

The three methods of testing are compared by placing the cottons of each season in their order of rank according to each test. It is found that although all the tests agree fairly well, the differences between the lea test and the single thread test results are negligible, while those between the results of the ballistic test and the other two tests are quite serious.

It was finally concluded that although there is not sufficient evidence available at present to justify discarding the lea test altogether in favour of the ballistic test, yet the latter should be regarded as a useful supplementary test.

(b) *Twist in yarns.*—The effect of twist on yarn-strength is different for different cottons. The exact determination of twist, therefore, is a matter of considerable importance, as it may frequently be necessary to know what twist should be inserted in a yarn for the manufacture of a given type of fabric from a particular variety of cotton. The measurement of twist in yarns, its variation in a bobbin and the influence on it of variation in count and winding on tension is dealt with in the following bulletin :—

Technological Bulletin, Series B, No. 13.—“*The Determination and Variation of Twist in Ring-Spun Cotton Yarns.*”—By D. F. Kapadia, B. Sc. **Yarn Twist.** Tech., B.A., and A. James Turner, M.A., D.Sc. It is pointed out in this bulletin that the method ordinarily employed for the determination of twist, which consists in untwisting 1" lengths of yarn, is open to two objections. In the first place it is not easy to decide the exact moment when the twist has been completely removed from the yarn, especially if it is spun from a short staple cotton. In the second place, on account of the large variation in twist along the length of the yarn, sampling errors are large and it is necessary to perform a great many tests in order to obtain a fairly reliable result. Accordingly, a new method for the measurement of twist is described, which consists of passing two single yarns between the front rollers of the ring frame and spinning in the usual way so that the doubling twist is substantially the same as in an equal length of the single yarn. Twist tests on such two-fold yarns can be made with great accuracy, using 10" lengths. This method was employed for the purpose of investigating the variation of

twist throughout a bobbin and also for ascertaining in what manner the variation of twist is affected by the variation in the winding on tension or the variation in actual count.

Both methods were employed in determining the twist in a large number of test samples of 20's, 30's and 40's counts for singles yarns and 2, 40's, 2, 60's, and 2, 80's for the two-fold grandrelle yarns. The values obtained were plotted in frequency polygons and the results were tabulated in the form of means of successive sets of 10, 20, 200 tests. From a comparison of the general mean with the means of the various sets it was concluded that if the twist is measured by the ordinary method, it is necessary to perform at least 100 tests on 1" lengths in order that the odds may be 5 : 1 that the mean value is correct to within 2 per cent. When, however, twist tests are made on two-fold grandrelle yarns, only 10 determinations of twist in 10" lengths are necessary to give the same degree of accuracy with the even higher odds of 10 : 1. As a practical application of these results, it should be remembered that an error of one tooth in the number of the twist wheel will make differences of 2 per cent., 2.7 per cent. and 3.3 per cent. respectively in the twist inserted in 20's, 30's and 40's yarns. It follows, therefore, that ten determinations of twist on 10" lengths of the grandrelle yarn are quite sufficient to arrive at a decision whether or not the correct twist wheel has been employed. Alternatively, if the ordinary method of measuring twist is used, at least 100 tests on 1" length of singles yarn would be necessary which would require a much longer time than the 10 tests on the two-fold grandrelle yarn.

On comparing the actual and the calculated twists in the different yarns it was found that, on the average, the actual twist is higher by 3.23 per cent. than the calculated twist. This excess of actual over the calculated twist was attributed mainly to the fact that the length of the roving delivered by the front rollers exceeds the length wound on to the bobbin owing to the contraction (milling up) resulting from the insertion of twist in the yarn. If in addition the effects of the thickness of the spinning bands and band slippage are also taken into consideration, the total allowance between the actual and the calculated twist should be 8.5 per cent.

As regards the variation of twist due to variation of winding-on tension, it was concluded that any effect of the difference in the winding-on tension may be completely masked by irregularities due to other causes, such as irregularities in roving and readjustment of the twist during the testing of the yarn.

The variation of twist throughout a full bobbin was examined by the new method. It was found that in the case of 2, 80's yarns there is no regular variation in the distribution of the twist, and, therefore, in this case, the effect of any variation in the winding-on tension is negligible. In the case of 2, 60's yarns there was slight tendency for the bottom of the bobbin to have rather less twist than the top of the bobbin. This was either due to the winding-on tension being somewhat high in the formation of the bottom of the bobbin or to the spinning of this portion having occurred when the spindle bands were

slackened. The 2/40's yarns showed the greatest divergence, the average twist decreasing in each quarter of the bobbin from the top quarter to the bottom quarter. This could only be explained by assuming that in this case the spindle band tension greatly increased, though there was no indication of any appreciable change in humidity before and during the spinning of the yarn.

The variation of twist due to variation in actual count was examined by weighing 20's single yarn in successive lengths, each 6" long, after the twist had been determined in each of the 6 inches. The correlation co-efficient between the two properties, twist and count, was found to be +0.655, which is definitely significant, showing that the variation of count is the most important factor causing variation in twist; while the position of the ring rail during winding on different parts of the bobbin and the variation in traveller speed are of subsidiary importance.

(3) OTHER INVESTIGATIONS.

The investigations mentioned above have been completed and the results obtained and chief conclusions drawn have been described in *Technological Bulletins*. In addition to this, the following investigation has been completed, though an account of it is yet to be written :—

New stapling Apparatus by Dr. Nazir Ahmad, M.Sc., Ph.D., and C. Nanjundayya, M.Sc.—The work of correlating fibre-properties with the spinning values of Indian cottons carried out at the Technological Laboratory, has shown that mean fibre-length is more strongly correlated with the spinning value than any other single property of the cotton hair, the fibre-weight per inch taking the second place in this respect. In view of this the general practice at the Laboratory has been to determine only these two properties in the case of most of the samples received for tests. The two methods which are commonly in vogue for the determination of mean fibre-length are (1) Balls Sorter distribution method and (2) Baer Sorter method. The former gives fibre-length in addition to mean fibre-length, while the latter, as used at present, gives only mean fibre-length. The latter method has the advantage of economy in first cost, comparative ease in manipulation and less wear and tear of the instrument, but it is more subject to errors of personal judgment on the part of the operator. Both methods, especially the Balls Sorter method, take a large amount of time in the completion of a test, and, in view of the importance of the length property of cotton, it was felt that any method which would give equally reliable results in a shorter time would be a great improvement. The new method developed at the Technological Laboratory satisfies this condition besides possessing the advantages of low initial cost and remarkably little wear and tear with use. This method consists in mounting a hand-sliver on a set of combs, the fibres in the sliver are properly aligned, a tuft containing from 100 to 200 fibres depending upon the type of the cotton is pulled out and held between two tweezers. This tuft is cut into three unequal sections which are weighed on a sensitive torsion balance. The fibres in the first section are held between two

**The New
Stapling
Apparatus.**

glass slides and counted. From a knowledge of the weights of the three sections of the tuft and the known lengths of the first two sections the average length of the tuft is calculated. The weights of the three sections are added up and, as the number in the first section represents the number of all the fibres in the tuft, the fibre-weight per inch can also be calculated. Thus, it is possible to determine the mean fibre-length and fibre-weight per inch of a cotton in a single operation. It has been found that from 3 to 5 repeat determinations on the lines mentioned above are sufficient to yield results which are as reliable as those given by the Balls or the Baer Sorter method, with a considerable saving in time and labour. An apparatus has been designed on which the operations mentioned above can be suitably performed and it has been patented in many countries. When the arrangements for its manufacture are complete, this apparatus will be available at a price of approximately Rs. 350. A full account of the method and a description of the apparatus will soon be published.

(4) MEASUREMENT OF FIBRE PROPERTIES.

The fibre-properties of a cotton may be considered either in relation to its agricultural characters or in relation to its spinning value. The former line of attack is especially useful to the Cotton Breeder and through him to the cultivator, while the second line of attack is useful to the merchant and the millowner. It is not, of course, possible, in each and every case, to draw a hard and fast line of distinction between the two types of investigations. We shall first describe such investigations as deal with the fibre-properties of cotton in relation to its agricultural character, will interpose a short section dealing with the measurement of yarn characteristics and will finally give an account of the investigations dealing with the relationship between the fibre-properties and the spinning value of a cotton.

Fibre-properties in relation to agricultural characters.—The first problem to be tackled was the relationship between the ginning percentage and the various physical properties of the cotton fibre. The results of this investigation are described in the following bulletin :—

Ginning Per-
centage &
Lint Index.

(i) *Ginning Percentage and Lint Index.*—*Technological Bulletin, Series B, No. 4.*—*Ginning Percentage and Lint Index of cotton in relation to the number of cotton fibres per seed; the effect of environment on ginning percentage; and the determination of unit fibre-weight. By A. James Turner, M.A., B.Sc.*

It is pointed out in this bulletin that there are two ways of expressing the amount of lint on a single seed of any variety of cotton. The ordinary way is to express it as 'ginning outturn' or 'ginning percentage', while a more recent way is to express it as 'lint index', which is the weight of lint obtained from 100 seeds. The various factors, such as the volume and specific gravity of seed, the number of fibres on a single seed, the weight of individual fibres, etc., on which ginning outturn and lint index of a cotton depend are analysed, and the relative merits of these two expressions are compared. The results of the earlier workers are critically discussed and it is concluded that the lint index cannot be *measured* only by the number of fibres per seed, and that from the number of variables appearing in the equation for ginning percentage, no direct proportionality ought to exist between the ginning percentage and the



Fibre Testing Department.

number of fibres per seed or any other single property. These conclusions are confirmed by an examination of the results obtained at the Technological Laboratory for various Indian cottons. As regards the fluctuations in the ginning outturn, Balls's conclusions that (1) these are due to differences in the environmental conditions on the day of flowering, and (2) that the number of epidermal cells which sprout into hairs is determined by such differences are examined at some length. It is concluded that the available data do not enable us to decide whether or not the differentiation of the lint cells takes place on the day of flowering or what may be the influence of the environment on this differentiation.

It is further pointed out that it is advantageous to study the ginning percentage of individual seeds. From the results obtained for Aligarh A.19 and Punjab-American 4F cottons, it is shown that high ginning percentage is associated with low seed-weight. The weight of lint per unit seed surface is found to be the same, on the average, for the small, medium and large 4F seeds, but fluctuates considerably for individual bolls of A.19. From actual determinations of fibre-weight in each case, it is concluded that neither the total number of fibres per seed nor the number per unit area of seed-surface is directly proportional either to the seed-weight or to the ginning percentage.

The different methods for the determination of the weight of single fibre are discussed and it is concluded that the fibre-weight per unit length may have different values for different lengths of fibre, and that, in general, the tendency may exist for the shorter fibres to have a greater fibre-weight per unit length. The results obtained in the Laboratory are given to show that not only some varieties display greater fibre-weight per unit length for short lengths, but in some cases the fibre-weight of individual fibres decreases very considerably from the middle of the fibre to the apex. The values of fibre-weight per inch obtained for different lengths of a given sample are used for ascertaining the average number of fibres of different lengths per seed for some of the Indian cottons.

(ii) *Fibre weight per inch.*—In the bulletin mentioned above the two methods of measuring fibre-weight per inch of a cotton were examined and it was shown that the correctness of the results obtained by the cutting method was based upon the validity of two assumptions: first that the fibre-weight per inch is the same for the different group-lengths, and second that the fibre-weight per unit length is practically the same along the length of the fibre. In view of the importance of the fibre-weight per inch in relation to the spinning capacity and the agricultural characters of a cotton, it was regarded desirable to undertake an investigation to test the validity of the first assumption. The results of this investigation on 18 standard Indian cottons are described in the following Technological Bulletin:—

Technological Bulletin, Series B, No. 7.—*The weight per inch of fibres of different lengths per seed, for each of the standard Indian cottons. By R. L. N. Iyengar, B.Sc., and A. James Turner, M.A., D.Sc.*—Fibre-weight per inch for the different group-lengths was determined for each of the

**Fibre-weight
for Different
Group-
lengths.**

18 standard Indian cottons. From a consideration of the results it was concluded that it cannot be accepted as universally true that the fibre weight per unit length is the same for fibres falling in different group lengths of a given cotton. The cottons were classified according to their botanical species and it was found that for *hirsutum* cottons, the fibres of longer lengths generally have less fibre-weight per inch than the shorter fibres, while the *herbaceum*, *neglectum* and *indicum* cottons do not generally show any large change of fibre-weight with fibre-length, the chief exceptions being Aligarh A. 19 and Mollisoni, in which fibres of longer lengths have a smaller fibre-weight. Taking all the cottons into consideration, it was concluded that the variation of fibre-weight with group length, observed in some cases, is not sufficient to make this essentially different from the value obtained by the ordinary cutting method in which any such variation is ignored. There, however, still remains the possibility that the second assumption mentioned above is not valid and that the cutting method may give erroneous results owing to the variation of fibre-weight along the length of a single fibre.

The results of these tests made it possible to calculate the numbers of fibres of different lengths on a single seed for each of the standard Indian cottons. It was found that the number of fibres per seed differed greatly for different species, for different varieties of the same species, or for the same variety in different seasons. The values obtained were used to find out the relationship between the number of fibres per seed and (1) the lint index, or (2) the ratio of the lint-weight per seed to the seed-weight, or (3) the ginning percentage. It was concluded that as the unit fibre-weight is different for different cottons the number of fibres per seed cannot be proportional to the lint index. For all the cottons the correlation coefficient between the unit fibre-weight and the seed-weight was found to be -0.238 . This value is insignificant; nevertheless it rules out the possibility that the number of fibres per seed is proportional to the ratio of the lint weight per seed to the seed weight. Finally, the correlation coefficient between the number of fibres per seed and the ginning percentage was found to be $+0.33$ which is doubtfully significant and shows that there is no approach to direct proportionality between the two quantities when different species of cottons are included in the tests.

(iii) *Variation of fibre properties on the surface of a seed.*—It has been mentioned above that in the case of at least one fibre-property, namely fibre-weight per inch, the variation of this property with the position of the fibre on the surface of the seed has important bearing on the relationships between the number of fibres on the seed and the lint index and the ginning outturn of a cotton. Very little work has been done on the variation of physical properties of fibre with the position of the fibre on the seed, the few references in the literature on this subject being neither very clear nor always in agreement. Accordingly, it was felt desirable to carry out a systematic investigation on this problem. For this purpose the variation in fibre-length, fibre-weight and fibre-strength with the position of the fibre on the seed was investigated for 8 of the standard Indian cottons. The lint for the

experimental purpose was obtained from the following regions of the seed: (1) base, (2) apex, (3) right flank, (4) left flank, and (5) the hair removed by hand in gentle combing. The position of the point of rupture in a single hair break was also noted and the results are described in the following bulletin:—

Technological Bulletin, Series B., No. 14.—Variations in the properties of the Cotton Fibre in relation to its position on the surface of the seed. By R. S. Koshal, M.Sc., and Nazir Ahmad, M.Sc., Ph.D.—From an analysis of the results obtained the following conclusions were drawn:—

**E f f e c t of
p o s i t i o n o n
t h e S e e d.**

- (1) The frequency distribution of fibre-length is approximately symmetrical and normal, not only for fibres taken from the whole seed but also for fibres taken from different regions of the seed.
- (2) The mean fibre-length for fibres at the base of the seed is significantly greater than for fibres at the apex of the seed.
- (3) Not only is the asymmetrical distribution of fibre-strength a characteristic of the lint obtained from a single seed but also of the lint obtained from the different regions of the seed.
- (4) The mean fibre-weight per unit length and the mean fibre-strength are significantly higher for the apical than for the basal fibres.
- (5) The values of the mean fibre-length, the fibre-length distribution, fibre-weight and fibre-strength are practically the same for the right and left flanks of the seed.
- (6) The fibres which are removed in the process of combing the seed by hand are generally those which have got the least fibre-weight.
- (7) For about 80% of the fibres the point of rupture in single hair breaks is located near the apical end of the fibre.
- (8) The difference in the lint obtained from the apical and basal regions of the seed may amount to as much as 24% in fibre-length, 88% in fibre-weight and 67% in fibre-strength.
- (9) There is a distinct tendency for a high ginning percentage to be associated with low percentage difference between mean fibre-length of hairs taken from the apex and base of a seed.
- (10) Cottons which show large differences between apical and basal mean fibre-weight also show considerable difference between apical and basal mean fibre-strength. Thus while the mean value for fibre-strength and fibre-weight either for apical or basal are not correlated their differences are strongly correlated.
- (11) Dividing the cottons into botanical species it was found that cottons belonging to the *indicum* family gave the largest differences,

while those belonging to the *hirsutum* gave the lowest. The trend of the differences in the case of fibre-weight and fibre-strength is opposite to that for fibre-length.

The practical applications of these results are discussed in the remaining part of the paper. It is pointed out that, in selecting new strains, the Cotton Breeder should pay attention not only to the absolute values of the fibre-properties, but also to the percentage difference between the mean values of the properties for hairs on the apex and base of the seed. An analysis on these lines will differentiate between two strains in respect of regularity in length, weight and strength of their staple, thus enabling the breeder to select the particular strain which would yield a more uniform lint. Secondly, it is pointed out that, in view of the unexpectedly large differences in the properties of the basal and apical fibres, it is extremely necessary to take a fairly large sample for the determination of any of the fibre-properties. If the sample selected be small, particular care should be taken to ensure that it is thoroughly representative of the bulk, otherwise a preponderance of basal or apical hairs in the sample will introduce a large error in the result. Thirdly, the suggestion is made that if a method of differential ginning could be devised, lint possessing much greater length than the mean length could be obtained from a given cotton for spinning finer counts. The results were applied to such cases where a cotton has given an abnormal spinning performance in any one season, and it was found that such fluctuations in the spinning performance are not due to the upsetting of the equilibrium between the relative proportion of the basal and the apical fibres or to a sudden variation in their fibre-properties.

(5) MEASUREMENT OF YARN CHARACTERISTICS.

The characteristics of a yarn spun from a cotton are closely related to its fibre-properties. The method commonly employed in the investigations of the effects of latter on the former is such that the cotton fibre constitutes the starting point and the yarn the end point. The properties of the fibre are determined accurately for a number of Indian cottons and these are correlated, singly or in combination, with the characteristics of the yarns which are spun from the cotton. This problem, however, can be attacked in another way in which the yarn constitutes the starting point and its measured characteristics are expressed in terms of the properties of the fibres in the yarn itself. This line of attack is especially fruitful in such investigations in which the *differential* effect of the fibres in a cross section of the yarn is sought to be determined. Accordingly, this method was employed in order to ascertain quantitatively the part played by fibre fracture relative to fibre slippage and the manner in which these two factors changed with the twist in the yarn. The scope of this investigation was extended to determine the influence of twist and tension on the diameter of the yarn and the relation of distribution of twist to the number of fibres present in a cross-section of the yarn.

(i) *Yarn diameter and the influence of twist on diameter and strength of yarn.—*

Technological Bulletin, Series B, No. 9.—The influence of yarn twist on the diameters of cotton yarns and on the proportions of fibre-slippage and fibre-fracture in yarn breakage. By A. N. Gulati, M.Sc., and A. James Turner, M.A., D. Sc.

For the purposes of this investigation special mock-gradrelle yarns were prepared from six standard Indian cottons covering a fairly wide range of quality and botanical species. The yarn tests were made on 3-inch long specimens which were selected as being as uniform as possible, known twist being inserted in each specimen. The variation in twist and the diameter were noted and the specimen was broken at a constant rate of loading. After the rupture of the yarn the two broken pieces were removed and weighed and, finally by staining with congo red, the numbers of fibres which had slipped and broken respectively were determined. From the experimental results the following conclusions were drawn :—

Influence of twist on yarn diameter.

(1) It was found that for a counts range of 20's to 40's and for a twist range of 5 to 30 turns per inch the diameters of the yarns could be represented by the following formula :—

$$d = 0.066 + \frac{7}{\sqrt{n} \sqrt[4]{c^3} (1+0.008c)} \dots\dots\dots(1)$$

- where d = diameter of yarn in mms.
- n = turns per inch.
- c = counts of yarn.

Alternatively, a simpler formula, which was found to fit the results equally well within the practical range of twist constants 3 to 7, was as follows :—

$$d = \frac{1.9}{\sqrt{c} \sqrt[4]{n}}$$

This formula breaks down for very low twists.

- (2) The effect of tension on the diameter of the yarn is very small as compared with that of twist.
- (3) The distribution of the twist over a large range is such that the number of turns per inch in any part of the yarn is approximately inversely proportional to the number of fibres in that part.
- (4) The variation of twist causes the fibres to be more concentrated in the thin than in the thick parts of the yarn.

(5) The yarn strength is found to increase very slowly for all counts upto about 7 turns per inch; thereafter, both for 20's and 30's counts there is a rapid increase up to 17 turns per inch, though the increase is less rapid for 30's than 20's yarns. For 40's yarns the strength begins to increase rapidly only when 10 turns to the inch have been inserted.

(6) The maximum strength for different counts of yarn was attained at about the same twist, that is 30 turns to the inch. This corresponds to a twist constant of 7 for 20's, 5.5 for 30's and 4.5 for 40's. These maximum strengths do not reflect the highest standard warp counts of these cottons and it is therefore concluded that some of the fibre-properties are important for the fact that they determine the frequency and degree of thick and thin places in the yarn.

(7) These results do not agree with some of the earlier results and divergence was attributed to the fact that only such specimens as appeared uniform to the eye were selected in these tests, while in the earlier experiments the selection was random.

(8) Below 7 turns per inch the breakages of yarn takes place almost entirely by fibre slippage but, within the range of twist used in the spinning of commercial class yarns, breakage takes place chiefly by fibre fracture.

(9) There is a very close relationship between percentage of fibre fracture and yarn strength, the simple correlation coefficients between the two lying between 0.94 and 0.99 for the different yarns.

(10) At high twists the percentage of fibre-strength utilised reaches a high figure. In fact in some cases it was found to exceed the total strength of the fibres in the cross-section of the yarn. The existence of these high values is attributed to the reinforcement of the weak fibres by the strong one lying close to them; this effect being especially noticeable in such uniform specimens as were used in these tests.

(ii) *Relationship between the results of lea test and single thread test.—*

The three methods which are commonly used in a technological laboratory for measuring and comparing the strength of yarns are (1) the lea test, (2) the single thread test and (3) the ballistic test. On page 14 we gave an account of an investigation carried out at the Laboratory with a view to comparing the results obtained by applying all the three methods to yarns spun from a number of standard Indian cottons. We saw that although there was a general correspondence between the results obtained by applying the three methods yet the agreement between them was far from perfect, and that even in the case of the lea test and the single thread test, which aim at measuring the same property, namely, the breaking strength of yarn, there were large differences in many cases which made it impossible for the results of one test to be calculated in terms of the other. Recently, Gregson suggested a method by which, according to him, the lea strength of a yarn could be deduced from its single thread strength. As the single thread test is free from several defects which rather

mar the scientific value of the lea test, it was felt that if this method could be found applicable to the Indian cottons it would result in a considerable saving in time and labour as it would then be possible to calculate the lea breaking strength of a yarn from the results of the single thread test. Accordingly, an investigation was undertaken to test the validity of this method to yarns spun from standard Indian cottons and the results obtained are described in the following bulletin :—

Technological Bulletin, Series B, No. 15.—Examination of a proposed relationship between the Lea Test and the Single Thread Test Results. By V. Venkataraman, M.A., and Nazir Ahmad, M.Sc., Ph.D.—For the purposes of this investigation the results of the lea test and the single thread test on 144 carded and combed yarns, ranging in counts from 6's to 80's and spun from 16 standard Indian cottons of the 1931-32 season, were used. In each case the observed value of the lea breaking strength was compared to that calculated according to Gregson's methods from the single thread strength. Furthermore, in order to examine the results critically, a quantity, called the 'lea ratio' which represents the percentage ratio of the lea breaking strength to 160 times the single thread strength was calculated. From an analysis of these results the following conclusions were drawn :—

Lea and Single Thread test results.

(1) The lea strength as calculated by Gregson's method is generally greater than the observed value when the lea ratio is less than 70 and less than the observed value when the lea ratio is greater than 70.

(2) When the lea ratio lies between 67 and 77 the percentage differences between the calculated and the observed lea strengths are comparatively small but even so a discrepancy of 5 per cent. is quite common and of 10 per cent. not uncommon. When, however, the lea ratio either exceeds 77 or is less than 67, the discrepancy between the calculated and the observed lea breaking strength may be quite large.

(3) These discrepancies were found to diminish if suitable correction was applied for the difference in lengths of the test specimens in the lea test and the single thread test, but even so, they were found to be as high as 60 per cent. for a carded yarn and 28 per cent. for a combed yarn. Thus when the lea ratio does not lie between 67 and 77 Gregson's method breaks down completely.

(4) Even with these limitations this method would be capable of serving some useful purpose if the lea ratio bore some simple relationship to the counts of the yarn spun from a cotton. It was found, however, that there is no relationship whatever between the counts and the lea ratio so that unless the lea test is actually performed it is not possible to foretell its lea ratio and thus to calculate, even approximately the lea breaking strength of its yarns.

(5) In view of these considerations the only practical application of the method suggested by Gregson is that it can serve as a check upon the lea test in those cases in which the lea ratio lies between 67 and 77.

(6) Even with similar yarns spun from duplicate lots of the same cottons, the percentage difference between the calculated and the observed lea breaking strength was found to be quite large in several cases. In such cases the values of yarn irregularity were generally high and it was concluded that these discrepancies are due to differences in the structure of the yarn which are revealed more minutely by the single thread than by the lea test.

(6) RELATIONSHIP BETWEEN FIBRE-PROPERTIES AND YARN CHARACTERISTICS.

We shall now consider the investigations carried out at the Laboratory on such fibre-properties of cotton as have direct bearing upon the characteristics of yarns in general and their strength in particular.

The first problem to be investigated in this connection was the relationship of fibre-strength with yarn-strength. The results of this investigation are described in the following Technological Bulletin:—

(i) *Fibre-strength and Yarn-strength.*—

Fibre-strength. *Technological Bulletin, Series B, No. 1.—The Relation of Yarn-strength to Fibre-strength. By A. James Turner, M.A., B.Sc.*—After reviewing, at some length, the experiments of the earlier workers, the results obtained at the Laboratory with twelve Indian and two American cottons are discussed. The mean fibre-strength and the fibre-weight per inch of these cottons were ascertained, they were spun into 20's counts and the lea strength and the single thread strength of the yarns were determined. The correlation coefficient between the count-strength product and the mean fibre-strength was found to be -0.305 . This value is on the border line of significance but the negative sign indicates the paradoxical result that high yarn strength is associated with low fibre-strength. When, however, due allowance is made for the number of fibres in the cross section of the yarn by using not the fibre-strength itself but the ratio of fibre-strength to fibre-weight per inch, the correlation coefficient between the count-strength product and this ratio works out to $+0.048$. The positive sign removes the paradoxical feature referred to above, but the very small value of this coefficient shows that the count-strength product is not at all correlated with the ratio of fibre-strength to fibre-weight per inch. It was further found that the percentage of fibre-strength utilised in each yarn according to the single thread test varies from 37.8 to 64.3 for the different cottons while the percentage of fibre-strength, utilised in the lea test varies from 26.5 to 46.5. For all the 14 cottons the average percentage of fibre-strength utilised is 50.8 for the single thread test and 36.6 for the lea test. It was pointed out that although no general relation could be established between fibre-strength and yarn strength, yet from purely physical considerations, yarn-strength must depend to an appreciable extent, upon the fibre-strength of a cotton. It was suggested that in

all probability the direct effect of fibre-strength is masked by several other factors which were considered in considerable detail. Among such factors which are responsible for the deficiency of actual yarn-strength as compared with that calculated from fibre-strength, the following may be mentioned :—

- (1) The fibres in a yarn are tested in groups whereas in the fibre-strength test they are tested individually.
- (2) Only a part of the fibre is tested in the fibre-strength test.
- (3) The effect of twist is to make the fibres lie spirally in the yarns, the resulting torsional forces may weaken the fibre under tension.
- (4) Imperfect yarn structure may result owing to variation in (1) count, (2) proportion of weak and strong fibres, (3) twist and (4) disposition of the fibres, thereby causing a deficiency in yarn strength.
- (5) Towards their ends fibres in a yarn do not bear a load equal to their strength.

The influence of each of these factors in the light of such experimental evidence as available was discussed. It was also pointed out that the total effect of these factors in reducing yarn strength is offset by the fact that the weak fibres in the yarn are reinforced to some extent by the strong ones lying close to them. From a consideration of all the results, the conclusion was drawn that while it is not at present possible to assign definite magnitudes to each of these factors, it is easy to understand why only a small proportion of strength of the fibres is apparently used in a yarn.

The next fibre-property to be considered in its relation to the spinning value was the clinging power of a cotton. This is a measure of the surface friction of one fibre to another, and it plays an important role during the drafting processes. The results of this investigation are described in the following Technological Bulletin :—

(ii) *Clinging Power and Spinning Quality.*—

Technological Bulletin, Series B, No. 8.—The Clinging Power of Cotton. **Clinging Power.**
 By Hari Rao Navkal, M.Sc., and A. James Turner, M.A., D.Sc.—The value of this property was determined for 44 Indian cottons and one American cotton by pulling a group of ten fibres of the cotton between pads made from parallelised fibres of the same cotton. In a preliminary experiment it was found that the clinging power depended upon the pressure on the pads increasing with the pressure though the relative magnitude of the increase was not so rapid as that of the pressure itself. In the subsequent experiments the pressure on the pads was so adjusted as to be approximately equal to that experienced by the fibres of a yarn on the point of breaking under tension. The correlation coefficient between clinging power and the spinning value of a cotton was found to be -0.67 , which is significant but would lead to the paradoxical result that cottons suitable for spinning coarse counts tend to have relatively high values of clinging power. The only conclusion that could be

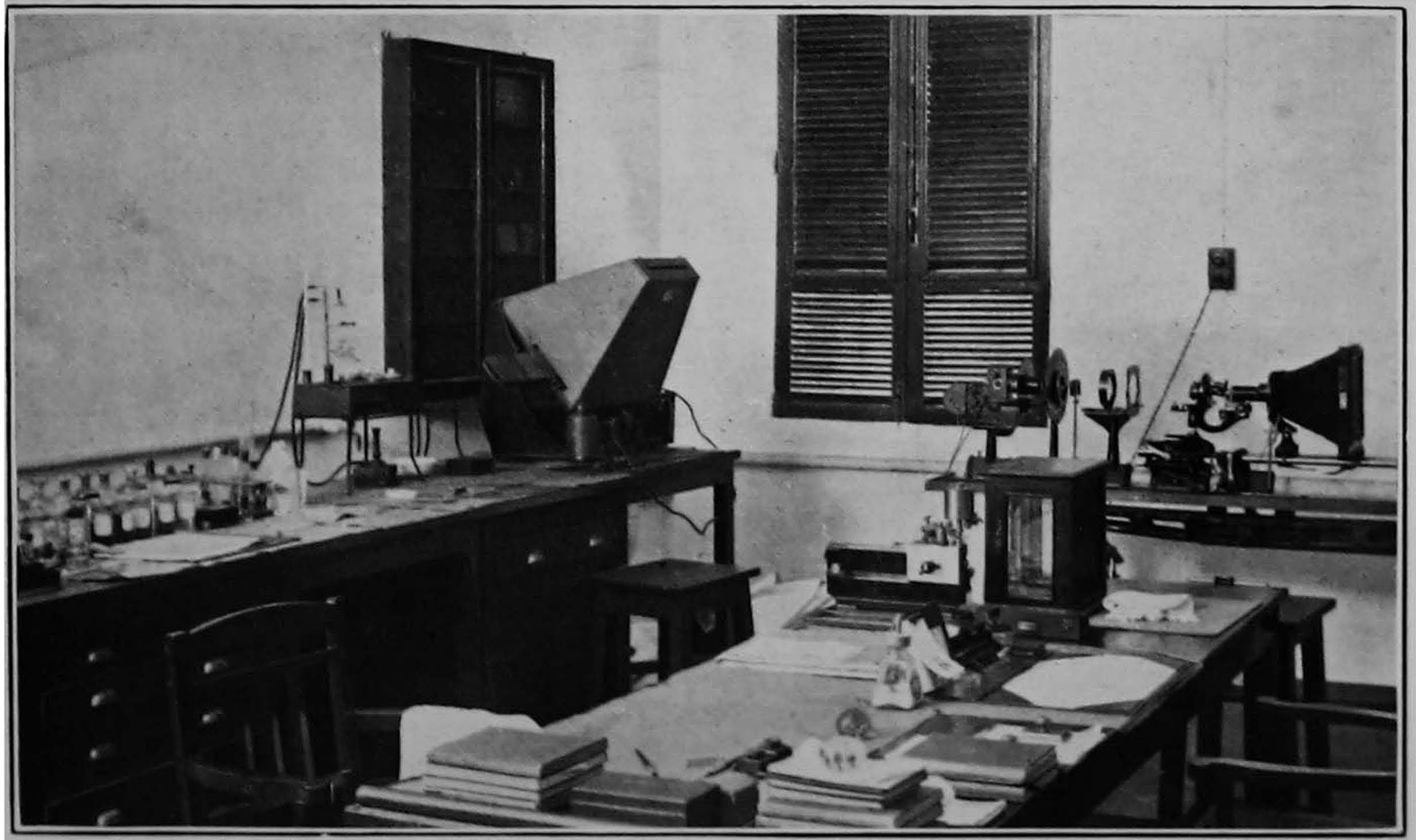
drawn from the negative sign of this coefficient was that cottons possessing high clinging power would not be so readily amenable to the drafting processes which would soon put a limit to spinning them economically into finer counts. It was, however, pointed out that it would be more correct to take not the actual experimental value, which was determined for $\frac{1}{8}$ " lengths of the fibres, but the value of the clinging power of the whole fibre per unit fibre-weight per inch. The correlation coefficient between this ratio and the highest standard warp counts was found to be + 0.60, which is comparatively high and statistically significant. The sign and value of this coefficient lead to the conclusion that there is a marked tendency for those cottons which have high clinging power in relation to their length and fineness to be spinnable to comparatively high counts. The correlation coefficient between the clinging power per unit fibre surface and the highest standard warp count was found to be -0.10, which shows that it is a property which does not appreciably affect the highest standard warp count to which a cotton can be spun. Finally, the correlation coefficients between the clinging power and certain other properties of the fibre were calculated. It was found that the shorter and coarser cottons tend to have higher individual clinging power, but that in the yarn the greater number of the finer and longer fibres present offsets the greater individual clinging power of the coarser fibres, so that the finer fibres actually have a much higher total clinging power in a yarn of a given count.

(iii) *Fibre-length Irregularity and Spinning Quality.*—

The next property whose influence on the spinning value investigated was the fibre-length irregularity of a cotton. It is fairly commonly known that all the fibres of a cotton, even when taken from a single seed, do not possess the same length, but that their individual lengths are spread over a considerable range. Thus it may happen that two cottons may possess the same mean fibre-length and yet the spread of fibres may be quite different in them. These two cottons, so far as their spinning performance is concerned, will behave differently, the more regular cotton giving, as a rule, better results than the less regular one. It was, therefore, felt that a systematic investigation on the fibre-length irregularity of Indian cottons and the relationship of this property with the other fibre-properties and spinning values of these cottons would yield instructive results. The results of this investigation are described in the following Technological Bulletin:—

**Fibre-length
Irregularity.**

Technological Bulletin, Series B, No. 16—Fibre-length Irregularity in Cotton.
By Nazir Ahmad, M.Sc., Ph.D., and Hari Rao Navkal, M.Sc.—It is pointed out in this bulletin that the short fibres present in a cotton are a source of trouble throughout the different processes in the manufacture of yarn. At an early stage in the blow-room they form a thin layer on the hopper exhaust cages and thus cause the scutcher lap to develop the effect of licking. In the card-room they constitute the bulk of the flat strip waste, thereby raising the waste losses of the cotton. Finally, in the ring frame, where the rollers are normally set with reference to the average length of a cotton, the short hairs constitute the 'floating fibres'. Since these are not held by



Microscopy Room.

the rollers at either end they disturb the orderly alignment of the fibres in the yarn and produce uneven yarn structure which is mainly responsible for deficiency in yarn strength and for abnormal breakages in the winding frame and the loom. Furthermore, the free ends of these short hairs, by sticking out in all directions as a result of accumulation of electric charge, sometimes give the yarn a fuzzy appearance. The extent to which these deleterious effects would be noticeable in a cotton would depend upon the relative proportion of short hairs present in it. It was, therefore, felt that an objective method for ascertaining and expressing the fibre-length irregularity of a cotton would be highly useful. It was suggested that fibre-length irregularity of a cotton should be defined as the percentage ratio by weight of all the fibres in a representative sample, which measure less than three-fourths of its modal length. The values of fibre-length irregularity were found, according to the definition given above, for 63 standard Indian cottons and 30 agricultural samples. Furthermore, the values of the simple correlation coefficients between fibre-length irregularity and (1) the mean fibre-length, (2) the fibre-weight per inch and (3) the spinning values of these cottons and the values of the multiple correlation coefficients between all these properties were calculated. For the standard Indian cottons the simple correlation coefficients between fibre-length irregularity and (1) mean fibre-length and (2) fibre-weight per inch were found to be + 0.63 and -0.55 respectively, showing that relatively the longer and finer cottons have a tendency to be more irregular in length than the shorter and coarser ones. These results, however, did not hold valid for the agricultural samples, which covered a much wider range of length and fibre-weight. For both types of cottons, namely, the standard Indian cottons and the agricultural samples, the inclusion of fibre-length irregularity did not materially raise the value of the multiple correlation coefficients between the fibre-properties and the spinning values of these cottons. At first sight it would appear from this result that fibre-length irregularity has very little influence upon the spinning value of a cotton, but it must be remembered in this connection that the multiple correlation coefficient between fibre-length, fibre-weight and spinning value of a cotton is already so very high (0.906 for the standard Indian cottons and 0.937 for the agricultural samples) that in order that the irregularity percentage should appreciably alter it, its contribution to the spinning value of a cotton must be comparable in importance to that of either mean fibre-length or fibre-weight per inch.

(iv) *Fibre Maturity and Yarn Neppiness.*—

The investigations which we have considered above were concerned with those fibre-properties which have a direct bearing upon the strength of yarns spun from a cotton. In addition to strength, however, there are other characteristics of a yarn as well, which should be taken into account in assessing its quality. Among these the number of neps present in a yarn occupies an important position. There is sufficient evidence to show that the chief factors ultimately responsible for neppiness in yarn are immature fibres, motes and seed-bits which act as nuclei for the formation of these neps during the mechanical treatment to which a cotton is subjected in the manufacture of

yarn. Accordingly, an investigation was undertaken principally to determine the relationship between the percentages of mature and immature hairs in a cotton and the number of neps in the yarn spun from it, but at the same time the effect of such factors as locality of growth, heredity, season, type of ginning machinery upon yarn neppiness were also studied and the relationships between the fibre-maturity and the other fibre-properties of a cotton were examined. The results of this investigation are described in the following bulletin :—

**Fibre-
Maturity.**

Technological Bulletin, Series B, No. 20.—“Fibre Maturity in relation to Fibre and Yarn characteristics of Indian Cottons”. By A. N. Gulati, M.Sc., and Nazir Ahmad, M.Sc., Ph.D., F.Inst.P.—From a consideration of the experimental data the following conclusions are drawn :—

- (1) Different cottons behave differently in regard to the effect of season on fibre-maturity; in some cottons fibre maturity fluctuates violently with the season, while in others it is independent of it.
- (2) In the case of Banilla cotton, locality of growth has a pronounced effect on the degree of fibre-maturity.
- (3) Selections from the same common parents grown under almost identical conditions may differ significantly in regard to fibre-maturity.
- (4) The saw-gin does not exercise any selective action on the immature or half-mature fibres present in a cotton. If it is found that the saw-ginned samples give more neppy yarns than the roller-ginned samples of the same cotton, it is probably due to the rolling up of the short bits into which some of the longer fibres may break during the passage through the saw-gin.
- (5) The correlation coefficient between fibre-maturity and mean fibre-length of a cotton is insignificant, but detailed analysis of the data shows that a majority of the short staple cottons possess high percentages of mature hairs, while a majority of the comparatively long staple cottons are characterised by low percentage of mature hairs.
- (6) High fibre-maturity goes hand in hand with high fibre-weight per inch and high fibre-strength, the simple correlation coefficient between the two attributes being +0.60 and +0.72 respectively. The mature fibres are so definitely stronger than the immature ones that, in every case, the lower quartile for the former is greater than the upper quartile for the latter.
- (7) Yarn neppiness is significantly correlated to the number of immature hairs in a cotton. When due allowance was made for the type of ginning machinery employed, it was found that the simple correlation coefficient between yarn neppiness and the combined percentage of immature and half-mature hairs is +0.67 for 28 samples.

(8) That the correlation coefficient is not higher than is actually found is due to the influence of various causes which tend to lower this relationship. The most important of these causes are (1) the dispersal of some immature hairs in the nep-free yarns, (2) the presence of some mature hairs in the neps, and (3) the difficulty of counting accurately the number of neps in a yarn. The influence of each of these factors is discussed in some detail.

(9) The influence of fibre-maturity on the spinning value of a cotton is masked by other fibre-properties, notably mean fibre-length and fibre-weight per inch. On making a detailed analysis, it is found that in medium and long staple cottons higher fibre-maturity is usually associated with better spinning performance, while in short staple cottons the reverse is the case. The simple correlation coefficients between fibre-maturity and highest standard warp counts for the two types of cottons were found to be $+0.56$ and $+0.66$ respectively.

(10) The importance of taking into account maturity percentages, in addition to other fibre-properties, in judging the quality of a cotton is discussed.

(v) *Wax Content and Feel.*—

Hitherto we have considered investigations concerning such fibre-properties as are either related to the agricultural characters of the cotton (ginning percentage, lint index, number of fibres per seed, etc.) or have a close relationship with the strength and other characteristics of the yarns spun from it. There are, however, certain physical characteristics of a cotton which the trade take into account in assessing its quality but which are ordinarily not expressed in terms of any measurable property of its fibre. One such characteristic is the *feel* of a cotton, which must in some ways be related to the amount of waxy material present on the fibres. As one of the objects of cotton fibre research is gradually to replace the subjective estimates of the quality of a cotton, formed by a hand-and-eye examination, by objective measurements of the properties of its fibres, an investigation was undertaken to ascertain how the *feel* of a cotton, as estimated by an expert grader, depended upon its wax content. The results of this investigation are described in the following bulletin :—

Technological Bulletin, Series B, No. 18.—“ *A Note on the Wax Content of Indian Cottons with special reference to their Feel*”. By Nazir Ahmad, M.Sc., Ph.D., and D.L.Sen, M.Sc.Tech., A.I.C.—It is pointed out in this bulletin that although the amount of waxy material associated with cotton fibres rarely exceeds 0.6 per cent., it plays an important part in the spinning, wetting, dyeing and scouring processes and has besides a direct bearing upon the **Wax Content.**

feel of a cotton as estimated by a grader. Accordingly, the wax percentages of 11 Indian varieties and one non-Indian (Kampala) trade variety covering a wide range in feel, were determined. In order to reduce errors of personal judgment, three expert graders were asked to express their opinions regarding the feel of these cottons in terms of the standards adopted by them in their daily practice.

It was found as a result of these experiments that the wax content of Indian cottons may range from 0.229 per cent. to 0.468 per cent. This range is much wider than that indicated by some earlier workers and, owing to its overlapping the range for the American and the Egyptian cottons, the wax content cannot be used, as suggested by them, as a means of differentiating the Indian from the American or the Egyptian varieties. It was further found that the exotic varieties, grown in India, have, on the whole, higher wax contents than the indigenous types. The graders' estimates were found to disagree among themselves and with the results of the wax determination tests and threw into prominent relief the necessity of evolving an objective method for defining the *feel* of a cotton and expressing it in terms of some such property as its wax content. Accordingly, as a first step, the following scale, which represented the greatest common measure of agreement between the graders' reports and the results of the tests, was suggested:—

						<i>Wax Content (Per Cent.)</i>
Very silky	..	..	..	..	..	above 0.500
Silky	..	..	..	..	..	0.425-0.500
Slightly silky	..	..	..	..	..	0.350-0.425
Roughish	..	..	..	..	..	0.300-0.350
Rough	..	..	..	..	..	below 0.300

(vi) *Prediction of the Spinning Value of a Cotton from its Fibre Properties.—*

We have hitherto confined ourselves to the description of those investigations in which the influence of one fibre-property (fibre-strength, clinging power, fibre-length irregularity, or fibre-maturity) on the spinning quality of a cotton was studied though it was inevitable that in the discussion of results other fibre-properties should also be taken into account. For many years the central problem of the Technological Laboratory has been the establishment of a formula by which the spinning value of a cotton could be predicted, with reasonable accuracy, from its measurable fibre-properties. For this purpose comprehensive tests have been made on Standard Indian cottons, which for the most part represent improved types developed by the Agricultural Departments and cover practically the entire range of Indian cottons as regards spinning quality. Each sample was spun in duplicate lots, into suitable counts with moderate twist and its spinning value was expressed, from



Yarn Testing Room.

its yarn-strength results, in terms of the highest standard warp counts for which it was regarded suitable. At the same time it was subjected to fibre tests for the determination of (1) mean fibre-length, (2) fibre-weight per inch, (3) fibre-strength, (4) fibre-rigidity, (5) number of convolutions per inch, (6) ribbon width and (7) clinging power (for some samples). The method of correlation was adopted for the derivation of the prediction formula. The results of this investigation relating to 95 samples of standard Indian cottons, grown mostly between the seasons 1926-27 and 1929-30, are described in the following bulletin :—

*Technological Bulletin, Series B, No. 17.—“The Prediction of the Spinning Value of a Cotton from its Fibre Properties. By A. James Turner, M.A., D.Sc., and V. Venkataraman, M.A.—*In the introductory part of this bulletin the various prediction formulæ suggested by earlier workers are discussed. It is pointed out that in some cases only one fibre property had been taken into account, which made the treatment rather imperfect as there is enough evidence to show that a complete explanation of the spinning value of a cotton cannot be given in terms of either mean fibre-length or fibre-strength. In other cases the differences between the cottons were comparatively small; the formula derived had thus a restricted range of applicability and even within this range it was not always found to yield satisfactory results. As a result of this discussion it was concluded that no very comprehensive investigation has so far been published dealing with the relation of a number of fibre-properties to spinning value of a cotton.

**Prediction of
Spinning
Value from
Fibre Pro-
perties.**

After describing the methods of tests and the technique adopted at the Technological Laboratory in dealing with this problem, the regression equation between the spinning value and the fibre-properties is given. This equation for 95 samples, which is the prediction formula referred to above, is as follows:—
 $X_1 = 71.6 \quad X_2 = 70.8 \quad X_3 = 20.8 \quad X_4 = 17.9 \quad X_5 = 0.037 \quad X_6 = 4.4 \quad X_7 = 14.1.$

In this equation

- X_1 = highest standard warp counts,
- X_2 = fibre-length, (in.),
- X_3 = fibre-weight per inch (in. 10^{-6} oz.),
- X_4 = ribbon-width, (10^{-3} inch),
- X_5 = fibre-strength, (oz.),
- X_6 = fibre-convolutions,
- X_7 = fibre-rigidity, (oz. in. $^2 \times 10^{-6}$).

It should be noted that the number of samples covered by this formula is much larger than has been the subject of other investigations. In order

to test the accuracy of this formula the highest standard warp counts as calculated from this formula and those by taking one or more fibre-properties into consideration are compared with those actually found from the results of the spinning tests. The result of such a comparison is shown below in a tabular form :—

TABLE 4.

Predicted values derived from Prediction Formula for—	Percentage of samples for which the actual highest standard warp count does not differ from the predicted by more than.	
	10 per cent.	20 per cent.
Length only	51	69
Weight per inch only	33	53
Length and Weight per inch	44	76
Length, Weight per inch and Strength	44	75
All six fibre-properties	49	80
No formula, i.e., the deviation of the individual results from the grand mean.	18	29

It will be seen that when both fibre-length and fibre-weight per inch are taken into consideration the prediction-formula agrees with the actual results within 10 per cent. in 44 per cent. of the cases and within 20 per cent. in 76 per cent. of the cases. The inclusion of fibre-strength or fibre-width does not improve the results at all, but a slight improvement is obtained if the six fibre-properties are taken into consideration, the percentage of cases for which the predicted agrees with the actual value to within 20 per cent. rising to 80. Though this slight improvement is statistically significant, it is not at all compatible with the extra time and labour spent in the determination of any properties beyond mean fibre-length and fibre-weight per inch.

The particular cases which gave pronouncedly anomalous results are considered and it is suggested that lack of agreement between the predicted and the actual spinning value in such cases may be due to the following factors :—

- (1) It is assumed that *all* the fibre-properties are linearly correlated with the spinning value ; this is certainly not the case with fibre-strength and fibre-rigidity.

(2) Only the average values of the fibre-properties have been used in this investigation; the degree of variability of each of these properties may also have an effect on the spinning value.

(3) Two cottons having the same hair-weight per inch may yet differ inasmuch as one cotton may have a large diameter with a thin cell wall and the other a small diameter with a thick cell-wall. Such differences would be revealed by maturity tests which were not made on these cottons.

(4) The cotton fibres of the yarn are not those which comprise the raw cotton on which hair tests are made.

(5) As regards the strength tests these measure the strength of the weakest point of the fibre. In the yarn, however, the strong as well as the weak parts of the fibre are subjected to tension.

In order to study the effect of the various fibre-properties on the spinning value of a cotton the total and partial correlation co-efficients between each of these properties and the spinning value were calculated. These are given below for the 95 samples:—

Number of cotton samples	95
Total Correlation between Highest Standard Warp Counts and—	
Fibre-length	+0.87
Fibre-weight per inch	-0.80
Ribbon-width	-0.69
Fibre-strength	-0.33
Convolutions	+0.46
Fibre-rigidity	-0.67
Partial Correlation Co-efficient between Highest Standard Warp Counts and—	
	(95 samples 5th order)
Fibre-length	+0.70
Fibre-weight per inch	-0.36
Fibre-width	-0.23
Fibre-strength	+0.10
Fibre-convolutions	+0.20
Fibre-rigidity	+0.06

The *total* correlation co-efficients do not distinguish between the inter-relationships between the various fibre-properties. Thus the total correlation

co-efficient between length and the highest standard warp counts may be high not only because of the direct effect of length on the spinning value but also because the long cottons, as a rule, are fine, and the fineness of cottons also play a part in determining the spinning value. In the *partial* correlation co-efficients, however, the effects of all other fibre-properties except the one under consideration is eliminated. Applying the statistical criteria we find that the partial correlation co-efficients between highest standard warp counts on the one hand and fibre-length and fibre-weight per inch on the other are both significant for odds of 1:100, while the others are insignificant. If the odds are lowered to 1:20, then the co-efficients for fibre-width and convolutions also become significant. Furthermore, we arrive at the extremely important result that for Indian cottons the influence of mean fibre-length on the spinning value is much more important than that of fibre-weight per inch. Thus W.L. Ball's view, based upon experiments with Egyptian cottons that "length is definitely less important than fineness" does not hold for the Indian cottons.

We have now completed the description of those investigations on which Technological Bulletins have been already published. In addition to these four other investigations have been completed on which bulletins will be issued in due course. These are as follows :—

(7) OTHER INVESTIGATIONS.

Fibre-strength Variation with Humidity. (i) *Variation of Fibre-Strength with Humidity.*—The fibre-strength of a cotton depends very largely upon the humidity of the atmosphere in which the tests are carried out. As the atmospheric humidity in Bombay ranges from about 30 per cent. R.H. to 80 per cent. R.H. and as the strength tests are made all the year round, it is necessary to have definite information as to the manner in which the strength of cotton fibres varies with humidity so that the necessary correction may be applied to the results of tests performed at different times of the year. For this purpose 5,000 fibres of Surat 1027 A.L.F. were tested for strength on the Magazine hair tester at humidities ranging from 40 per cent. to 75 per cent. R.H., the number of fibres broken at each humidity being 1,000. Side by side some strength tests were made on fibres taken from the outside and the inside of a bale to determine the effect of exposure to sunlight, air, moisture, etc., on the strength of cotton fibres.

Hair-weight Variation along a Fibre. (ii) *Variation in Hair-weight per Inch along the Length of a Fibre.*—It is stated on page 20 that the ordinary method of determining the hair-weight of a cotton, in which fibres are cut in 1 cm. lengths, is based upon two assumptions, namely, (1) fibre-weight per inch is the same for fibres falling in different length groups and (2) that the fibre-weight per inch does not vary appreciably along the length of the fibre. The validity of the first assumption was critically examined and the results of the investigation have already been described on page 20. A parallel investigation was undertaken to test the validity of the second assumption. For this purpose 36 standard Indian cottons, belonging to the two seasons, 1927-28 and 1928-29 were selected. The fibres were removed direct from the seeds in order to differentiate the basal from

the apical ends. The investigation was divided into two parts. In the first part the fibre tufts were mounted upon Baer Sorter combs and the longest and the modal fibres were drawn out. These were cut with a multiple cutter into four sections, each quarter inch long, and each section was weighed on a sensitive micro-balance. In the second part the unit fibre-weight of each of the 36 cottons was found, both by the cutting method and the whole fibre method, by weighing about 2,000 fibres of each cotton. A full account of this investigation will be published in due course, but it may be mentioned here that the assumption that the fibre-weight per inch does not vary appreciably along the length of the fibre was not substantiated by the results of these tests and since then this property has been determined at the Laboratory by weighing whole fibres.

(iii) *Variation of Fibre-Strength with the Length of the Fibre.*—With the Indian cottons the mean fibre-length is found to be more strongly correlated with the spinning value than any other property of the fibre, its weight per inch occupying the second place. Therefore, if the Cotton Breeders have to regard high spinning performance as the sole criterion for their improved types, they would be inclined to select on the basis of length and fineness of the staple. But the longer and finer cottons generally possess a weaker staple than the shorter and coarser ones, and, therefore, it is possible that by concentrating on length and fineness of staple, its strength may be sacrificed to some extent. Though the effect of fibre-strength on the spinning value of a cotton is often masked by other factors (these have been considered on page 26), it is clear from physical considerations that the strength of the fibres must ultimately make an appreciable contribution to yarn strength. The question therefore arises: What is the happy mean between length, fineness and strength of a staple which would give the best all round results? Furthermore, in the ordinary method of determining fibre-strength, the tests are made on 1 cm. length of the fibres. This has but little correspondence with the actual conditions prevailing in the yarn, where whole fibres are subjected to tension. Thus, in estimating the contribution of fibre-strength to yarn-strength, it would be highly instructive to know the strength of whole fibres falling in different length grades from which the weighted mean for the cotton can be calculated. In order to throw light on these two problems tests have been made on 7 Indian and 2 non-Indian cottons. In each case the fibres were sorted out into different length grades, the range of length for all cottons extending from 17/8" to 3/8". The fibres were broken on the Magazine hair tester of which the disc was suitably modified to permit the tests on the long fibres. On the average some 2,000 fibres were broken for each cotton.

**Hair-strength
Variation
with Length
of Fibre.**

(iv) *Chemical Analysis of Standard Indian Cottons.*—In order to study the effects of seasonal variation and soil factors upon the chemical constitution of the cotton fibre, the standard Indian cottons of four seasons, 1926-30, were analysed, and, in each case, the wax content, the nitrogen content, the phosphoric acid content and the ash percentage were determined. The moisture content of each sample was found prior to the analytical tests, so that the results could be expressed on dry weight of cotton. The wax content

**C h e m i c a l
A n a l y s i s.**

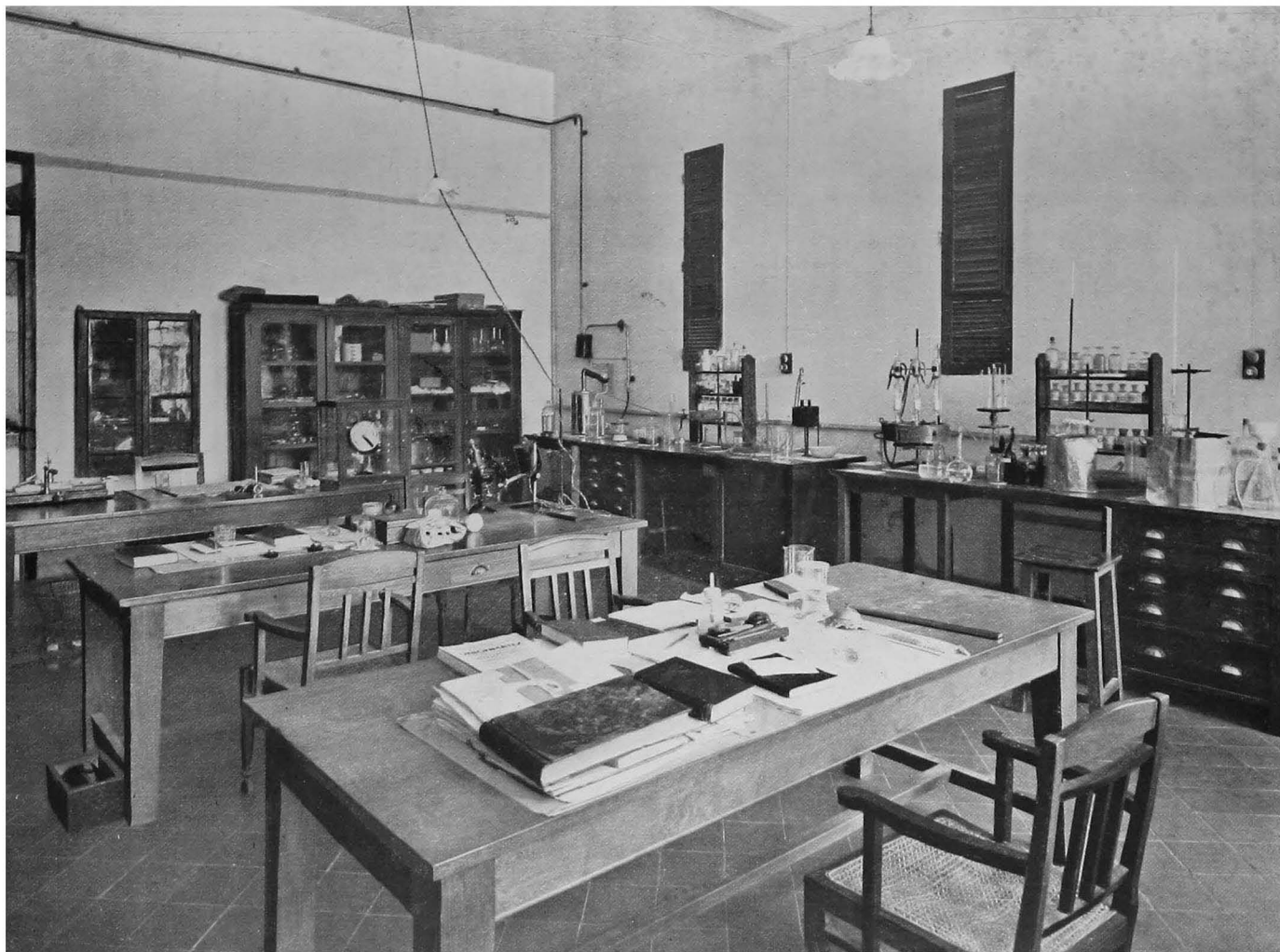
was determined by extraction with hot benzene, for nearly 6 hours in a Soxhlet apparatus. The percentage of nitrogen was found according to Kjeldahl's method. The amount of phosphoric acid was determined by dissolving the cotton in concentrated sulphuric acid and nitric acid, precipitating the phosphoric acid as ammonium phosphomolybdate, dissolving the washed precipitate in $\frac{N}{2}$ Na OH and titrating with $\frac{N}{2}$ H₂ SO₄. Finally, the ash content was found directly by burning a known quantity of the cotton in a platinum crucible, the process being continued until the weight became constant. The results of this investigation will be published in due course.

It may be opportune here to give a brief account of the other investigations undertaken in the Chemistry Section of the Laboratory. It has been mentioned on page 1 that soon after the Laboratory commenced work, the question of preventing the introduction of the nefarious boll-weevil into India from abroad loomed large on the horizon. It was absolutely essential to develop some method by which the possibility of such a catastrophe occurring could be entirely eliminated and the solution was found in the fumigation of the imported bales by hydrocyanic acid gas. It was necessary for this purpose to carry out systematic tests to find the doses which may be fatal to the weevils, the time for which cotton should be exposed to the action of the gas, the means by which the concentration of the gas may be measured from time to time to maintain it at the proper level, the effect, if any, of the gas on the quality of the cotton, and, finally, to translate these laboratory results into practical methods suitable for the fumigation of a large number of bales. All this work was done in the Chemistry Section, and a full account of it will be found in a *Memoir of the Department of Agriculture in India*, Vol. X, No. 5, 1928, by A. J. Turner and D. L. Sen.

Another problem of practical importance which was tackled in the Chemistry Section was the spontaneous combustion of cotton. There has been a persistent belief among some people that the fires which sometimes break out in cotton godowns are not due to any external agency, but are caused by the spontaneous combustion of cotton. Tests were made at the Laboratory in order to find out whether the opinion is supported by scientific evidence. An analysis of the various *possible* causes of spontaneous ignition shows that it may have its origin in the following:—

- (1) Liberation of inflammable gases due to bacterial decomposition of cotton cellulose, especially in the presence of excessive moisture.
- (2) Generation of heat due to the oxidation of unsaturated oils present in the cotton as impurity.
- (3) Production of sparks by the rupture of the hoops.

In order to test the first hypothesis small samples of cotton, containing 10 per cent., 20 per cent. and 27 per cent. moisture respectively were placed in flasks and sealed. Three sets of three flasks of each type were prepared; one



Chemistry Room.

set was exposed daily to the sun, the second was kept in the shade inside the Chemistry Room and the third set was heated daily for half an hour at 190° F. The gas in the flasks was removed each day and the flasks were resealed. It was observed that although fungoid growth set in after a few days in many of the flasks, yet all attempts to explode the gas collected from them were unsuccessful. This shows that the amount of gas generated by the bacterial decomposition of cotton when damp is so small as to be hardly a likely cause of spontaneous combustion.

With a view to testing the second hypothesis small bales of cotton of approximately the same density as the trade bales were prepared. The cotton in these bales was impregnated with different amounts of cotton seed oil, some of the bales being pressed dry, others containing varying amounts of water added to them. Two bales of each type were prepared and of the two sets thus obtained one set was placed in the open where it was exposed in the sun, while the other was kept inside the Chemistry Room. In a subsequent experiment three bales were placed under a heavy weight to reproduce so far as possible, the conditions of storage inside a cotton godown. The bales were left in this manner for several months, but no sign of any of the bales taking fire by itself was observed. Thus the results of these experiments as well run contrary to the belief in the spontaneous combustion of cotton.

No experiments were made to test the validity of the third hypothesis, but it may be pointed out that the hoops may be broken several times without once creating a spark. Thus although the possibility of a fire occurring in this way is not entirely absent, the chances that it will do so are extremely remote.

Another investigation carried out in the Chemistry Section is the effect of manurial treatments on the fibre-properties and spinning value of cotton to which a reference is made on page 41.

(8) MISCELLANEOUS.

We have now completed our description of the systematic investigations on the properties of cotton fibre and yarns undertaken at the Laboratory. In addition, three other Technological Bulletins, dealing with miscellaneous subjects, have been issued and these will now be briefly described.

(i) *Antiquity of Indian Cottons.*—

Technological Bulletin, Series B, No. 3.—“*A Note on the Early History of Cotton.*” By A. N. Gulati, M.Sc., and A. James Turner, M.A., B.Sc.—The work described in this Bulletin was done on extremely small pieces of fabrics and yarns which were unearthed during the excavations at Mohenjo-daro. These specimens of fabric and yarn were found adhering to some of the articles which saw the light of the day as a result of these excavations. Since the period of the Mohenjo-daro civilisation could be fixed fairly approximately from other sources as lying between 2500 and 3500 B.C. tests were made on these specimens to determine the nature of the fibre from which they were prepared.

**Early History
of Cotton.**

As might be expected these small pieces of fabrics and yarn, which had remained underground for nearly 5,000 years, were in an extremely tender and brittle condition. The tests were made on three specimens, the first being a minute fragment of fabric, one-tenth of an inch by three-tenths of an inch, very much tendered and adulterated, the second and the third being very small pieces of string. It was found that all these specimens were made from cotton; the fabric must have weighed originally 2 oz. to the square yard, and must have been prepared from 34's counts and contained 60 ends per inch and 20 picks per inch. One string proved to be a 24-fold cord composed of two cords each containing 12 strands of 18's counts and the other a 24-fold cord made by the twice doubling of 6-fold cords the count of each of the six single strands being 14's. These discoveries thus showed that the cultivation of cotton and the manufacture of yarns and fabrics from it must have reached a fairly high level in India as early as 3000 B.C. One of these samples was examined in considerable detail in order to ascertain how the properties of fibre of which it was made compared with the present day cottons, and if possible to assign to it a particular species of *Gossypium*. Owing to the very small size of the samples only tentative results could be drawn, and it was concluded that the cotton used was not of the *herbaceum* but of the *arboreum* type. The evidence was insufficient to identify it as anyone of the varieties into which the *arboreum* cottons have been classified. One of the cords referred to above was found to be dyed and a few tests made on the dye showed that it was probably of the madder type.

Cloth Sampling. (ii) *Selection of Warp Specimens in Cloth Sampling.*—

Technological Bulletin, Series B, No. 11.—“*Random and Systematic Selections of Warp Specimens in Cloth Sampling.*” By A. James Turner, M.A., D.Sc.—The object of this investigation was to compare the merits of systematic selection of warps in cloth sampling with random selection. It was admitted that random selection is theoretically more satisfactory than systematic selection, especially if periodicity occurs in a fabric, in which case erroneous results are likely to be obtained. However, reasons were advanced to show that the likelihood of disturbance due to periodicity is exceedingly small. On the other hand, the systematic method has the advantage of simplicity in marking out a fabric and the chances of mistakes being made in the marking out by this method are less than in the random method. Strength tests on warp specimens of three fabrics, two cotton and one linen, showed that random selection did not yield better results than systematic selection.

Cotton Research upto 1927: (iii) *Review of Work Done.*—

Technological Bulletin, Series B, No. 2.—*Research in Cotton Technology in India upto 1927.*—By A. James Turner, M.A., B.Sc.—This bulletin summarises the results of various investigations carried out at the Technological Laboratory upto 1927.

(iv) Manurial Experiments.—

It is well-known that in the cultivation of cotton crop on a commercial scale, the climatic factors are beyond human control while soil fertility can be improved to a large extent by the judicious application of suitable manures. The main function of applying manures is either to make up the deficiency of certain constituents in the soil or to neutralise others that are in excess, and thereby furnish the plant with all the essential elements in the right proportion needed for its germination, growth and nutrition. As the cotton plant readily responds to proper fertilisers, the effect of manurial treatment on the yield and quality of lint is of direct importance to grower and the consumer. With this end in view, tests on samples of cotton grown with different manures were carried out and a paper containing the results of these tests was read before the Indian Science Congress held in Bombay in January 1934. These results are summarised below :—

Effect of Manurial Treatment on the Yield, Fibre Properties and Spinning Value of a Cotton.—In the two successive seasons, 1928-29 and 1929-30, Cambodia cotton (*Gossypium hirsutum*) was grown in a number of plots in Coimbatore, each plot being given a different manurial treatment with the following fertilisers, namely, ammonium sulphate, potassium sulphate, superphosphate of lime and their mixtures. In each field, one plot was unmanured to give the control sample. It was found that the application of fertilisers either failed to produce any significant increase in yield or even produced a depressing effect when the soil in the field is already naturally rich. But when the soil is poor and deficient in substances necessary for plant nutrition, a heavy increase in yield is obtained by using these fertilisers. The results of the fibre and spinning tests showed that treatment with these fertilisers results in somewhat stronger and less neppy yarns if the soil fertility is originally low but that no such improvement is observed or even a negative effect may be produced when the soil is inherently rich. This result is of practical importance as indiscriminate use of fertilisers, without noticing the inherent soil fertility, may involve the agriculturist in additional expenditure without bringing him corresponding monetary return in the shape of higher yield or better quality lint. **Manurial
Treatments.**

(v) Field Experiments.—

Most of the Cotton Breeders in India are faced with the very difficult situation of solving the problems relating to their particular locality or cotton with limited field plots at their disposal for these experiments. Thus, the arrangement of the available plots for the field experiments with a view to solving the maximum number of problems with minimum number of replications, arrangement of plots, etc., is a matter of utmost importance to the breeders. In order to secure a higher standard of field experimentation and some measure of uniformity in varietal trials, the Advisory Board of the Imperial Council of Agricultural Research at their meeting held in February 1934 decided that the subject of the 'Layout of the Field Experiments'

should be considered by the Crops and Soils Wing of the Board of Agriculture. Accordingly, the following paper, in view of the importance of the subject, was sent for consideration by the Crops and Soils Wing of the Board of Agriculture :

Field Experiments. *The Application of modern methods of Field Experiments for improving the yield and quality of Agricultural Produce. By R. S. Koshal, M.Sc.—* The object of the paper was to show how field experiments can be arranged to give the maximum return for the labour and money spent on them. It is pointed out that the old methods of field experimentation were, to a great extent, defective due to improper layout of the plots. The modern methods, due to Dr. R. A. Fisher, are described at length, specially with reference to (i) effect of different manurial treatments on the yield and quality of a crop and (ii) the effect of weather on crops. Suggestions for conducting field experiments on a uniform basis with a view to getting comparable data are also given.

Two further papers, mainly of statistical interest were also published :

(i) *Application of the Method of Maximum Likelihood to the improvement of curves fitted by the Method of Moments by R. S. Koshal, M.Sc.*

(ii) *The effects of Rainfall and Temperature on Percolation through drain gauges by R. S. Koshal, M.Sc.*



Spinning Laboratory:

III. SPINNING TESTS AND TECHNOLOGICAL RESEARCH.

The spinning tests carried out at the Technological Laboratory fall under two heads:—

1. Routine tests.
2. Technological Research.

The routine tests are made on four types of samples, namely, (1) Agricultural samples, (2) Representative trade varieties, (3) Leaflets, and (4) Mill samples.

The work done under each head will now be described.

1. Routine Tests.

(1) AGRICULTURAL SAMPLES.

From the very outset one of the main functions of the Technological Laboratory was the testing of samples supplied by the Cotton Breeders and other Agricultural Officers engaged in the task of improving the quality of Indian cottons. It was recognised at an early stage that the results of these tests would be of very great importance to the agricultural officers as by themselves they could gather information only as regards the field characters of a cotton such as flower and boll shedding, yield per acre, ginning percentage, general stand of the plant, etc., etc., but they had no ready means available to estimate the spinning performance of the varieties evolved by them. In view of the fact, however, that their improved varieties would eventually come into the market and would depend for their further propagation on their acceptability to the spinners it was necessary that information should also be available with respect to the waste losses and the spinning performance of these cottons. Before the Indian Central Cotton Committee was instituted some of the Agricultural Departments had entered into arrangements with certain mills for the carrying out of tests on their improved varieties. Experience, however, had shown that, in actual practice, these arrangements did not work satisfactorily in all respects. The mills, which are primarily run for profit, could not be expected at all times either to set apart a portion of their machinery for experimental purposes or to devote the meticulous care and large amount of time necessary for obtaining accurate results. Even if they did so as a matter of courtesy, the conditions as regards temperature, humidity, details of treatment, etc., varied greatly not only from one mill to another but even in the same mill at different times of the year. As these factors have in many cases considerable influence on the spinning performance of a cotton, the results obtained for the same variety by different mills and even by the same mill at different times of the year may not be strictly comparable. Such arrangements, whereby the improved varieties of the Agricultural Departments are tested in the mills, have been tried in other countries and had to be dropped owing to the drawbacks mentioned above. For instance, spinning

tests were made on the Empire cottons at the various mills in Manchester for several years, some time back the Shirley Institute recognised the necessity of possessing their own spinning laboratory in which tests would be carried out under controlled and reproducible conditions. In the same manner, the Ministry of Agriculture, Egypt, had until recently sent samples of its new varieties to various mills in England and the Continent, but, realising the necessity and the advantages of laboratory tests, they have now added a new wing equipped with the spinning machinery to their Institute at El Giza where tests would be made in future on all the new varieties developed by the Cotton Breeders in Egypt.

(a) *New Varieties*.—The samples supplied by the Agricultural Officers for spinning tests came under several categories. The most important among these, as mentioned above, are the improved varieties on which a spinning test is required in order to estimate their performance and to compare it with the performance of the local cottons. It may not perhaps be out of place to mention that before one or two improved varieties can be finally selected, tests have to be made on a large number of samples from amongst which the most promising strains are retained by a process of elimination. The process usually starts by making fibre tests on a large number of small samples, out of which only those are retained for further multiplication and cultivation on a larger scale which, in addition to exhibiting the best field characters, also give the best fibre test results. When the selection is thus narrowed down to a reasonably small number, the selected varieties are grown in trial plots and the produce obtained is sent to the Laboratory for fibre and spinning tests. In view of the fact that cotton often shows great seasonal and environmental variation it is not safe to go by the results of tests carried out on the produce of one season or one locality only, but these tests have to be repeated in successive seasons and on samples grown at different places before any definite conclusions can be drawn. At the end of this period, the field characters, the fibre properties and the spinning performance of the various samples are analysed and compared and the variety which gave the best average results is finally selected. Among the cottons which have been tested at the Laboratory in this manner for several years, which have finally been selected for cultivation on a large scale, which have been received in the market and have proved acceptable to the spinner, mention may be made of Banilla, Jayawant and Verum 262. Banilla cotton is now being grown on 1,20,000 acres in Khandesh and, in spite of seasonal fluctuations, has given much better results than the local N. R. cotton which it replaced. Jayawant cotton, which was developed on account of its higher resistance to wilt as compared to Dharwar 1, is now being grown to the extent of about 40,000 bales of 400 lbs. each in the districts of Dharwar, Belgaum and Bijapur. Verum 262 and its further selections, Late Verum and V. 434, which are a great improvement on the Oomra cottons of Central Provinces and Berar, are now being grown on large areas and in a few years will change the entire aspect of the cotton crop in these Provinces. In all these cases, the cultivators have benefited to the extent of several lakhs of rupees by the replacement of the older and inferior types by the newer and improved varieties. It can be claimed without

any exaggeration that the selection of these cottons for large scale cultivation would have been extremely difficult, if not impossible, if fibre and spinning tests had not been carried out on numerous strains at the Technological Laboratory. In this connection, mention may also be made of 38F and 43F, which are further selections from the Punjab-American stock, and, in the course of the tests carried out during the last few years at the Laboratory have given much better results than the present-day Punjab-American cottons. From a consideration of these results it is expected that in the near future one or the other of these new types will be given out for general cultivation and will bring higher monetary return to the farmers. Similarly mention must be made of the tests carried out at the Laboratory on long staple varieties which are being tried at Sakrand. Some of these varieties, which are meant for cultivation in the new lands brought under cultivation by the completion of the Sukkur Barrage, are fully $1\frac{1}{4}$ " long and are capable of being spun into 60's carded yarns. These, when grown on a large scale, will go a long way in satisfying India's need for long staple cottons.

(b) *Field Experiments.*—In addition to tests on improved varieties the Laboratory also undertakes tests on samples supplied by the Cotton Breeders in connection with their various experiments which are undertaken with a view to obtaining information as regards the influence of various factors upon the quality of lint. This information is acquired mainly in the interest of the farmers to whom it is passed on when sufficient data are available. For instance, tests have been made at the Technological Laboratory on samples of the same cotton grown under conditions identical in all respects except that of amount and frequency of irrigation. The influence of water on the yield and the quality of cotton is well-known in a general way but it is necessary that definite information should be available for the different varieties to ascertain the particular treatment which would give optimum results. Accordingly, experiments were made in which, keeping other conditions similar, different amounts of water were applied at different intervals, and the results as regards yield, ginning percentage, fibre-properties and spinning performance were compared to find out which treatment gave the best all-round results. This information when available for a sufficient number of years to eliminate the seasonal effect should be of the highest importance to the cultivator. Similarly, experiments were made on the rotation of crops in which cotton was grown after various other crops to find out which particular rotation gives the best results as regards the yield, ginning percentage, fibre-properties and spinning performance. Information along these lines, too, should be of great material help to the cultivator. Again, tests have been made on the effect of different manures, both organic and inorganic, on the fibre-properties and the spinning quality of lint. Similarly the produce from plants affected by frost and attacked by boll-worm has been tested and results compared with those from healthy plants so that the extent of damage may be gauged and remedial measures may be taken by evolving varieties which mature early or can put up stouter resistance to the onslaught of pests, if the damage done is considerable. Similarly, tests have been made to ascertain the effect on the quality of lint of growing the cotton on ridges as against growing it on flat. The results of all these tests

on samples raised in connection with field experiments have not been published but have been supplied to the Cotton Breeders, who, no doubt, have made proper use of them by disseminating the information to the cultivators in their areas.

In addition to carrying out tests on samples received in connection with the various field experiments the Technological Laboratory has undertaken tests on well-established varieties of cotton with a view to finding out either the comparative merits of two varieties or the extent of variation in quality of any one variety. In regard to the former mention may be made of the large number of tests which were carried out on samples of Surat 1027 A.L.F. and 1A Long Boll grown in neighbouring plots in the different talukas of Gujarat to enable the Committee to decide its policy as regards cotton cultivation in Gujarat. In regard to the latter, mention may be made of the tests that have been made on Banilla cotton grown in different seasons in different parts of Khandesh in order to determine the extent of variation with respect to season and locality of growth.

As the activities of the Indian Central Cotton Committee expanded and its schemes in the Provinces multiplied the work of the Technological Laboratory in connection with the testing of agricultural samples steadily increased from the date of its inception. This will be seen best from the following table in which the number of agricultural samples tested at the Laboratory from year to year since 1924 are given, while these figures are represented graphically in Fig. 1.

TABLE 5.—*Number of Agricultural samples tested at the Laboratory during each year ending 31st August.*

Season.	No. of samples tested.
1924-25	46
1925-26	57
1926-27	81
1927-28	64
1928-29	117
1929-30	136
1930-31	212
1931-32	171
1932-33	318
1933-34	366

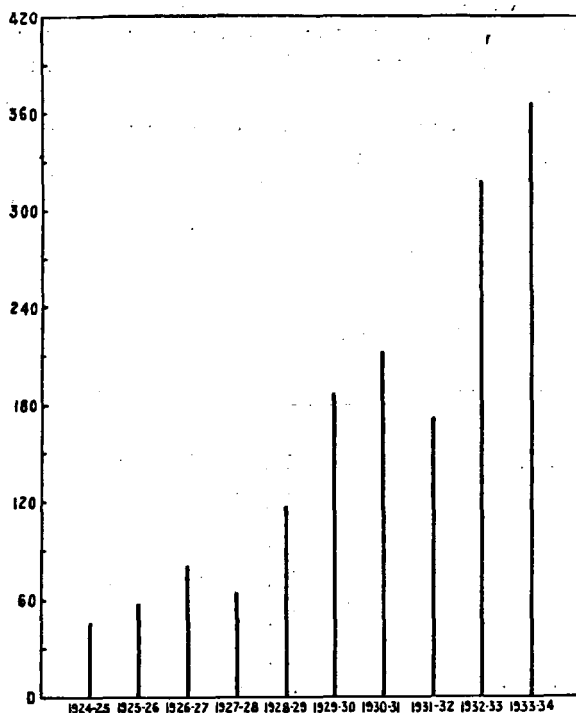


Fig. 1.—Number of Agricultural Samples.

It will be noticed from the above Table that beginning with 46 samples in 1924-25 the number of agricultural samples tested at the Laboratory rose to 186 in 1929-30 and to 366 in 1933-34. These figures speak for themselves and are clear proof of the reliance which is placed by the Cotton Breeders on the results of the Laboratory tests and their usefulness to the agricultural officers. The Laboratory has established its reputation in countries other than India and requests have been received from the Agricultural Departments of Uganda and Ceylon to subject their improved varieties to tests.

It should be mentioned in this connection that the Technological Laboratory does not merely perform the function of carrying out tests on samples supplied by the agricultural officers but goes one step further and often advises them with regard to the type of work on which experimentation may yield valuable results. Thus, experiments on the effect of different amounts of irrigation, to which a reference has been made above, were undertaken at various centres at the advice of the Technological Laboratory.

(2) REPRESENTATIVE TRADE VARIETIES.

In addition to tests described above the Technological Laboratory has undertaken for the last four years spinning tests on several representative trade varieties. These tests fall under two categories.

(a) In accordance with an arrangement entered into between the East India Cotton Association and the Indian Central Cotton Committee, tests have been made on samples of fair average quality of the chief trade varieties of the Indian cotton crop. The results of these tests are published for general information in 2-3 page technological circulars, which, besides the details of machinery and treatment, waste losses, spinning particulars, characteristics of yarns spun, etc., contain a valuation report on each sample furnished by the Standards Committee of the East India Cotton Association. The following list gives a description of the samples which are tested in each season under this head :—

List of samples supplied by the East India Cotton Association, Ltd., Bombay, for tests each year.

- | | |
|--------------------|-------------------------|
| 1. C. P. No. 1. | 14. Kadi-Viramgam |
| 2. Berar | 15. Westerns (Jhavaria) |
| 3. Khandesh | 16. Farm Westerns |
| 4. Nanded | 17. Compta |
| 5. Latur | 18. Upland (Gadag) |
| 6. Muttia | 19. Bijapur |
| 7. Punjab-American | 20. Bagalkote |
| 8. Broach | 21. Tinnevelly |
| 9. Jagadia Farm | 22. Cambodias |
| 10. Surat | 23. Karungannis |
| 11. Navsari | 24. A. R. Kampala |
| 12. Dholleras | 25. A. R. Busoga |
| 13. Kalagin | 26. A. R. Jinja |

(b) The second category relates to samples tested in accordance with the arrangements entered into between the Indian Central Cotton Committee on the one hand and the Bombay Millowners' and the Ahmedabad Millowners' Associations on the other. These tests are made on the first arrivals of the new crop of a season and are carried out with the maximum speed possible in order to give the necessary information to the mills regarding the performance of these cottons in each season. The results of these tests are also published for general information in the form of 2-3 page circulars on lines similar to

those for the East India Cotton Association samples, except that the valuation reports are furnished by mills supplying the samples. The following list gives a description of the samples tested under this head :—

List of samples received in accordance with the arrangements made with the Millowners' Associations of Bombay and Ahmedabad.

BOMBAY.

- | | |
|---------------------|-------------------------|
| 1. Bengals | 11. Nandyal |
| 2. Khandesh | 12. Northern Cambodia |
| 3. Central India | 13. Farm Westerns |
| 4. Moglai | 14. Westerns (Guntakal) |
| 5. Hubli Coompta | 15. Miraj |
| 6. Hubli Upland | 16. Surat |
| 7. Bailhongal | 17. Navsari |
| 8. Broach | 18. Tirupur |
| 9. Tirupur Cambodia | 19. African. |
| 10. Karunganni | |

AHMEDABAD.

- | | | |
|------------|---------|-----------|
| 1. Jagadia | 2. Kadi | 3. Bawla. |
|------------|---------|-----------|

These tests are made with two objects. In the first place they place in the hands of the trade and the industry, both in India and abroad, reliable information regarding the waste losses, spinning behaviour and spinning performance of a number of trade varieties which, as will be seen from the lists given above, are fairly representative of the cotton crop. Secondly, as these tests are performed on similar samples in the successive seasons, they enable the trade to find out if a particular variety of cotton is deteriorating or improving in the course of time. If it is found that a variety is going down in quality, the reasons for its deterioration can be investigated and remedial measures, if any, can be adopted. Thus, the results of these tests, taken over a number of years, can prove highly useful to the trade, as, in the absence of any authentic data, it may not be always possible to decide whether or not any particular variety is maintaining its quality.

As in the case of the agricultural samples the work of the Laboratory in connection with technological research and the testing of trade varieties has

steadily continued to expand from the date of its inception. This will be seen from the following table and graph which show the number of samples tested under these heads from year to year since 1924-25 :—

TABLE 6.—*Number of samples tested in connection with trade and special tests for each year ending 31st August.*

Season.	No. of samples tested.
1924-25	..
1925-26	38
1926-27	31
1927-28	46
1928-29	12
1929-30	37
1930-31	89
1931-32	134
1932-33	125
1933-34	166

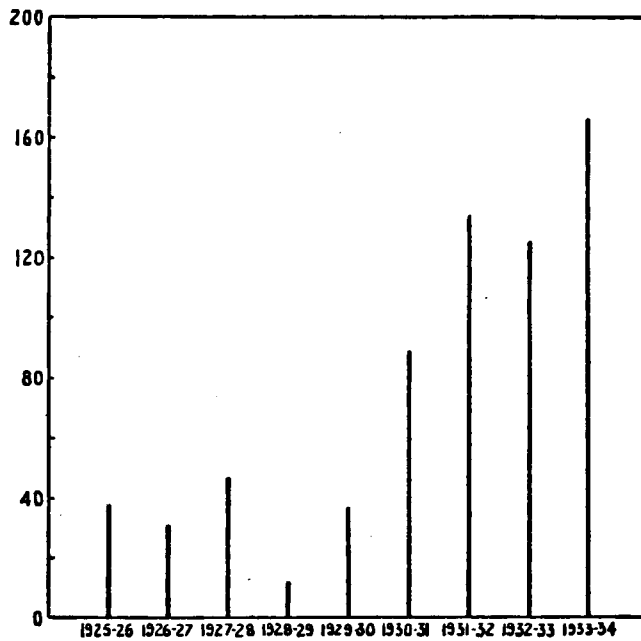


Fig. 2.—Number of Trade Samples.

Until recently the Technological Circulars issued by the Laboratory contained the results of tests on one season's cottons only. As most of the trade cottons are tested in the successive seasons, it was felt that the informative value of these circulars would be greatly enhanced if the results of the previous tests are also included in them. Accordingly, since 1932-33 the results for the previous seasons' cottons are also published. It is hoped that this would be helpful in revealing any deterioration or improvement in the quality of any one type with the lapse of time. It is gratifying to note that these circulars on trade samples are quoted widely in the English and Continental textile journals and supply the necessary information regarding the relative performance of Indian cottons to millowners in all countries.

Further, the opinions of the East India Cotton Association and the Millowners' Associations were invited last year on the desirability of publishing an annual bulletin containing the results of all the tests on trade samples. All agreed that such a bulletin would prove extremely useful and it has been decided to publish it from this year for the information and benefit of the trade and the industry.

(3) LEAFLETS.

In addition to the Technological Circulars four leaflets have been issued containing the results of such investigations as were regarded of special importance to the growers or consumers of cottons. Some of these leaflets were translated in the vernaculars and all were distributed on a large scale. These leaflets are as follows :—

1. Note on the Harmful Effects of adulterating Good Quality Indian Cottons.
2. Note on Green Stained Sind-American Cotton.
3. Blow-room Treatment in Relation to Leafiness in Cotton.
4. Blow-room Treatment for a long-Staple Cotton.

(4) MILL SAMPLES.

All the tests which have been described so far have been made free of charge in the interests of the Agricultural Departments, the trade or the industry, and the reports containing the results of these tests and investigations have been distributed either free or supplied at a nominal price. In addition, the Laboratory has undertaken, since 1932, fibre and spinning tests on samples sent by the mills and firms, in their private capacity, on payment of certain fees laid down by the Indian Central Cotton Committee. Every effort is made to give such information as is required by the mills and firms regarding their samples, but these tests are undertaken subject to the condition that they do not interfere with the normal work of the Laboratory. The fees charged for the various tests are as follows :—

SCALES OF FEES.								Rs. a.
(1) FIBRE OR YARN TEST :								
(a) Mean fibre-length	..	..	..	..	..	..	..	7 8
(b) Fibre-weight per inch	..	..	..	..	..	..	..	7 8
(c) Fibre-strength	..	..	..	..	..	..	..	10 0

	(d) Lea Test	7 8
	(e) Ballistic test	7 8
	(f) Single Thread Test	7 8
	(g) Twist	7 8
(2)	FIBRE & BLOW-ROOM TEST :	
	(a) Fibre tests as for (a)-(c) above.	
	(b) Blow-room only	10 0
(3)	FULL TEST :	
	(a) Fibre tests as for (a)-(c) above.	
	(b) Spinning test only	35 0
	(c) do. on combed cotton	50 0
(4)	VARIETY OF COTTON (BROAD CLASSIFICATION)	25 0
(5)	IDENTIFICATION OF FIBRE (MICROSCOPIC TEST)	15 0
(6)	PERCENTAGE OF SIZE	7 8
(7)	DO. GREASE	7 8
(8)	DO. FREE ACID	15 0
(9)	PRESENCE OF MILDEW	7 8
(10)	CAUSES OF MILDEW GROWTH	30 0
(11)	PERCENTAGE OF IMMATURE FIBRES :	
	(a) In lint or kapas	10 0
	(b) In yarn or cloth	15 0
(12)	WAX CONTENT :	
	(a) 1 Sample	12 8
	(b) 2 Samples	22 8
	(c) 3 Samples	30 0
	(d) Each additional sample	7 8
(13)	DETERMINATION OF MECHANICAL INJURY TO FIBRE	10 0
(14)	TESTS IN ADDITION TO THE ORDINARY 3 ROLLER SYSTEM (per system) ..	10 0
(15)	CLOTH SAMPLES :	
	(a) Actual counts	15 0
	(b) Actual twist	20 0
	(c) Single thread strength	20 0
(16)	MOISTURE TESTS :	
	(a) 1 Sample	5 0
	(b) 2 Samples	7 8
	(c) 3 Samples	10 0
	(d) 4 Samples	12 8



**His Excellency the Viceroy proceeding to the Spinning Laboratory
after visiting the Research Laboratory.**

2. Technological Research.

Although the work of testing the agricultural samples increased by leaps and bounds, the Technological Laboratory did not restrict its activities only to such samples, but realised the necessity of carrying out, on its own, technological investigations which may prove useful to the trade and the industry. These investigations cover a wide range of problems connected with the influence of various factors, outside and inside the Laboratory, on the spinning quality of a cotton. Among the factors prevailing outside the Laboratory may be mentioned (a) storage of kapas prior to ginning, (b) humidification of cotton before pressing, (c) different degrees of compression in a bale, (d) different types of ginning machinery, (e) variation in the moisture content of a bale with atmospheric humidity, etc., etc. As regards the factors prevailing inside the Laboratory and the different treatments in the blow-room and the spinning-room, the problems which have been investigated included (a) the effect of humidity and temperature on the spinning behaviour of a cotton, (b) the effect of repeated blow-room treatment, (c) the effect of different spindle speeds, (d) the effect of different twists and drafts in the fly frames, (e) different twists in the ring frame, etc., etc. In addition, tests have been made on standard Indian cottons and representative trade varieties which are available in fairly large quantities in the market. The results of these investigations are published in the form of Technological Bulletins, Series A, and hitherto 27 such Bulletins have been issued. In the following pages, these have been classified under various headings in order to show the type and the scope of the technological investigations carried out at the Laboratory. These will now be considered briefly :—

(I) TECHNIQUE OF SPINNING AND FIBRE TESTS.

Technological Bulletin, Series A, No. 1, "Explanatory Note on the Conduct of Spinning Tests in the Technological Laboratory, and Standard Cotton Tests Reports." By A. James Turner, M.A., B.Sc.

Technological Bulletin, Series A, No. 25, "Testing of Indian Cottons for Quality at the Technological Laboratory." By Nazir Ahmad, M. Sc., Ph. D.

Before any investigations could be undertaken on the spinning quality of Indian cottons it was necessary to describe the special technique which had been developed at the Laboratory for dealing with small samples. Two bulletins have been issued on this subject. The first one was published at the very outset and contained an account of the testing methods and the technique employed at the Laboratory. During the next 10 years this technique was perfected and considerable information had accumulated regarding the relative importance of the various fibre properties and yarn-characteristics and the most suitable methods for their determination. Accordingly, another Bulletin was issued on the subject in 1933 giving a detailed description of the spinning technique employed at the Laboratory and the various methods adopted for carrying out tests on cotton fibre and yarn.

**Technique of
Spinning &
Fibre Tests.**

(2) PHYSICAL CONDITIONS INSIDE THE LABORATORY.

The Effect of Humidity and Temperature Conditions inside the Laboratory.

Technological Bulletin, Series A, No. 4, "The Effect of Temperature and Humidity on Cotton Spinning, with particular reference to conditions in Bombay. By A. James Turner, M.A., B.Sc.

Technological Bulletin, Series A, No. 10, "Further Tests on the Effect of Temperature and Humidity on Cotton Spinning." By A. James Turner, M.A., B.Sc.

**Effect of
Temperature
& Humidity
on Spinning.**

Before the technological research and the routine work of the spinning laboratory could be pushed forward, it was necessary to carry out a systematic investigation to determine the particular conditions of humidity and temperature which would give optimum results. The influence of these two factors was investigated with regard to the comfort of the workers, workability of the cotton and the appearance and strength of yarns. The complete investigation was carried out in two parts. The first series of tests led to the laying down of standards of tests for optimum results in the work of the Laboratory, brought out in a definite manner the effect of low humidities and high temperatures on the strength and appearance of yarns and the workability of cotton and gave the necessary information regarding the limits to which humidity must be raised and temperature lowered if troubles are to be avoided in the processing of the material and satisfactory results are to be obtained with respect to the appearance and strength of the yarns. The detailed information contained in this Bulletin should prove invaluable to up-country mills as it would give them the precise knowledge regarding the temperature and humidity conditions which must prevail if optimum results are to be obtained, at a minimum cost, in respect of satisfactory processing of material, strength and appearance of yarn and comfort of workers. Conditions other than these, either above or below the necessary limit, would entail economic loss in one form or another. From the second series of tests the important conclusion was drawn that although coarse counts may be spun at fairly low humidities, it is necessary to raise the humidity for the spinning of counts higher than 40's, if bad spinning troubles are to be avoided. Another conclusion drawn from these tests which should be specially mentioned is that while the yarns spun under various conditions of temperature and humidity may be similar in evenness and neppiness, yet these may differ widely in their appearance, as for instance, the yarns spun under the hot-dry conditions are very oozy indeed, full of snarls, and exceedingly crimp, while the yarns spun under high and moderately high humidity are free from these defects.

(3) PHYSICAL CONDITIONS OUTSIDE THE SPINNING LABORATORY.

The object of the investigations carried out under this head is to determine the effect on the spinning quality of a cotton of such conditions as may prevail either before baling the cotton or between baling and its

receipt at the Laboratory. Several problems have been investigated under this head but the one of which the results have already been sent up for publication is the effect of storage of kapas on the spinning quality of a cotton :

(i) *Storage of kapas prior to ginning.*

Technological Bulletin, Series B, No. 19, "Effect of Storage prior to Ginning on the Spinning Quality of Cotton." By Nazir Ahmad, M.Sc., Ph. D., F. Inst. P. **Storage of kapas.**

The need for carrying out this investigation arose in the following way : In certain parts of the country the opinion is held that beneficial results accrue from storing kapas for a period of 4-6 weeks prior to ginning, the idea underlying being that during the storage the development of the fibre continues and that some of the oil oozes out from the seed into the fibre, thereby improving its lustre and spinning quality. These views which are often repeated in books and articles on cotton, if substantiated by experiment, should be of considerable economic value to the cotton grower. Accordingly, three Punjab cottons were selected for the purposes of this investigation and samples were obtained from the same kapas heap, one sample of each cotton being ginned immediately after picking and the other after 4 weeks' storage. The results of this investigation show that there is no truth in the statement that the development of the fibre either in length or cross-section continues during the period of storage nor there is any truth in the statement that oil oozes out from the seed into the fibre making it soft and pliable. Thus, the results of this investigation do not support the view so often advanced by various people that the storage of kapas has any beneficial effect upon the spinning quality of a cotton. At the same time it was pointed out in the Bulletin that the storage of kapas, especially if it is picked in a dirty condition and stored in a damp place without due regard to ventilation and sun drying, may adversely affect the quality of lint as a result of the growth and activity of the cellulose destroying micro-organisms. It was therefore concluded that as, on the one hand, the risk of deterioration is large and, on the other, no corresponding benefit is conferred in the form of an improvement in the fibre properties or the spinning quality of the cotton, the most desirable course would be to gin the kapas immediately after picking.

Other problems which have been investigated under this head are as follows :—

(ii) *The effect of using different speeds and settings in the gins on the fibre properties and spinning quality of a cotton.*—For this purpose 8 Indian cottons representing short, medium and long staple varieties were selected and, in each case, the kapas was divided into 2 portions which were ginned respectively on a single roller gin and a saw gin. The scope of the investigation was extended by employing different knife roller settings in the case of the two roller gins and different speeds in the case of the saw gin. The objects of this investigation are to find out the effects of different knife roller settings in the roller gin and different speeds in the saw gin on the fibre properties and spinning quality of each of the 8 Indian cottons. **Different gin speeds and settings.**

Artificial Humidification. (iii) *The effect of artificial humidification before pressing the bales on the quality of cotton.*—For this purpose, three lots of the same cotton were damped with different quantities of water, thoroughly mixed and pressed into bales which were stored for some time in the Laboratory to allow the water to bring about its deteriorating action on cotton. Samples were drawn at regular intervals from these bales and subjected to fibre and spinning tests.

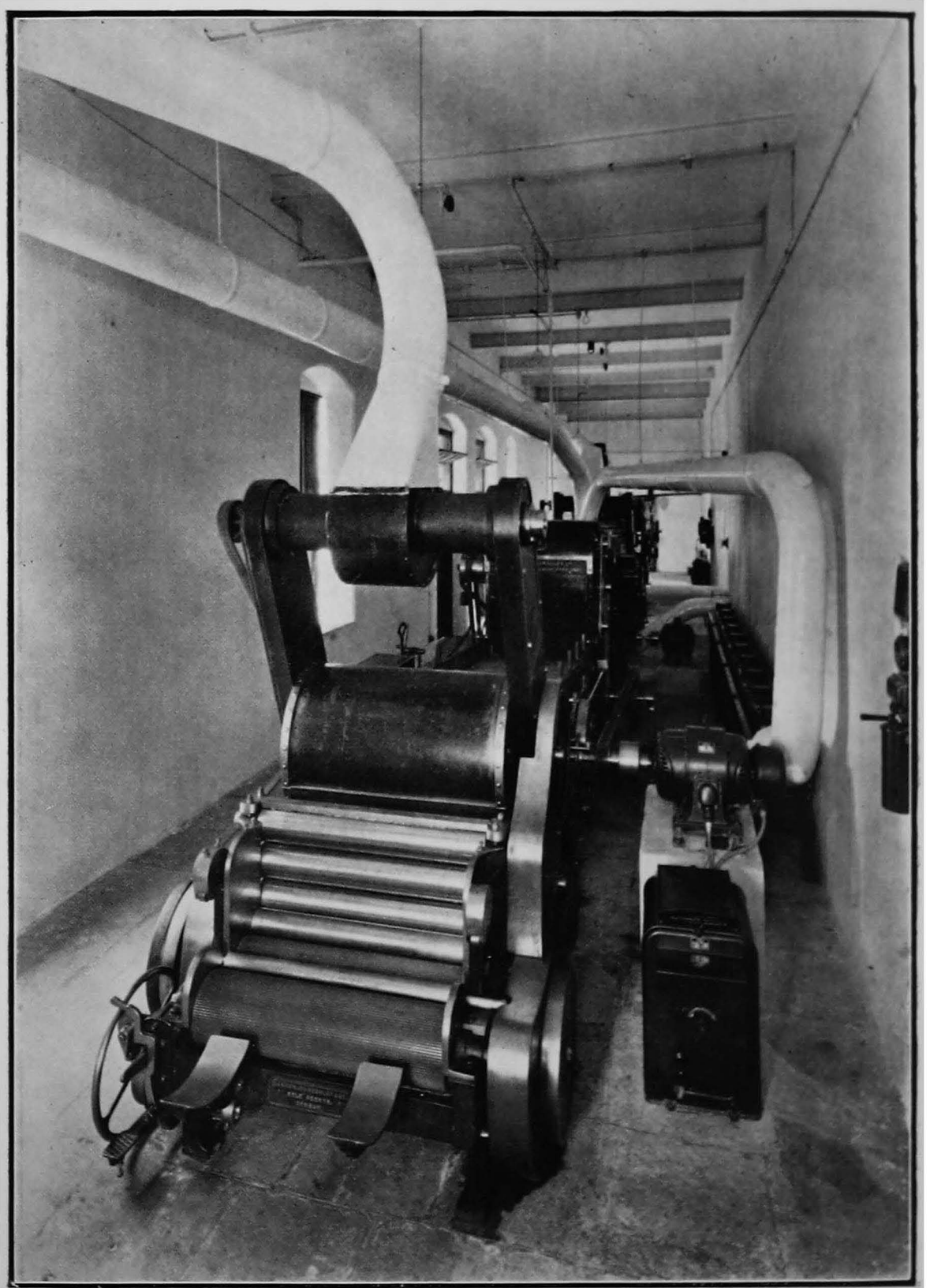
Deterioration of Broach cotton. (iv) *The deterioration of Broach cotton with time.*—This problem was undertaken at the request of the East India Cotton Association in view of the opinion held by many cotton merchants that Broach cotton deteriorates rapidly on storage than other types. The matter was referred to the Agricultural Department of the Bombay Presidency and it was decided that before any selection work could be undertaken to evolve a type which would stand the test of time better it was necessary to ascertain whether the deterioration takes place only in the colour of the cotton or also in its fibre strength and spinning quality.

The investigations (i)-(iii) have either been completed or are nearing completion and as usual an account of each will be published in the form of a technological bulletin as soon as possible.

Storage in open and in godown. (v) *Comparison of the effect of storage in the open and in a shed at Karachi.*—Unlike Bombay the Karachi Cotton market possesses very few covered godowns and the cotton bales, for the most part, are kept, prior to disposal, in the open in the thole yard where they are exposed to the action of sea air, rain, salt and infection-carrying pests. The Karachi market has made rapid strides during the last few years and a very large number of bales are received there for export from the Punjab and Sind. The question, therefore, has been raised: What exactly is the extent of the deterioration suffered by the bales stored in the open in comparison to those stored in a godown. It is clear that an answer to this question is necessary before a decision can be arrived at as to whether the construction of a sufficient number of godowns would repay in the form of higher premia for the cottons stored in these godowns. Accordingly, this investigation has been undertaken at the request of the Karachi Cotton Association. For this purpose 6 bales each of the three varieties, Punjab-desi, Sind-desi and Punjab-American which are mainly received in the Karachi market were purchased. Three bales of each variety were kept inside a shed and the other three outside in the thole yard. Samples drawn initially from each of the 18 bales were, on the one hand, subjected to fibre and spinning tests and, on the other, valued by expert graders. At the end of 6, 12 and 18 months samples were again drawn from one bale of each variety kept in the open and inside the godown, and were subjected to similar tests and valued by expert graders for change in colour.

(4) PROCESSING OF COTTON AND TESTS ON INDIAN COTTONS.

A large number of problems have been investigated under this head and the results of these investigations have been published in the form



New Blow Room from the South end.

of Technological Bulletins. The object of each investigation and the chief conclusions drawn from the experimental results will now be described briefly.

(i) *Blow-room treatment*—

Technological Bulletin, Series A, No. 5.—The effect of subjecting cotton to repeated blow-room treatment. By A. James Turner, M.A., B.Sc. **Repeated Blow-Room Treatment.**

It was noticed that some of the cottons tested at the Laboratory contained much foreign matter such as leaf and seed coat, which could not be entirely eliminated by the normal blow-room treatment given to these cottons. As a result the yarns obtained from these cottons contained a certain amount of dirt and leaf which detracted from their appearance. Apart from cleaner picking and better ginning, the only obvious way of obtaining clean yarns is to subject these cottons to a severe blow-room treatment. It was, however, felt that this course could not be adopted without first making an investigation to ascertain whether such a treatment in the blow-room would not damage the fibre, thereby resulting in weaker or less even yarns. Accordingly experiments were made on three Indian cottons which contained large quantities of foreign matter. These cottons were given 2, 3 and 4 treatments in the crighton and 3, 4 and 5 passages in the scutcher. The results of these tests show that 3 or 4 treatments in the crighton opener as compared with the normal two treatments yield very small increase in the total waste for each additional treatment and that the extra treatments made very little difference either to the behaviour of the cotton in spinning or to the strength or appearance of the yarns spun from it. The effect of additional scutching was found to be very similar to that of additional crighton opening. It followed from these results that although no serious damage was done to the fibre yet the degree of improvement in the cleanliness of yarns resulting from repeated blow-room treatment was very small and therefore there was clearly an upper limit to which a dirty cotton could be cleaned in this manner. Hence the remedy for obtaining cleaner yarns lay in cleaner picking and better ginning as it was found that the leaf bits and seed coats which are embedded in the cotton are very difficult to remove by repeated blow-room treatment. It was pointed out that the conditions of experiment in the blow-room of the Laboratory differed somewhat from those obtaining in the mills where, owing to lack of uniformity in the flow of cotton, intermediate accumulation in the crighton opener may take place resulting in some damage to the cotton staple.

(ii) *Spindle Speeds.*

Technological Bulletin, Series A, No. 7.—The effect of different spindle speeds on the results of spinning tests. By A. James Turner, M.A., B.Sc. **Different Spindle Speeds.**

In the initial stages of tests at the Technological Laboratory comparatively low speeds were used in the spinning of various counts from 20's to 40's. Later on, it was desired to raise the spindle speeds to bring them in greater conformity with the modern mill practice which aims at greater production. Moreover, on account of the great diversity of cotton samples received for tests at the Laboratory, it was frequently necessary to vary spindle speeds in order

to avoid excessive yarn breakages in the ring frame. The question therefore arose as to whether the change in the spindle speeds might render invalid a comparison of results between two cottons spun at different speeds. Accordingly, an investigation was undertaken on 8 Indian cottons using low spindle speed of 8,600 r.p.m. for all counts on the one hand and the relatively higher speeds of 8,900 r.p.m., 9,550 r.p.m. and 9,950 r.p.m. for 20's, 30's and 40's counts respectively. An analysis of the results showed that within the comparatively narrow limits of these tests the higher spindle speeds made no difference whatever to the number of ring frame breakages or to the strength, extension, evenness and neppiness of the yarns. It was, therefore, concluded that so long as the counts of yarns spun are well within the spinning capacity of a cotton, there is every justification for using higher spindle speeds but that if the cotton is being spun near its spinning limit, an increase of spinning speed would cause increase in the number of yarn breakages both because of the greater unevenness of the finer count and also because of its greater weakness. The greater unevenness of the yarns spun at higher speeds is mainly caused by excessive vibration of the machinery which would cause instability of the spindles and irregular movement of the rollers in their necks. It was further pointed out that in addition to the effect on yarn characteristics and the wear and tear of machinery run at excessively high speeds the human factor must also be taken into consideration as at such speeds more yarn breakages occur than can be pieced by the tenter resulting in the production of larger amounts of waste.

(iii) *Balanced and unbalanced drafts.*

Unbalanced and Balanced Drafts. *Technological Bulletin, Series A, No. 8.—The effect of using unbalanced drafts instead of balanced drafts in the spinning preparation for spinning tests. By A. James Turner, M.A., B.Sc.* Owing to the large number of yarns spun in connection with the tests on cottons carried out at the Technological Laboratory the practice was adopted of preparing only one set of rovings for three different counts which were obtained by suitably changing the drafts in the ring frame. The result of this practice was that whereas the draft for one count was balanced, those for the other two counts were unbalanced. If balanced drafts had been aimed at for all the counts spun from a cotton by preparing three sets of rovings of different hank numbers not only the time involved would have been exceedingly large, but the chances of mistakes being made in each of the preparatory machines would have been correspondingly greater. The question therefore arose what difference, if any, does the use of unbalanced instead of balanced drafts make to the results of tests when a cotton is spun into three different counts from the same hank roving. In order to ascertain the extent of this effect, 8 Indian cottons were spun into three counts each with balanced drafts on the one hand and unbalanced drafts on the other. An analysis of the results shows that the difference in the system of drafting made very little difference to the number of breakages in the ring frame or to the evenness, neppiness, strength and extension of the yarn. It was concluded from these results that a comparatively wide variation is possible in the series of drafts used in the spinning tests without affecting the results to any appreciable extent, thereby justifying

the procedure adopted at the Technological Laboratory for spinning three different counts from one set of rovings. In a theoretical discussion, appended to the Bulletin, the effects of various factors such as the fluting of the bottom drafting rollers, the clinging power of the cotton, and the irregularities of length and thickness of the fibre which may influence the irregularity in the yarn, were examined in their relation to the particular problem of balanced and unbalanced drafts and it was concluded that there is no adequate reason to expect appreciably different results from the two systems of drafts employed in these tests.

(iv) *Passage in the drawing frame.*

Technological Bulletin, Series A, No. 11.—The effect of using either one head or two heads of drawing instead of three heads of drawing in the spinning preparation for spinning tests. By A. James Turner, M.A., B.Sc. The process of drafting which causes a certain amount of irregularity is closely connected with that of doubling which tends to reduce the major inequalities in the material arising from the lack of uniformity in the scutcher lap. This is, however, effective only when the number of ends doubled is approximately equal to the draft—a state of affairs which prevails only in the drawing frames. In the subsequent stages the draft employed in the fly frames and the ring frame is so much greater than the number of ends doubled that inequalities due to drafting cannot be compensated for by doubling. Therefore, as by doubling in the drawing frame we can only hope to smooth out the major inequalities of the card sliver, the question arises—how many heads of drawing should be employed? This investigation was undertaken to ascertain the effect of employing one, two or three heads of drawing on the spinning behaviour of a cotton and the characteristics of the yarn spun from it. For this purpose, 8 Indian and 2 American cottons were selected and subjected to tests. The results of these tests show that, whether the card sliver was subjected to one, two or three heads of drawing, it made little difference to the number of yarn breakages sustained in the ring frame. It was found, however, that the yarns of two and three heads of drawing were somewhat stronger than those of one head of drawing but that the difference between the yarns of two and three heads of drawing was extremely small. The results of this investigation therefore justified the practice adopted at the Technological Laboratory of using only two instead of three heads of drawing. It is, however, pointed out in the bulletin that the card sliver used for drawing in these tests was the production of a single card and that if, as in mill practice, card slivers from a number of cards were to be fed to the first head of drawing, the results would be affected to the extent of the differences between the different card slivers. This effect, therefore, would have to be allowed for in applying the results of these tests to mill practice.

One, Two
or Three
Heads of
Drawing.

The investigations which have been briefly described above were mainly concerned with the different aspects of the spinning technique employed at the Laboratory. They were in the nature of spade work and were necessary in order to ascertain how far this technique was justified by the results of actual

tests and in what directions modifications were indicated. The ground was now ready to undertake investigations of a somewhat different type, namely, the spinning quality of Indian cottons and the effect thereon of different treatments in the card-room. One of the first problems to be investigated under this head was the spinning of mixings of cottons using the ordinary and different systems of high draft spinning. Hitherto two bulletins have been issued on this subject, and the following account gives a brief summary of the scope of the investigations and the general conclusions drawn from the results:—

(v) *Ordinary and High Draft Systems of Spinning.*

High Draft systems on mixings of Indian and American. *Technological Bulletin, Series A, No. 15.—Preliminary spinning tests of mixings of Indian and American cottons using the ordinary and high draft systems. By R. P. Richardson, A.T.I., and A. James Turner, M.A., D.Sc.* For the purpose of this investigation two cottons were selected, namely, C. P. Wun (Indian) and Texas (American). Each cotton was first spun separately on four different systems, viz., (1) single roving, ordinary draft; (2) double roving, double draft, ordinary frame; (3) and (4) double roving, double draft, on two different systems of high draft spinning. Mixings of the two cottons in varying proportions were prepared and spun into suitable counts, with two different twists, on the four systems mentioned above. In addition, a further test was made in which yarns were spun on the high draft systems direct from single intermediate roving prepared from a mixing containing 50 per cent. American and 50 per cent. C. P. Wun. From an analysis of the results the following conclusions were drawn:—

(1) There is no difficulty in spinning a mixing of two cottons differing in staple length by $\frac{1}{8}$ ", when they have approximately the same fibre-weight per inch.

(2) On a good high draft system it is possible to spin as good a yarn direct from intermediate roving as from ordinary roving on the ordinary system.

(3) By spinning from double roving and using double draft on a high draft system it is possible to obtain a yarn of decidedly higher quality than that produced on the ordinary system, with at least as high a rate of production.

(4) Using a mixing containing equal quantities of suitable American and Indian cottons, it is possible to spin on a high draft system a 20's yarn equal in quality to similar yarn spun from American cotton alone, with no loss in production and a considerable saving in the cost of the mixing.

High Draft systems on mixings of Indian cottons. *Technological Bulletin, Series A, No. 19.—Application of different systems of high draft spinning to mixings of Indian cottons. By R. P. Richardson, F.T.I., and Nazir Ahmad, M.Sc., Ph.D.* In this investigation the two cottons selected were both Indian, namely,

Cambodia Co.1 and C.P. Wun which differed not only in staple length but also in fibre-weight per inch. The scope of the tests was enlarged by employing three different systems of high draft spinning and by using the ordinary system fitted with (a) band drive and (b) tape drive arrangements for the spindles. Besides the spinnings on the ordinary system the two cottons and the mixings from them in different proportions were spun, with two different twists, from double hank roving and from intermediate roving on each of the three high draft systems. The counts spun in these tests extended from 10's to 36's and the drafts employed ranged from 5.15 to 15.38. As the quality of the mixing improved these were spun into finer counts which were so selected that two out of the three counts were common to two contiguous mixtures. This procedure made it easy to compare at one and the same time the behaviour of the two mixtures and the relative merits of the various high draft systems. The analysis of the experimental data was preceded by a short discussion on the principal causes responsible for producing irregularity in the structure of yarn and the part played by the physical and chemical properties of the fibre during the process of drafting. It was concluded from this discussion that cottons possessing long and fine fibres are capable of withstanding the disturbing effects of long drafts to a much greater extent than those possessing short and coarse fibres. The main conclusions drawn from an analysis of the experimental results are as follows :

(1) There is no difficulty in spinning yarns from mixings of two cottons differing by as much as 40% in fibre-weight per inch and one-fourth inch in staple length. It will be noticed that this conclusion as well as the one drawn from the results of the preceding investigation run contrary to the commonly accepted view that it is not feasible to spin a mixture of cottons possessing appreciably different fibre-properties. The results of these two investigations show that considerable latitude is permissible in the choice of two cottons which can be mixed together and spun without any serious difficulty into suitable yarns.

(2) Twist as an aid for reducing yarn breakages in the ring frame is most effective when short staple cottons are spun in ordinary system and least so when comparatively long staple cottons are spun in any of the three high draft systems.

(3) Yarns spun on high draft systems are invariably more even than those spun on the ordinary system. Among the latter spinning from double roving, double draft, gave the most uneven yarns, while the tape-drive yielded, on the whole, more even yarns than the band drive arrangement.

(4) Double roving, double draft on the ordinary system should preferably be employed with finer mixings as, with coarser mixings, this system gave weaker yarns than single roving, ordinary draft.

(5) Yarns spun from intermediate roving on the high draft systems compared very favourably with those spun from ordinary roving on the

ordinary system, although they do not come up to the level of those spun from double roving on the high draft systems.

(6) The percentage differences inlea-breaking strength of yarns spun on the high draft systems and the ordinary system diminishes rapidly as the quality of the mixing improves. Thus, the high draft systems were found to be more effective in raising yarn strength with coarser than with finer mixings.

(7) One of the three high draft systems employed in these tests was decidedly inferior to the other two systems. Among the latter, one system gave definitely better results than the other in the coarser counts though in the finer counts there was nothing much to choose between the two systems.

(8) Increase in yarn strength resulting from inserting higher twist is greatest when short staple cottons are spun of the ordinary system. Coupling this result with the one relating to the decrease in the number of yarn breakages in the ring frame it is concluded that the binding effect of twist on fibres is most pronounced when short cottons are spun on the ordinary system.

(vi) *Effect of twist.*

Effect of Twist. *Technological Bulletin, Series A, Nos. 17.—Limit spinning tests on Cambodia and Mollisoni cottons. By R.P. Richardson, A.T.I., and A. James Turner, M.A., D.Sc.* The next problem to be investigated was the effect of twist in increasing the strength of yarns spun from a cotton. In the case of most yarns spun at the Laboratory three twist multipliers (namely, 3.75, 4 and 4.25) are ordinarily used. It was, however, clear from the very outset that much higher yarn strengths could be obtained or, alternatively, the cottons could be spun into much finer counts, by employing higher twist multipliers. Accordingly, the behaviour of two standard cottons, Cambodia and Mollisoni, spun with twist multipliers ranging from 3.75 to 5.0 was investigated and the results described in the above-mentioned bulletin. From an analysis of these results the following conclusions are drawn:—

(1) Cambodia Co. 1 may be spun from carded single roving up to 52's without too frequent bad spinning troubles, provided a twist constant of not less than 4.5 is used, and even up to 60's with a twist constant of 5. The yarn at these limiting counts, however, is very weak and very uneven. Mollisoni cannot be spun above 8's counts if bad spinning troubles are to be avoided, and, even at this count, the twist constant employed must not be less than 4.5.

(2) The influence of twist on yarn evenness is practically negligible, but, for a given twist constant, the unevenness of yarn increases with the fineness of count. In the case of Cambodia, the lea-count strength pro-

duct for a given count increases with the twist multiplier until the latter attains the value of 4.25 or 4.5 after which the strength falls. In the case of Mollisoni, however, the lea-count strength product continues to increase right up to a twist constant of 5.0.

(3) The yarn extension, both for Cambodia and Mollisoni, gradually decreases as the count becomes finer, but for a given count, increases as the twist increases.

(vii) *Effect of Combing.*

Technological Bulletin, Series A, No. 27.—Combing of Good Quality Indian Cottons. By R. P. Richardson, F.T.I., and Nazir Ahmad, M.Sc., Ph.D., F. Inst. P. Combing of
Indian
cottons.

The next problem to be undertaken was to explore the possibilities of spinning good quality Indian cottons into fine counts after subjecting them to the combing process. The need for carrying out this investigation was indicated, on the one hand, by the growing tendency in textile manufacture to spin finer counts, and, on the other, by the steady improvement in the quality of the Indian cotton crop. For the purposes of this investigation, four Indian cottons, namely, Punjab-American 289F, Cambodia Co. 1, Surat 1027 A. L.F. and Nandyal 14, which possess longer staple than the others, were selected. These were combed to the extent of 20% and 30% and the combed material was spun on the ordinary system and a high draft system in counts ranging from 50's to 80's. Besides this, the carded material was also spun for purposes of comparison on both the systems in counts ranging from 30's to 40's. The comber wastes from these cottons were mixed, in the proportion of 1 : 3, with four comparatively short staple Indian cottons, namely, Punjab-American 4F, Karunganni, Wagad and C. P. No. 1 and the mixtures were spun into coarse counts in order to investigate the possibilities of utilising the comber wastes. From an analysis of the experimental results the following conclusions are drawn :—

(1) The mean fibre length of the combed material for each of the four cottons was either equal to or only slightly higher than that of the carded material. Contrary to expectations, therefore, the combing process did not bring about a large increase in the mean fibre-length of any of these cottons.

(2) The combing process, however, was remarkably effective in reducing the fibre-length irregularity of each of these cottons. The improvement in this direction was most pronounced in the case of the cotton which needed it most.

(3) The 20 per cent comber waste was in each case found to be about 15 per cent shorter than the cotton from which it was extracted. Its fibre-length irregularity, however, was independent of the cotton, being nearly the same in each case.

(4) The hair-weight per inch of the combed material was, in each case, very nearly equal to, or a little higher than, that of the carded material, depending upon the botanical variety of the cotton.

(5) Yarn breakages in the ring frame were, on the whole, less on the high draft than on the ordinary draft, making it possible to spin finer counts on the former system.

(6) The process of combing considerably reduced, though did not completely eliminate, neppiness in cottons and was most effective in the case of such cottons as ordinarily gave rise to very neppy yarns.

(7) Yarns obtained from the mixtures of the comber waste and the short staple cottons are in each case more neppy than those spun from the pure cottons.

(8) Combing good quality Indian cottons to the extent of 20 per cent made a very considerable improvement in their spinning performance so that it was possible to spin 50's and 60's yarns from cottons which are ordinarily regarded suitable for spinning up to 30's warp. The response to the combing treatment, however, was different for the different cottons and it was found that for these four cottons at least the percentage improvement in spinning value followed the order of the mean fibre-length of the cottons.

(9) In practically all cases the high draft system yielded stronger yarns than the ordinary system, the increase in strength being more pronounced in the case of some than in that of other cottons.

(10) In the case of three cottons, the beneficial effects of (1) combing to the extent of 20 per cent and (2) spinning on the high draft system, were found to be additive, while in the fourth case, in which the effect of the 20 per cent combing alone was very large, such was not the case.

(11) Whereas combing to the extent of 20 per cent raised the spinning capacity of these cottons by a very considerable amount, combing to the extent of 30 per cent did not in all cases confer a benefit commensurate with the extra loss of 10 per cent fibres. The use of the higher degree of combing may not, therefore, prove an economic proposition in all cases.

(12) The yarns spun from 20 per cent combed cotton on the high draft system were nearly equal in strength to those obtained from 30 per cent combed cotton on the ordinary system. Thus, it would be more economical to comb the cotton to the extent of 20 per cent and employ a high draft system than to push combing to the extent of 30 per cent and use the ordinary system.



Spinning Room.

(13) Taking the results of the fibre and the yarn tests together, it is clear that the main causes for the very considerable improvement in the spinning capacity of a cotton conferred by the combing process must be sought in factors other than a mere increase in fibre-length, these factors being principally a more regular disposition and greater length uniformity of the fibres in the combed material.

(14) Employing a special technique no difficulty was experienced in spinning yarns from mixtures of the combed wastes and the low quality cottons. In three cases out of four, the yarns spun from the mixtures were somewhat weaker than, while in the fourth case they were equal in strength to, those obtained from the pure cotton.

The investigations which have been briefly described in the preceding pages are those on which Technological Bulletins have already been issued. In addition, another four investigations have been undertaken under this head. The experimental work in connection with these has been completed and the results are being analysed for publication. These are as follows :—

(viii) *The effect of using balanced and unbalanced drafts on mixings prepared from Indian cottons.*—It has been mentioned on page 58 that the investigation on the effect of using balanced and unbalanced drafts showed that considerable latitude was permissible in the choice of drafts in the ring frame without affecting, to an appreciable extent, either the spinning behaviour of the cotton or the appearance and strength of yarns spun from it. These experiments were, however, made on pure cottons. In view of the fact, however, that it is rather the exception than the rule for mills to use pure cottons for their spinning preparations, it was felt desirable to extend the scope of this investigation by carrying out similar tests on mixings prepared from Indian cottons. Accordingly, mixings of varying proportions were prepared from Cambodia Co. 1 and Wun, Kampala and Surat 1027 A.L.F., Punjab-American 4F and Punjab-American 289F and yarns were spun from rovings of suitable hank numbers employing balanced and unbalanced drafts. These yarns ranged in counts from 10's to 50's while the variation in unbalanced drafts was from 4.5 for 20's to 9.0 for 40's, the corresponding variation in the balanced drafts being from 5.8 for 20's to 7.2 for 40's.

Balanced and Unbalanced Drafts on Mixings of Indian Cottons.

(ix) *The effect of employing different roller settings in the fly frames.*—Owing to the large number of samples tested at the Technological Laboratory, it has not been possible frequently to alter the roller setting intervals in the fly frames in accordance with the commonly accepted notions regarding the relationship of this factor with the staple length of the cotton. In order to meet the ever growing demand on the resources of the Laboratory, some standards of roller setting intervals in fly frames had to be adopted at the very outset. In view of the fact, however, that cottons tested at the Laboratory cover a wide range of fibre properties, it was thought desirable to undertake a

Different Roller Settings.

systematic investigation on the effect of different roller settings in the fly frames on the spinning behaviour of a cotton and the strength and appearance of yarns spun from it in order to ascertain the most suitable roller settings for each of the three types of Indian cottons, namely, short, medium and long staple. The three cottons selected for this purpose were Surat 1027 A.L.F., Punjab-American 4F and K. 22 and each of these cottons was spun into two suitable counts with roller settings in the fly frames and the ring frame varying from 1/16" to 3/16" gauge. Tests on the yarns included lea breaking strength, ballistic work of rupture, single thread and extension besides determination of yarn evenness and yarn neppiness.

Further Work on High Draft Spinning. (x) *Further work on the application of high draft systems of spinning to Indian cottons.*—It has been mentioned above that hitherto two bulletins have already been issued on the use of high draft systems as against the ordinary system of spinning as applied to Indian cottons. Since the last bulletin on the subject was issued the Technological Laboratory acquired three new systems of high draft spinning and it was thought desirable to make further tests in which the new systems were also included. For this purpose spinning preparations were made from Superfine Oomra, P.A. 4F, and mixtures of these two cottons, Cambodia Co.2 and its mixtures with P.A. 4F and Superfine Oomra. These were spun on the ordinary system from single and double hank rovings and on the six high draft systems from double hank roving and from intermediate rovings.

Different Twists in Ring Frames. (xi) *The effect of employing different twists in the ring frames.*—It has been stated on page 62 that an investigation was carried out to explore the possibilities of spinning Indian cottons into much higher counts than usual by inserting higher twists in the ring frame. This work has now been extended by making tests on two other cottons, namely, Superfine Oomra and P.A. 4F. The former cotton was spun into counts ranging from 8's to 16's while the latter was spun in counts ranging from 20's to 36's, the twist multipliers used in these tests varying in a graded manner from $3\frac{1}{2}$ to $5\frac{1}{2}$.

Tests on Standard Indian Cottons. (xii) *Standard cottons and other varieties*—A large number of tests have been made on Indian cottons with a view to determining their fibre properties and spinning performance. Principal among these are the tests carried out at the Laboratory on Standard Indian cottons. These cottons are, for the most part, improved types which are being grown on a steadily increasing scale in different parts of India. Many among them were evolved by the Agricultural Departments and were maintained in a pure state in order to serve as standards of reference for new strains and for samples raised in connection with the agricultural experiments. The Standard cottons tested at the Laboratory have been so selected as to include a few cottons from each of the major cotton growing provinces and also to represent the chief botanical varieties of the Indian cotton crop. The following list gives the distribution of these cottons according to the Provinces, the season in which they were first tested

at the Laboratory and the area under cultivation for the latest season available in each case :—

LIST

Cotton.	Season in which the cotton was first tested at the Laboratory.	Area under cultivation (acres).
BOMBAY :—		
Jayawant (Kumpta)	1926-27	1,38,140
Gadag 1 (Dharwar-American)	1923-24	69,420
Surat 1027 A.L.F.	1923-24	2,34,700
Wagad 8 (Dholleras)	1925-26	800
PUNJAB :—		
Punjab-American 4F	1924-25	7,13,500
Punjab-American 289F	1924-25	31,140
Mollisoni (Bengals)	1925-26	7,27,560
UNITED PROVINCES :—		
Aligarh A. 19 (Bengals)	1924-25	49,430
C. 402 (U.P.)	1931-32	3,460
CENTRAL PROVINCES AND BERAR :—		
(a) Verum 262 (Nagpur)	1926-27	89,560
(b) Verum 262 (Akola)	1927-28	
HYDERABAD STATE :—		
Umri Bani	1924-25	9,25,560
MADRAS :—		
Cambodia Co. 2	1924-25	47,000
Nandyal 14 (Northern)	1923-24	3,300
Hagari 1 (Western)	1924-25	2,00,300
Karunganni C7	1924-25	17,000

Each year these cottons have been subjected to a thorough examination for their fibre-properties; they have been spun in duplicate lots into suitable counts, and the chief characteristics of the yarns have been accurately determined. The objects of carrying out these detailed tests in these cottons are as follows :—

(i) Since these cottons include improved varieties from all the major cotton growing Provinces of India and are themselves grown under nearly

as identical conditions as possible, the results obtained serve as a scale of reference. The performance of either trade varieties or agricultural samples can be compared with that of the Standard cotton grown in the locality.

(ii) As the tests are repeated season after season, they afford an excellent means for the study of seasonal variation in the fibre-properties and spinning performance of these cottons. This study is valuable in two ways. In the first place it gives definite information regarding the average quality of the Standard Indian cottons and the maximum variation we may expect in any one season. In the second place since the standard cottons have been selected with an eye to the geographical distribution of the commercial crop, variation in their quality would reflect to a certain extent the variation in the quality of the commercial crop due to seasonal factors.

(iii) The third purpose served by these tests is to provide data for the correlation of fibre properties of a cotton with its spinning performance. The importance of this line of investigation and the main results already achieved have already been discussed on page 33.

(iv) The fourth object of these tests is to place in the hands of the trade detailed information regarding these cottons which now cover nearly 15 per cent of the area under cultivation in India.

The results of the tests carried out on these cottons are published annually in the form of a Technological Bulletin entitled 'Technological Reports on Standard Indian Cottons.' Besides the results of the fibre and spinning tests, this bulletin contains information on the following points: a brief history of each cotton, the districts of growth, sowing dates and growing period, soil characteristics, rainfall, temperature, plant particulars, yield of seed cotton, ginning percentage and area under cultivation. Each of these bulletins thus constitutes a hank book on the Standard cottons and may be used with advantage by the merchant, the spinner and the agricultural officer.

(xiii) *Punjab Cottons*.—Besides the tests on standard Indian cottons which have so far been described in ten bulletins, the following Technological Bulletins dealing with tests on other Indian cottons have been issued.

Punjab Cottons, 1928-29. *Technological Bulletin, Series A, No. 13.—Technological Report on samples of Punjab-American and Mollisoni (Desi cotton) grown in different parts of the Punjab in 1928-29 by A. James Turner, M.A., B.Sc.* This bulletin contains an account of the results of tests carried out on six samples of P.A.4F, four samples of P.A. 289F and four samples of Mollisoni grown in different parts of the Punjab in 1928-29.

(xiv) *Banilla Cotton.*

Technological Bulletin, Series A, No. 16.—Technological Report on Banilla Cotton, 1924-30, by A. James Turner, M.A., D.Sc. Beginning with 1926-27, when the seed of Banilla cotton was first given out for general cultivation, the area under its cultivation steadily increased in successive seasons until in 1930-31 it stood at 100,000 acres. During these years numerous tests were made on samples of this cotton grown mostly at the experimental farms at Dhulia and Jalgaon. The results of these tests were collected together in the above-mentioned Bulletin in order to bring out the seasonal and environmental variation in the fibre properties and the spinning quality of this cotton. For purposes of comparison, the results of tests carried out on the Local N. R. cotton, which was replaced by Banilla cotton, were also included in this Bulletin.

Banilla,
1924-30.

Technological Bulletin, Series A, No. 22.—Technological Report on Banilla, 1930-32, Cotton, by Nazir Ahmad, M.Sc., Ph.D. Mention has been made above of the bulletin issued on samples of Banilla cotton. It was stated therein that these samples were mostly grown on the Government Experimental Farms at Dhulia and Jalgaon. In view of the fact that the Banilla cotton had spread all over Khandesh, it was thought desirable that fibre and spinning tests should be made on samples of this cotton grown in the districts in order to ascertain the variation in its quality due to environmental and seasonal factors. Accordingly, tests were made on 19 samples grown in 1930-31 and 6 samples grown in 1931-32 in different parts of Khandesh. From the results of these tests the following conclusions were drawn :

Banilla
1930-32.

The average values of mean fibre-length and fibre-weight per inch for the 1930-31 crop are 0.73" and 0.180×10^{-6} oz., while the average performance of the Banilla crop corresponds to 14's standard warp counts. In the same season, the fibre-properties and the spinning performance of Banilla cotton, grown in different parts of Khandesh, show considerable variation. Similarly, the samples grown at the same place in the two successive seasons, did not always give similar results. On the whole, samples grown in East Khandesh gave better performance than those from West Khandesh, while samples grown in neighbouring villages of the same Taluka were generally found to be very nearly equal in performance.

(xv) *Mixings.*

Technological Bulletin, Series A, No. 20.—Spinning tests on mixings of long staple and short staple Indian cottons, by Nazir Ahmad, M.Sc., Ph.D. The general practice in the mills is to mix two or more varieties of cotton for their spinning preparations. The important point, however, to be noted in this connection is that, in the choice of cottons for these mixtures, the uniformity of each type is assumed and the spinner mixes them in the proportions best suited to his purpose. If he is asked to work with growths of dubious character and quality, his calculations would be upset and the results obtained by him would, in many cases, fall short of expectations. In certain cotton growing districts in India the practice prevails of adulterating a better type of

Mixings.

cotton with an inferior type. This practice is not only unwelcome to the mills, but, in the long run, gives a bad name to the district as a result of which its reputation suffers and even its good produce does not fetch sufficient premia, thereby inflicting monetary loss on the farmers. The investigation described in this bulletin was undertaken in order to bring out the harmful effects of adulterating good quality cottons with inferior types. For this purpose mixtures in varying proportions were prepared from P.A. 289F and Mollisoni, P.A. 4F and Mollisoni, and Karunganni and Pullichai. The results of these tests show that, in all cases, the practice of mixing a superior variety with an inferior type impaired the quality of the yarn even if the proportion of the short staple cotton was relatively small. The number of yarn breakages in the ring frame were found to mount up, the yarns became progressively less even and in one case (P.A. 4F and Mollisoni) they were considerably more neppy than those spun from either of the two pure cottons. It was found that in some cases the diminution in yarn strength was phenomenal. In other cases, where the fibre properties of short staple variety differed considerably from those of the long staple variety, the diminution in yarn strength was found to be both regular and continuous. From the results of the tests the rule was formulated that an increase of 10 per cent. in the proportion of the short staple variety pulled down the highest standard warp counts of the mixture by 3 units. This rule should be useful either for inferring the spinning performance of a mixture of known composition or for estimating the composition of a given mixture, if the performance of one of its components is known.

IV. EXHIBITS.

At its meeting held in July 1931, the Indian Central Cotton Committee decided that sets of exhibits from standard Indian and certain other improved varieties of cottons should be prepared at the Technological Laboratory. One set was prepared at the request of the Imperial Council of Agricultural Research and was exhibited in the World's Grain Exhibition and Conference held in July-August 1933 in Regina, Canada. Another set was prepared for the Directors of Agriculture who can send it to the Agricultural Fairs and Exhibitions held in the country as the occasion demands.

It was suggested by the Indian Trade Commissioner in London, that the Indian Central Cotton Committee should send some exhibits of Indian cottons to be shown at the Cotton Exhibition at the White City, London. This was approved by the Committee and a large number of exhibits consisting of Baer-Sorter patterns, halo-length patterns, card-slayers, yarn bobbins, yarn knots, etc., were prepared at the Laboratory from six Standard cottons and sent to the Trade Commissioner.

Exhibits were also prepared for the office of the High Commissioner for India for purposes of display in the Samples Room of India House, London.

V. MOISTURE CONTENT OF INDIAN COTTONS AND ALLIED PROBLEMS.

Owing to its hygroscopic properties a certain amount of moisture is always associated with cotton at ordinary humidities and temperatures. This may be called the "natural" moisture content of cotton, though it should not be inferred that cotton has not the capacity to absorb, and even to retain for some time at least, moisture in excess of its 'natural' moisture content. It frequently happens that, over and above its natural moisture content, water is deliberately added to cotton, usually before it is pressed into a bale. The origin of this practice lies in the belief that a certain *minimum* percentage of moisture in the cotton is necessary for the satisfactory operation of baling it, and that if the atmospheric humidity conditions prevailing at the factory are such that the 'natural' moisture content of the cotton is less than this minimum, then the deficiency must be made up by adding a certain quantity of water to it. Whether this belief is founded upon fact or fancy is problematical; certain it is that the practice of prehumidification is sometimes carried too far and that cotton is damped to such an extent as to suffer in quality. This is mainly brought about through the agency of cellulose-destroying micro-organisms, which multiply rapidly in a damp atmosphere. If they are left undisturbed in conditions favourable to their growth they stain the cotton badly and render its fibre weak and brittle. It must be remembered in this connection that even if the *average* moisture content of a pre-humidified bale is not very high, it will contain numerous patches with localised over-damping, which will form suitable breeding places for these micro-organisms. The result of the disruption of fibres will be an increase in the waste losses of the cotton and a decrease in the strength and regularity of the yarns spun from it. Apart from it the indiscriminate damping of cotton is not fair to the buyer who has to pay for the elusive water at the market rate of cotton—a payment which often represents a vanishing quantity especially if the bale is subsequently stored in a less humid atmosphere. Thus, the amount of water in baled cotton and its influence on the quality of lint are matters in which both the merchant and the spinner are deeply interested.

The Indian Central Cotton Committee at its meeting held on 15th--16th December 1930, decided that a beginning should be made by the Technological Laboratory by undertaking moisture tests on different varieties of Indian cottons. It was felt that the results of these tests, so far as they relate to the trade bales, as received in the Bombay market, would prove invaluable in laying down standards of moisture content applicable to Indian cottons and thereby curbing the malpractice of watering the cotton. The East India Cotton Association placed two rooms in the Cotton Exchange, Sewri, at the disposal of the Laboratory for this work. These were converted into a Moisture Testing Section and were equipped with two electrically heated conditioning ovens and other necessary apparatus. The work of testing

Indian cottons for moisture commenced on the 29th January 1931 and upto date no less than 742 samples have been tested. All these tests have been carried out by Mr. D. L. Sen.

The samples on which moisture test determinations have been made fall under the following categories :—

(a) *Trade Bales.*—These tests were carried out with a view to ascertaining the mean moisture content of the different trade varieties, its variation with the time of the year and the average percentage of moisture in the Indian cottons as received in the Bombay market. For this purpose the firms were requested to give Mr. Sen facilities for drawing samples from their bales to which they very kindly agreed. Furthermore, in view of the marked effect on the moisture content of a bale of (1) the humidity at the pressing factory, (2) the period of storage in Bombay and (3) the humidity during this period, they were asked to supply information regarding the date of pressing of the bale and the place at which it was pressed. The approximate humidity at the pressing factory could then be inferred by referring to the weather reports issued by the Meteorological Office, Poona, while the average humidity prevailing at Sewri during the period of storage was known from the readings of a continuous thermo-hygrograph. In addition to the Indian cottons, some tests were also made on Egyptian, American and African cottons for purposes of comparison. The total number of samples falling in this class is 328.

(b) *Appeal Committee samples.*—These samples were sent for tests by the Appeal Committee of the East India Cotton Association to ascertain how the moisture content of cotton which appeared damp in the survey compared with that of the ordinary trade bales. Hitherto, 51 samples belonging to this class, have been received and tested.

Summary of Results.—The following table gives a distribution of the 379 samples falling in these two classes and the average results obtained :

TABLE 7.

Description of Cotton.	No. of samples tested.	Average moisture content per cent.	Moisture regain per cent.
Indian	338	6.40	6.86
Egyptian	18	7.34	7.94
African	14	7.49	8.10
American	9	8.35	9.10

The moisture content, in each case, is calculated on the initial weight of the cotton.

The following table gives the results in a more detailed form, in which the moisture content and the moisture regain (calculated on the bone dry weight of the cotton) have been shown for the various types on which these tests were performed.

TABLE 8.

Description of cotton.	No. of samples tested.	Average.		Moisture regain per cent.	
		Moisture content per cent.	Moisture regain per cent.	Maximum.	Minimum.
Punjab	24	6.26	6.69	8.20	4.73
Kumpta	49	6.57	7.05	9.31	4.81
Madras	35	6.98	7.52	10.51	4.46
Western	11	6.50	6.96	8.55	6.18
Khandesh	10	5.49	5.82	8.20	4.48
Broach	32	5.61	5.95	7.83	4.51
C. P.	36	5.48	5.81	8.10	4.13
Berar	26	6.27	6.70	8.07	4.77
Hyderabad (Moglai) ..	20	6.86	7.39	9.56	4.82
Kathiawar	12	6.71	7.21	9.42	5.07
Surat	1	7.85	8.52	..	..
U. P.	3	7.45	8.04	8.37	7.59
Sind	3	6.81	7.31	8.54	6.32
Mysore	4	7.01	7.55	8.76	6.55
Indore	2	6.13	6.63	6.75	6.30
UNSPECIFIED SAMPLES :—					
(a) Appeal Committee ..	51	6.65	7.15	9.85	5.09
(b) Trade samples ..	19	7.05	7.58	9.42	5.86
Egypt	18	7.34	7.94	10.42	6.12
Africa	14	7.49	8.10	9.75	6.16
America	9	8.35	9.10	9.95	8.22

(c) *Specially pressed bales.*—As at least some of the trade bales could not be free of the suspicion of pre-humidification, it was necessary, in order to fix the minimum moisture percentage, to make tests on bales pressed under known condition which precluded the possibility of damping the cotton. Accordingly 40 bales, of various varieties, were pressed either under the direct supervision of a member of the staff of the Laboratory or at a reliable factory and the humidity and temperature prevailing at the factory at the time of pressing each bale were noted. From the time of their receipt in Bombay to the time of drawing the samples a continuous record of humidity and temperature was maintained and the moisture determinations were carried out on five or ten samples drawn from the different parts of each bale.

(d) *Technological Bulletin, Series A, No 23.—Variation of Moisture Content of Baled Indian Cotton with Atmospheric Humidity, by Nazir Ahmad, M. Sc., Ph.D.* The percentage of water in a bale of cotton depends upon the atmospheric humidity which varies over a fairly wide range in Bombay. Now, the results of the moisture tests described above are, strictly speaking, valid only for the particular humidity at which the tests are carried out. In view of these reasons it was necessary to ascertain exactly the manner in which the moisture content of different trade varieties of Indian cottons responded to changes in humidity so that the maximum variation is known for making due allowance for the humidity factor. For this purpose one bale each of Bengals and Broach were stored in one of the cotton godowns, Sewri, and weighed once a week for over a year on a platform balance. Similarly, one bale each of Berar and Broach were kept in a room in the Cotton Exchange Building and were weighed once a week for the same period. A continuous record of the temperature and humidity prevailing in both the places was maintained. Furthermore, a fifth bale—one of Berar cotton—was stored in the Laboratory, and the hourly variation in its weight and the changes in the humidity and temperature were recorded, on the same chart by means of a device especially made for this investigation. This experiment was repeated in two seasons, 1930-31 and 1931-32; with this difference that in the latter season the three bales—one each of Bengals, Berar and Broach—were stored in a cotton godown only. At the end of the period of observations, samples were drawn from different parts of each bale and their moisture contents were determined. The results of this investigation have been described in *Technological Bulletin, Series A, No. 23* from which the following important conclusions are reproduced:

**Moisture
Content
Variation
with At-
mospheric
Humidity.**

(1) The rate of absorption of moisture by a bale, depends, to a very large extent, upon the amount of moisture already held by it. As its thirst for moisture is gradually satisfied, it becomes more and more sluggish in picking up additional moisture, even when the prevailing humidity is fairly high. If it is left in an atmosphere of any given humidity for a sufficient length of time, equilibrium is established between the atmosphere and the bale; it becomes fully saturated with moisture and its weight remains stationary so long as the humidity does not change. In practice, owing to the constant fluctuations in atmospheric humidity such a state of affairs is more the exception than the rule.

(2) If, owing to a large change in the atmospheric humidity a bale of cotton is picking up or losing moisture at a high rate, a short-lived change in humidity in the opposite direction produces but a small effect on the trend or rate of absorption or loss of moisture by the bale.

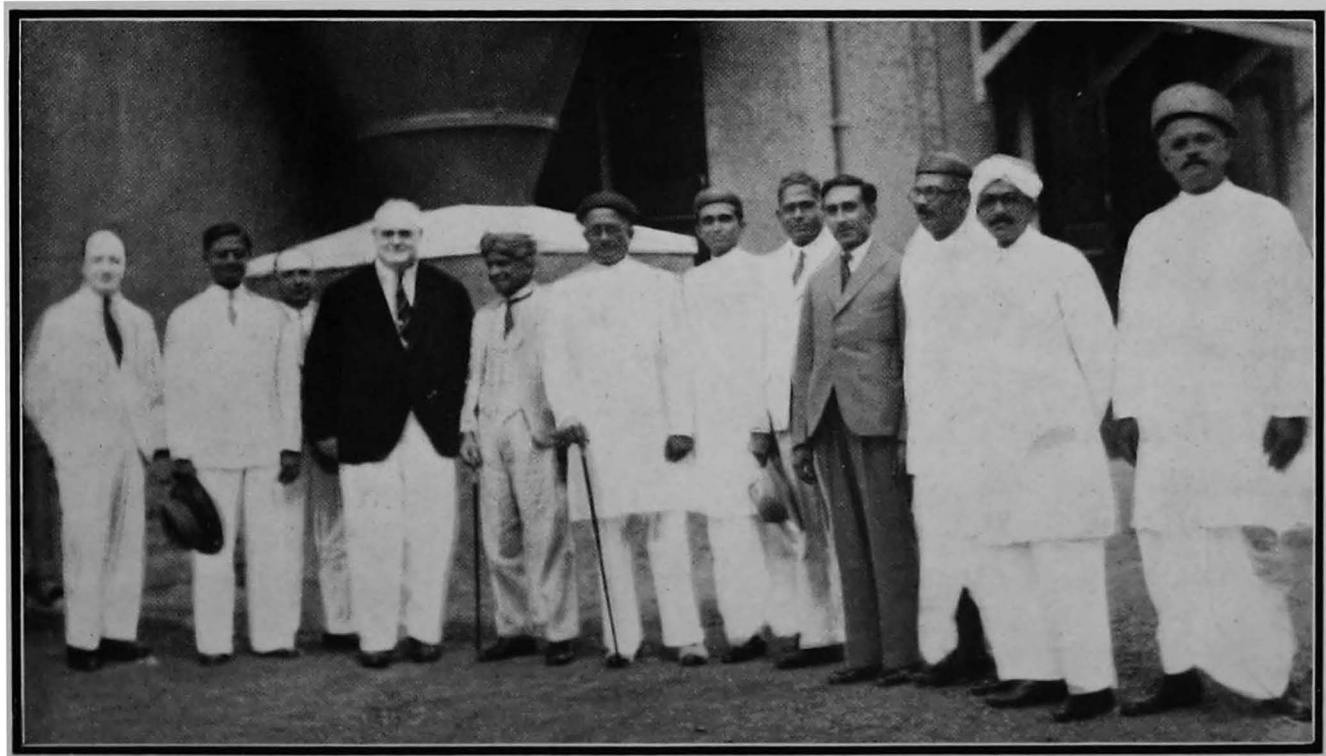
(3) Comparing the Broach and the Berar bales kept in a godown, we find that the latter showed a higher rate than the former both in absorption and loss of moisture although the maximum percentage of

moisture which they held during the monsoon was the same in the case of both bales. We also notice that when the humidity fell the Berar bale retained a larger quantity of moisture than the Broach bale.

(4) If, after the monsoon, cotton bales are stored for about four months in a relatively dry place, where the atmospheric humidity is about 40 per cent. R. H., they will give out practically all the moisture absorbed by them during the monsoon.

(5) Comparison of the behaviour of the Broach, the Berar and the Bengals bales, stored under identical conditions, shows that, starting with practically the same moisture content as the Bengals bale, the Broach bale absorbed moisture at a higher rate in an atmosphere of ascending humidity, so that, by the end of the monsoon, it had absorbed nearly $1\frac{1}{2}$ lbs. more moisture than the Bengals bale and its moisture content was found to be nearly 0.4 per cent. higher. The Berar bale started with a low moisture content than either the Broach or the Bengals bale. It, however, picked up moisture at first at a much higher rate than either of the other two bales, thereby greatly reducing the initial difference but later on slackened its rate of absorption and when the monsoon came to an end, although it had absorbed nearly 12 lbs. of moisture as against $10\frac{1}{2}$ lbs. and 9 lbs. respectively for the Broach and the Bengals bales, its moisture content was still appreciably lower than that of the former and slightly lower than that of the latter bale. At the cessation of the monsoon, when the atmospheric humidity descended, the rate of loss of moisture was very nearly the same for the Berar and the Bengals bale, while it was appreciably higher for the Broach bale, so that when the bales recorded their lowest weight for the season, the moisture content of all the three bales stood at practically the same value. Thus the Broach bale, which absorbed water at a higher rate, also showed greater propensity for parting with it.

(e) *Spinning tests on prehumidified bales.*—In view of the fact that the addition of moisture to cotton affects not only its weight but also its waste losses and spinning performance, especially if the bale is stored in a humid atmosphere for some time, it was regarded desirable to perform spinning tests on samples drawn from prehumidified bales. For this purpose Messrs. Volkart Bros. very kindly placed 4 bales of Amraoti cotton at the disposal of the Laboratory. These bales were prepared from the same style of cotton, but each contained a different quantity of water which was added to it before pressing. Samples drawn from these bales at regular intervals have been subjected to fibre and spinning tests and simultaneously the moisture contents of these samples were also determined. After each occasion on which the samples were drawn the bales were re-pressed by hand and stored in a cotton godown. Similarly, fibre and spinning tests have been made on samples drawn from bales of Digras cotton which were kindly supplied for this purpose by the East India Cotton Association. These bales also were pre-humidified to different degrees and the experimental plan adopted with them is the same as with the Amraoti bales. Altogether 49 samples have been tested for moisture in connection with these experiments.



Group taken on the occasion of the Opening of the Extensions of the Laboratory, 1935.

VI. SUMMARY.

1. The problem of averting the possible danger of the introduction of the cotton boll-weevil in India through the agency of the imported American bales was successfully tackled and a practical method of fumigating the bales was developed. The outcome of the solution of this problem was the issue of a notification by the Government of India requiring all American cottons consigned for India on or after the 1st December 1925 to be imported through the Port of Bombay and there to be fumigated in the manner devised by the Laboratory. This work is now done by the Fumigation staff who are attached to the Laboratory and who perform the routine fibre tests in their spare time (p. 1).

2. The two main objects of the work of the Laboratory are (1) to undertake spinning tests on improved varieties of cotton and (2) to establish relationships between the measurable fibre characteristics and the spinning quality of a cotton. The work under the first object is extremely valuable to the cotton breeder as it places in his hands authentic data, obtained under known and reproducible conditions, regarding the spinning performance of his varieties and enables him to decide, at an early stage in his experimentation, which of these varieties would prove acceptable to the spinner. The second object aims at dispensing with the necessity of making spinning tests on numerous strains in the early stage of their trial, thereby effecting considerable saving in time, labour and money, and accelerating the pace of agricultural research on cotton. It furthermore strives to enable the spinner to assess the performance of his cottons, by applying prediction formula, from a knowledge of their fibre-properties. The methods developed or employed at the Laboratory in the furtherance of these two objects tend gradually to replace the subjective estimates, which are liable to errors of personal judgment, by exact data free from these defects. Good progress has been made in both directions. The number of samples tested for the cotton breeders has steadily increased from year to year reflecting growing confidence in, and reliance on, the work of the Laboratory, and prediction formulae, especially applicable to Indian cottons, have been derived (p. 33, p. 46).

3. The routine fibre tests are not only indispensable to the cotton breeder but are also useful to the trade and the industry in many ways. Thus, when the East India Cotton Association sought to establish standards of length for the African cottons the Laboratory made numerous fibre-length tests on samples of fair average quality of A. R. Kampala, A. R. Busoga and A. R. Jinja. Again various mills and firms have frequently sent their samples to the Laboratory to compare two cottons, to ascertain the effect on the same cotton of different ginning treatments, to find out the extent of variation in different bales of the same lot, to determine whether a particular variety comes up to the requisite

standard, etc., etc. The number of samples subjected to fibre tests has increased steadily as will be seen from the following table :—

No. of samples on which only fibre-tests have been made.

Season.	No. of samples tested.
1925-26	3
1926-27	18
1927-28	4
1928-29	45
1929-30	9
1930-31	37
1931-32	60
1932-33	119
1933-34	45

4. In the research work on cotton fibre, the first problem to be solved was to find out the exact size of the small samples required for the determination of any one single fibre-property. It is necessary that the sample selected should on the one hand be representative of the bulk, and on the other should not be so large as to take a great deal of time. The fibre-properties considered were (i) fibre-length, (ii) fibre-width, (iii) number of convolutions, (iv) fibre-strength and (v) fibre-rigidity. The study of the frequency distributions of the various properties threw light on several interesting points relating to the development of the fibre during the growth of the plant and it was found that (p. 9):

- (i) The mean value and the probable error of a single observation are quite sufficient to indicate the composition of a sample in the cases of (a) fibre-length, (b) fibre-width and (c) convolutions, but that :
- (ii) caution must be exercised in the use of the mean values for fibre-strength and more particularly for fibre-rigidity for which the distribution is highly asymmetrical. For these two properties it is desirable to make use of the upper and the lower quartile in addition to the mean value.
- (iii) The following minimum number of tests are regarded as giving sufficiently reliable results :—

Fibre-property.	No. of fibres for representative sample.	Total range (per cent. of mean) for which the odds are 20 : 1 that the random sample will lie therein.
Fibre-length	500	11
Fibre-width	300	2.7
Convolutions	500	19
Fibre-strength	500	15
Fibre-rigidity	500	48 (odds 5 : 1)

5. The next problem was to compare three methods for determining fibre-strength. Experiments were made with (i) Balls, (ii) O'Neill and (iii) Barratt's apparatus, and it was concluded that whereas Barratt's apparatus gives much higher results than that obtained by the other two instruments, these agree fairly well if a large number of readings is taken and if calcium chloride solution is used in the O'Neill tester. It was also pointed out that the Magazine tester has the advantage of the speed of working and the O'Neill tester economy in the initial cost (p. 12).

6. Comparative experiments were also made on three methods of testing yarns for strength, *viz.*, (i) lea test, (ii) single thread test and (iii) ballistic test. From the results it was concluded that although there is not sufficient evidence available at present to justify substituting the ballistic for the lea test, yet the former should be regarded as a useful supplementary test. The results of the lea test and the single thread test were found to agree more closely with one another than with those of the ballistic test (p. 14).

7. A new method for measuring twist in yarns was derived at the Laboratory, which consists of passing two single yarns between the front rollers of the ring frame with the back rollers removed so that the doubling twist is substantially the same as in the case of the single yarn. Twist tests on two-fold mock grandrelle yarns prepared in this manner can be made on 10" lengths. From the results obtained it was concluded that if the twist is measured in the ordinary way by using 1" lengths of single yarns, it is necessary to perform at least 100 tests to achieve an accuracy of 2% for the mean value. When, however these tests are made according to the Laboratory method on two-fold grandrelle yarns, only 10 determinations on 10" lengths are necessary to give the same degree of accuracy (p. 15).

8. A new apparatus for the determination of mean fibre-length and fibre-weight of cotton has been developed in the Laboratory. Besides possessing the advantages of low initial cost and remarkably little wear and tear, it gives as reliable results as the Balls Sorter or Baer Sorter in a shorter time. The two properties are determined in one series of operation. This apparatus has been patented in many countries (p. 17).

9. Experiments were made to find out the relationship between the ginning percentage and the lint index of a cotton with the number of fibres on a single seed. It was concluded that no direct proportionality should exist between ginning percentage and the number of fibres per seed and that the lint index also cannot be expressed only in terms of this seed character. It was shown that the available data do not enable us to decide whether differentiation of the epidemic cells takes place on the day of flowering or what may be the influence of environment on this factor. It was found that high ginning percentage is associated with low seed weight. The influence of the variation of fibre-weight per inch in different group lengths was discussed in detail (p. 18).

10. Arising from the foregoing conclusions an investigation was undertaken to test the validity of the assumption that fibre-weight per inch is the same for different group-lengths. It was found that for the *hirsutum*

type of cottons, fibres of longer lengths generally have less fibre-weight per inch than the shorter fibres, while for the *herbaceum*, *neglectum* and *indicum* types no large variations were observed, the chief exceptions being Aligarh A 19 and Mollisoni, in which fibres of longer lengths have a smaller fibre-weight per inch (p. 20).

11. A systematic investigation was undertaken to study the variation in the physical properties of fibre growing on different regions of the seed. It was found that the mean fibre-length is less, while the fibre-weight per inch and the fibre-strength are greater, for the apical than for the basal fibres, the differences being significant in all cases; that for the two flanks of the seed the values of these three fibre-properties are practically the same, and the fibres which are removed in the process of combing the seed by hand are generally those which have the least fibre-weight per inch. It was further found that in fibre rupture most of the hairs break near their apical ends, that there is a distinct tendency for a high ginning out-turn to be associated with low percentage difference between mean fibre-length of hairs taken from the apex and the base of a seed and that the cottons belonging to the *indicum* family gave the largest, while those belonging to the *hirsutum* group gave the lowest, differences, the trend for fibre-weight and fibre-strength being opposite to that for fibre-length. In discussing the practical significance of these results it was pointed out that cotton breeders should pay attention not only to the absolute values of the fibre-properties, but also to the percentage differences between the values for the apical and the basal hairs so as to obtain the greatest possible uniformity in regard to length, weight and strength of staple and the ginning out-turn of the variety (p. 21).

12. An investigation to determine the influence of twists on the diameters of cotton yarns and on the relative proportions of fibre-slippage and fibre-fracture in yarn breakage was next undertaken. It was found that for the practical range of twist (No. of turns per inch) n , in yarns of count No. c , the diameter, d in mms, is given by the simple formula $d = \frac{1.9}{\sqrt{c} \sqrt{n}}$.

This formula holds good except for very coarse counts. It was further found that the maximum strength for different counts of yarn is attained at about the same twist *i.e.*, 30 turns to the inch. This corresponds to a twist constant of 7 for 20's, 5.5 for 30's and 4.5 for 40's. It was further shown that below 7 turns per inch the breakage of yarn takes place almost entirely by fibre slippage, but with the twists ordinarily used it occurs chiefly through fibre fracture and that there is a close relationship between the latter and yarn strength (p. 23).

13. It had recently been suggested that lea breaking strength could be calculated from the single thread test results. This suggestion, on being put to the proof, was not substantiated by results pertaining to Indian cottons. It was found that only in a restricted number of cases the calculated value of the lea strength agreed moderately with the observed value, but that unless the lea test was actually performed it was not possible to foretell whether

or not the agreement would be obtained. It was pointed out that under these circumstances the only practical application of this method is to use it as a check upon the lea test (p. 25).

14. The influence of fibre-strength upon yarn strength was studied. It was found that contrary to expectation and *a priori* reasoning no general relation could be established between these two characters. The average percentage of fibre-strength utilised in yarn strength was found to be just over 50 in the single thread test and 36.6 in the lea test. The reasons for the absence of any relationship between fibre-strength and yarn-strength and the utilisation of only a fraction of the former in the latter were fully discussed, and the conclusion was reached that while it is not at present possible to assign definite magnitude to each of the several factors it is easy to understand why only a small proportion of strength of the fibres is apparently used in a yarn (p. 26).

15. The second property to be examined in its relation to yarn strength was the clinging power of cotton. It was found that there is a marked tendency for those cottons which have a high clinging power in relation to their length and fineness to be spinnable into fine counts, that although the fibres of the short and coarse cottons tend to possess higher individual clinging power, yet in a yarn spun from a long and fine cotton the greater number of hairs give rise to a much higher total clinging power, which offsets the greater individual clinging power of the coarser fibres (p. 27).

16. The next property whose relationships with the spinning value and the other fibre characters of cotton were studied was the fibre-length irregularity, which is a measure of the percentage of short fibres in a cotton. It was pointed out that these short fibres tend to raise the waste losses of a cotton, interfere with the drafting process and give a fuzzy appearance to the yarns. It was found that the inclusion of fibre-length irregularity did not appreciably improve the correlation between the spinning value and the hair properties of a cotton. This was explained on the ground that the correlation between these properties and the spinning value of a cotton is already so high that in order that the irregularity percentage should appreciably alter it, its contribution must be comparable in magnitude to that of either mean fibre-length or fibre-weight per inch (p. 28).

17. It was known in a qualitative way that the main factors responsible for yarn neppiness are immature fibres, motes and seed-bits, but the exact contribution of each had not been quantitatively studied. This was done here with respect to the fibre-maturity of Indian cottons. It was found that high fibre-maturity goes hand in hand with high fibre weight per inch and high fibre strength, that although the long Indian cottons are inclined to possess a relatively lower proportion of mature hairs yet in these cottons a comparatively high percentage of these hairs is associated with good spinning performance while in the short cottons the reverse is the case. Furthermore, yarn neppiness was found to be significantly correlated with the percentage of immature hairs, the departure from direct proportionality being due to certain factors which were fully discussed. In view of these results the

importance of taking fibre maturity into consideration by the cotton breeders was stressed. In a few cases the effect of such factors as heredity, environment, ginning machinery, etc., was also considered (p. 29).

18. An investigation was undertaken to ascertain the manner in which the feel of a cotton, as estimated by an expert grader, was related to its wax content. It was found that the wax content of Indian cottons may lie within 0.229 per cent. and 0.468 per cent. which represents a much wider range than that indicated by the earlier workers. It was further found that the exotic varieties, grown in India, have, on the whole, a higher wax content than the indigenous types. In view of the fact the estimates of feel made by these expert graders differed among themselves and with the wax determination results, the following scale for feel of cotton in terms of its wax content was recommended (p. 31):

Feel of cotton.	Wax content per cent.
Very silky	Above 0.500
Silky	0.425—0.500
Slightly silky	0.350—0.425
Roughish	0.300—0.350
Rough	Below 0.300

19. One of the central problems of the Technological Laboratory is the establishment of formulae which would enable one to predict the spinning value of a cotton from its measurable fibre-properties. For this purpose comprehensive fibre and spinning tests had been made on standard Indian cottons for a number of seasons. The statistical analysis of the results obtained showed that the two fibre-properties which are most closely related to the spinning value are mean fibre-length and mean fibre-weight per inch, the influence of other properties such as fibre-strength, rigidity, convolutions and ribbon width being insignificant for all practical purposes. The equation connecting the mean fibre-length, L, and the mean fibre-weight per inch, W, with spinning value, S, is given below :—

$$S=75.4L-79.5W-22.8.$$

The spinning value, as predicted from this equation, agrees to within 20% with the actual results in 76% of the cases. If all the six fibre properties are taken into consideration, the agreement is improved only by another 4 per cent. It may also be mentioned that the partial correlation coefficients between mean fibre length and fibre weight per inch on the one hand and the spinning value on the other are +0.70 and -0.36 respectively, which show that unlike the Egyptian cottons, length is more important than fibre weight per inch in the case of the Indian cottons. The various factors which may be responsible for the lack of agreement in the remaining 20% cases are discussed in the bulletin (p. 33).

20. An investigation was undertaken to test the validity of the common assumption that the fibre weight per inch is nearly constant along the length of the fibre. The results obtained showed that this assumption was *not* true for Indian cottons and since then the fibre weight determinations have been made by weighing whole fibres instead of one centimetre lengths (p. 36).

21. Two other investigations which have been completed and of which the results will be published in due course are (1) strength of fibres falling in different length grades and (2) the chemical composition of Indian cottons (pp. 37, 38).

22. Identification tests were made on extremely small pieces of fabrics and yarns unearthed during the excavations at Mohenjo-daro. These led to the very interesting conclusion that the cultivation of cotton and the manufacture of yarns and fabrics from it must have reached a fairly high level in India as early as 3000 B.C., though the earliest authenticated references in literature date back to only 800 B.C. It was surmised that the cotton used in the manufacture of these specimens was of the *arborcum* type (p. 39).

23. The merits of systematic selection of warps in cloth sampling were compared with those of random selection. It was concluded that although random selection is theoretically more satisfactory than systematic selection yet the latter method had the advantage of simplicity and in actual practice yields just as good results as the former (p. 40).

24. Tests on samples grown with manurial treatments showed that the application of fertilisers either failed to produce any significant increase in yield or even lowered it when the soil in the field is naturally rich, but when the soil is poor and deficient in substances necessary for plant nutrition, a large increase in yield may be obtained by using the right fertiliser. The fibre properties and the spinning quality of the cotton are not appreciably affected in most cases by the application of manure. These results are of direct practical importance to the cultivator as indiscriminate use of fertilisers may involve him in additional expenditure without bringing him corresponding gain in the shape of higher yield or better quality lint (p. 41).

25. The arrangement of the available plots for field experiments with a view to solving the maximum number of problems with minimum number of replications is a matter of utmost importance to the cotton breeder. In order to help him in his task a paper was prepared in which it was stressed that the old methods of field experimentation were defective due to the improper layout of the plots and the modern methods, due principally to Dr. Fisher, which were fully explained, are capable of yielding much more satisfactory results (p. 42).

26. The testing of samples supplied by the cotton breeders has been instrumental in improving the quality of cotton grown in several parts of India. By way of illustration mention may be made of Banilla, Jayawant and Verum 262. Banilla is now grown on an area of 1,20,000 acres in Khandesh, Jayawant

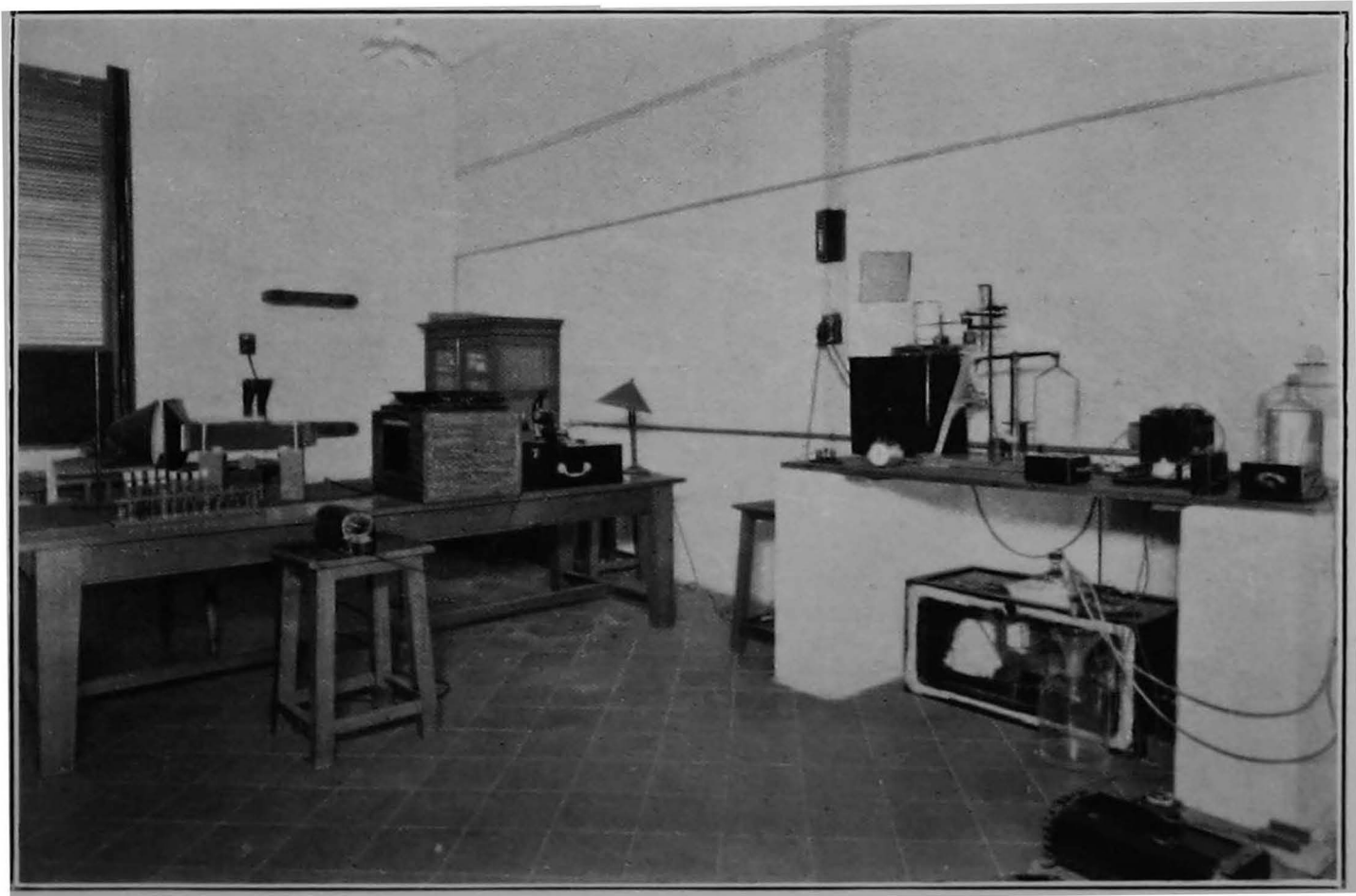
to the extent of about 40,000 bales in Dharwar, Belgaum and Bijapur. Verum 262 and its further selections Late Verum and V 434 represent a great improvement on the old *roseum* and Oomra cottons of Central Provinces and Berar and in a few years will change the entire aspect of the cotton crop in these provinces. In each case, the cultivators have benefited to the extent of several lakhs of rupees by the replacement of the older and inferior types by the newer and improved varieties. Similarly new strains are being tried for the Sukkur Barrage area which, grown on a large scale, will materially help in satisfying India's need of long staple cottons (p. 44).

27. In addition to improved varieties, tests are also made on samples grown in connection with various field experiments such as the effect of different irrigations, manures and fertilisers, dates of sowing, rotation of crops, etc., etc. The results of these tests are important to the cultivators to whom they are passed on in due course by the agricultural departments. These tests are not confined to samples of Indian cottons, but, with the growing reputation of the Laboratory, samples for tests have been received from other parts of the Empire as well. The Laboratory does not merely carry out tests on samples but goes one step further and frequently advises the cotton breeders as regards the type of work on which experimentation is likely to yield valuable results. The work of the Laboratory for the Agricultural departments has steadily grown as shown by the following table (p. 45) :

Number of agricultural samples tested from 1924-25.

Season.	No. of samples tested.
1924-25	46
1925-26	57
1926-27	81
1927-28	64
1928-29	117
1929-30	186
1930-31	212
1931-32	171
1932-33	318
1933-34	366

28. In order to make the work of the Laboratory more directly useful to the trade and the industry arrangements were made with the East India Cotton Association and the Bombay and Ahmedabad Millowners' Associations for the supply of samples of fair average quality of the chief trade varieties of the Indian cotton crop and the first arrivals of the new crop of each season. The results of tests on these samples are published in the form of 2-3 page circulars, which are freely distributed. These circulars are quoted widely in the textile journals and thus supply the necessary information regarding the performance of these cottons to millowners in all countries (p. 49).



Research Room.

29. The Laboratory furthermore undertakes tests on samples sent to it by the mills and firms in their private capacity on payment of certain fees laid down by the Committee. It is gratifying that the Laboratory tests on trade varieties and samples for technological research have grown from year to year as will be seen from the following table (p. 51):—

Number of samples tested in connection with the trade and technological tests.

Season.	No. of samples tested.
1925-26	38
1926-27	31
1927-28	46
1928-29	12
1929-30	37
1930-31	89
1931-32	134
1932-33	125
1933-34	166

30. The influence of temperature and humidity was investigated with regard to the comfort of the operatives, workability of cotton and the strength and appearance of yarns. The results showed that although short stapled cottons may be spun at fairly low humidities, it is necessary to raise the humidity for the spinning of counts higher than 40's if bad spinning troubles are to be avoided and that the yarns spun under hot-dry conditions are very oozy indeed, full of snarls and exceedingly crimped while those spun under high and moderately high humidities are free from these defects (p. 54).

31. An investigation to find out the effects of storage prior to ginning on the spinning quality of cotton showed that, contrary to the views held by some people, storage does not help in developing the fibre or improving its lustre, feel or spinning quality. On the other hand the fibre loses some of its 'bloom' and if the storage is protracted and proper care is not taken with regard to ventilation and drying of the sample, it is attended by a risk of bacterial and fungoid deterioration. The ginning of kapas, soon after picking and drying, is advocated (p. 55).

32. The effect of subjecting cotton to repeated blow-room treatment was investigated. It was found that, although no serious damage was done to the fibre, yet the degree of improvement in the cleanliness of yarns resulting from repeated blow-room treatment was very small. There is thus an upper limit beyond which a dirty cotton cannot easily be cleaned in this manner. The remedy for obtaining cleaner yarns, therefore, lies in cleaner picking and better ginning as the leafbits and seed-coats which are embedded in the cotton are very difficult to remove even by a rigorous treatment in the blow-room (p. 57).

33. The effects of employing different spindle speeds on yarn characteristics were studied. It was concluded from the results that so long as the counts of yarn spun are well within the spinning capacity of a cotton, there is every justification for using higher spindle speeds, but if a cotton is being spun near its spinning limit, an increase in spinning speed would cause increase in the number of yarn breakages. It was pointed out that in addition to the effect on yarn characteristics the wear and tear of machinery, the higher spinning waste resulting from more frequent breakages and the ability of tenters to cope with piecings should also be considered when high speeds are employed (p. 57).

34. An investigation was undertaken to ascertain the effects of using unbalanced instead of balanced drafts in the spinning preparations used in the Laboratory tests. The results obtained showed that with pure cottons a fairly wide range is permissible in the selection of drafts without appreciably affecting the number of breakages in the ring frame or the evenness, neppiness, strength or extension of the yarns. These results completely justified the practice of spinning three different counts from one set of rovings in order to effect economy of time (p. 58).

35. The next problem to be investigated was the effect of using either one head or two heads instead of three heads of drawing in the spinning preparations. The results showed that the yarns with two and three heads of drawing were significantly stronger than those obtained with one head of drawing, but that the difference between the yarns with two and three heads of drawing was extremely small. These results showed that under the Laboratory conditions only two instead of three heads of drawing may be employed. It should be noted in this connection that the card sliver used for drawing in these tests was the production of a single card and that if, as in mill practice, card slivers from a number of cards were fed to the first head of drawing, the results would be affected to the extent of the variation between the different card slivers (p. 59).

36. Experiments on the application of different systems of high draft spinning to mixings of Indian cottons were carried out in two series. Besides the ordinary system, two systems of high draft were employed in the first and three in the second series, the latter also covering comparative tests on band and tape spindle drive. The results of these tests showed that there is no difficulty in spinning yarns from mixings of two cottons differing by as much as 40 per cent. in fibre-weight per inch and $\frac{1}{4}$ " in staple length, that on a good high draft system it is possible to spin as good a yarn direct from intermediate roving as from ordinary roving on the ordinary system, or, alternatively, by spinning from double roving on a high draft system it is possible to obtain a yarn of superior quality to that produced on the ordinary system with no loss in production. It was further shown that twists as an aid for reducing yarn breakages and increasing yarn strength is most effective when short staple cottons are spun on the ordinary system and least so when comparatively long staple cottons are spun on a high draft system, that yarns

spun on a high draft system are more even and stronger than those spun on the ordinary system, but the percentage difference in strength between them diminishes rapidly as the quality of the mixing improves, and that double draft with double roving on the ordinary system should be employed if necessary, with the fine and not with the coarse mixings. The tape drive gave better results than the band drive, while the merits of the various high draft systems used were compared in detail (p. 60).

37. In order to find the limit spinning performance of some Indian cottons the effect of twist on yarn characteristics was investigated. It was found that Cambodia Co. 1 may be spun from carded single roving upto 52's without too frequent breaks, provided a twist constant of at least 4.5 is used and even upto 60's with a twist constant of 5. On the other hand Mollisoni could not be spun above 8's if bad spinning troubles were to be avoided, and even at this count, the twist constant employed was at least 4.5. The count strength product of Cambodia yarns increases upto a twist multiplier of 4.5 after which it falls, while that of Mollisoni yarns continues to increase right upto a twist multiplier of 5. The yarn extension, both for Cambodia and Mollisoni, was found to decrease gradually as the count became finer, but, for a given count, increased with the twist (p. 62).

38. The possibilities of spinning good quality Indian cottons into fine counts after subjecting them to the combing process were next investigated. From an analysis of the experimental results it was concluded that contrary to expectation the combing process did not bring about a large increase in the mean fibre length of the cottons, but it was remarkably effective in making the sliver more regular in length. Combing good quality Indian cottons to the extent of 20 per cent. made such an improvement in their spinning performance that it was possible to spin 50's and 60's yarns from cottons which are ordinarily regarded suitable for spinning upto 30's warp. Combing to the extent of 30 per cent., however, did not in all cases confer a benefit commensurate with the extra loss of 10 per cent. fibres. The yarns spun from 20's combed sliver on a high draft system were nearly as good as those obtained from 30 per cent. combed sliver spun on the ordinary system. The combing process was also effective in reducing yarn neppiness in such cottons as ordinarily suffer seriously from this defect. By employing a special technique no difficulty was experienced in spinning relatively coarse yarns from mixtures of comber wastes and low quality Indian cottons. These yarns were, on the whole, slightly weaker and somewhat more neppy than those given by the pure low quality cottons (p. 63).

39. Bulletins containing results of fibre and spinning tests and grader's and spinning master's reports are issued from time to time on well established varieties of Indian cottons which are grown on a commercial scale. One such bulletin dealt with the Punjab-American and the Punjab *desi* cottons of the 1928-29 season. Two bulletins have been issued on Banilla cotton, the first giving results of tests on farm samples upto 1930 and the second on samples collected from the cultivators' field in 1930-31 and 1931-32. The latter

tests showed that the average values of mean fibre length and fibre weight per inch for the 1930-31 crop are 0.73" and 0.180×10^{-6} oz. respectively, while the average performance of this crop corresponds to 14's standard warp counts. It further showed that samples grown in East Khandesh gave better results than those from West Khandesh. Similarly an annual bulletin is issued on 18 standard Indian cottons which mostly represent improved varieties and cover over 15 per cent. of the area under cotton cultivation in India (pp. 68, 69).

40. Tests were made in order to bring out the harmful effects of adulterating good quality cotton with inferior types. These showed that, in all cases, the practice of mixing a superior variety with an inferior type impaired the quality of the yarn, even if the proportion of the inferior variety was relatively small. The number of breakages in the ring frame were found to mount up, the yarns became progressively less even and weak, the loss in strength being phenomenal in some cases. A tentative rule was also formulated that an increase of 10 per cent. in the proportion of the short staple variety pulled down the highest standard warp counts of the mixture by 3 units (p. 69).

41. In addition to the investigations which have been briefly summarised above, some others have been completed of which an account will be published in the near future. These include study of the effects of using balanced and unbalanced drafts with *mixings* of Indian cottons, the effects of employing different roller settings in the fly frame and different twists in the ring frame and further work on the application of different systems of high draft spinning on Indian cottons (pp. 65, 66).

42. The amount of water in baled cotton and its influence on the quality of lint are matters in which both the merchant and the spinner are deeply interested. It was, therefore, decided to carry out moisture test on different varieties of Indian cottons to collect the data necessary for laying down suitable standards. This has been done with respect to samples drawn from guaranteed dry pressed bales and also from trade bales as are ordinarily received in Bombay. The latter tests gave the following average results :

Description of cotton.	No. of samples tested.	Average moisture content per cent.
Indian	344	6.38
Egyptian	18	7.34
African	14	7.49
American	9	8.35

It should be noted that the moisture content, in each case, is calculated on the initial weight of the cotton (p. 72).

43. The variation in the weight and the moisture content of bales of different trade varieties stored for over a year in Bombay was studied in two consecutive seasons and tables giving detailed results were published. These tables enable one to apply the necessary corrections due to changes in atmospheric humidity at any time of the year and also show the maximum variations in weight which one should expect from the dry to the monsoon season. The results of these tests further showed that the moisture absorbed by the bales during the monsoon is practically all given out in the following four months, that the rate of absorption of moisture by a bale depends largely upon the amount of moisture already held by it and that the bale which absorbs moisture at a higher rate also shows greater readiness to part with it, that if, owing to a large change in the atmospheric humidity a bale of cotton is picking up or losing moisture at a high rate, a short lived change in humidity in the opposite direction produces but a small effect. (p. 75).

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132	Spinning Test Report (No. 470) on samples of Farm Westerns Cotton, 1933-34.	May 1934 ..	0 4 0
133	Spinning Test Report (No. 471) on samples of Kumpta Cotton, 1933-34.	May 1934 ..	0 4 0
134	Spinning Test Report (No. 472) on samples of Jagadia Cotton, 1933-34.	May 1934 ..	0 4 0
135	Technological Report on Jayawant (Kumpta), 1933-34	June 1934 ..	0 4 0
136	Spinning Test Report (No. 481) on samples of Dholleras Cotton, 1933-34.	July 1934 ..	0 4 0
137	Spinning Test Report (No. 482) on samples of Kalagin Cotton, 1933-34.	July 1934 ..	0 4 0
138	Spinning Test Report (No. 483) on samples of Westerns Cotton, 1933-34.	July 1934 ..	0 4 0
139	Spinning Test Report (No. 487) on samples of Bailhongal Cotton, 1933-34.	July 1934 ..	0 4 0
140	Spinning Test Report (No. 488) on samples of Farm Westerns and Tirupur Cambodia Cottons, 1933-34.	July 1934 ..	0 4 0
141	Spinning Test Report (No. 489) on samples of Broach Cotton, 1933-34.	July 1934 ..	0 4 0
142	Spinning Test Report (No. 490) on samples of Jagadia Cotton, 1933-34.	July 1934 ..	0 4 0

TECHNOLOGICAL CIRCULARS—*contd.*

Circular No.	Title.	Date of Publication.	Price.
			Ra. a. p.
143	Spinning Test Report (No. 491) on samples of Bawla and Kadi Cottons, 1933-34.	July 1934 ..	0 4 0
144	Spinning Test Report (No. 498) on samples of Karunganni Cotton, 1933-34.	August 1934.	0 4 0
145	Spinning Test Report (No. 503) on samples of Navsari Cotton, 1933-34.	August 1934.	0 4 0
146	Spinning Test Report (No. 504) on samples of Cambodia Cotton, 1933-34.	August 1934.	0 4 0
147	Spinning Test Report (No. 509) on samples of Kadi-Viramgam Cotton, 1933-34.	August 1934.	0 4 0
148	Spinning Test Report (No. 510) on samples of Tinnevely Cotton, 1933-34.	August 1934.	0 4 0
149	Spinning Test Report (No. 511) on samples of Bagalkote Cotton, 1933-34.	August 1934.	0 4 0
150	Spinning Test Report (No. 514) on samples of A. R. Kampala, A. R. Busoga, and A. R. Jinja Cottons, 1933-34.	Sept. 1934 ..	0 4 0
151	Spinning Test Report (No. 515) on samples of Bijapur Cotton, 1933-34.	Sept. 1934 ..	0 4 0
152	Spinning Test Report (No. 516) on samples of Upland Cotton, 1933-34.	Sept. 1934 ..	0 4 0
153	Spinning Test Report (No. 517) on samples of Karunganni Cotton, 1933-34.	Sept. 1934 ..	0 4 0
154	Technological Report on Verum 262 (Nagpur), 1934-35.	Dec. 1934 ..	0 4 0
155	Technological Report on Verum 262 (Akola), 1934-35 ..	Dec. 1934 ..	0 4 0
156	Technological Report on Umri Bani, 1934-35 ..	Jan. 1935 ..	0 4 0
157	Technological Report on Punjab-American 289F, 1934-35.	Jan. 1935 ..	0 4 0
158	Spinning Test Report (No. 559) on samples of C. P. No. 1 Cotton, 1934-35.	Feb. 1935 ..	0 4 0
159	Spinning Test Report (No. 560) on samples of Berar Cotton, 1934-35.	Feb. 1935 ..	0 4 0
160	Spinning Test Report (No. 561) on samples of Khandedesh Cotton, 1934-35.	Feb. 1935 ..	0 4 0
161	Spinning Test Report (No. 566) on samples of Khandedesh Cotton, 1934-35.	Feb. 1935 ..	0 4 0
162	Spinning Test Report (No. 567) on samples of Moglaj Cotton, 1934-35.	Feb. 1935 ..	0 4 0
163	Spinning Test Report (No. 568) on samples of Bengals Cotton, 1934-35.	Feb. 1935 ..	0 4 0
164	Spinning Test Report (No. 570) on samples of Ujjain (Ujjain) Cotton, 1934-35.	Feb. 1935 ..	0 4 0
165	Spinning Test Report (No. 571) on samples of Ujjain (Mandsaur) Cotton, 1934-35.	Feb. 1935 ..	0 4 0
166	Spinning Test Report (No. 577) on Samples of Hubli Kumpta Cotton, 1934-35.	March 1935 ..	0 4 0
167	Technological Report on Gadag 1 (Dharwar-American), 1934-35.	April 1935 ..	0 4 0

TECHNOLOGICAL CIRCULARS.—*contd.*

Circular No.	Title.	Date of Publication.	Price.
			Rs. a. p.
168	Spinning Test Report (No. 582) on samples of Latur Cotton, 1934-35.	April 1935 ..	0 4 0
169	Spinning Test Report (No. 583) on samples of Nanded Cotton, 1934-35.	April 1935 ..	0 4 0
170	Spinning Test Report (No. 584) on samples of Muttia Cotton, 1934-35.	April 1935 ..	0 4 0
171	Spinning Test Report (No. 591) on samples of Broach Cotton, 1934-35.	June 1935 ..	0 4 0
172	Spinning Test Report (No. 592) on samples of Jagadia Cotton, 1934-35.	June 1935 ..	0 4 0
173	Spinning Test Report (No. 593) on samples of Punjab-American Cotton, 1934-35.	June 1935 ..	0 4 0
174	Spinning Test Report (No. 595) on samples of Bailhongal Cotton, 1934-35.	June 1935 ..	0 4 0
175	Spinning Test Report (No. 596) on samples of Broach Cotton, 1934-35.	June 1935 ..	0 4 0
176	Spinning Test Report (No. 597) on samples of Karunganni Cotton, 1934-35.	June 1935 ..	0 4 0
177	Spinning Test Report (No. 598) on samples of Tiruppur Cambodia Cotton, 1934-35.	June 1935 ..	0 4 0
178	Spinning Test Report (No. 599) on samples of Northern Cambodia Cotton, 1934-35.	June 1935 ..	0 4 0
179	Spinning Test Report (No. 600) on samples of Farm Westerns Cotton, 1934-35.	June 1935 ..	0 4 0
180	Spinning Test Report (No. 601) on samples of Westerns Cotton, 1934-35.	June 1935 ..	0 4 0
181	Spinning Test Report (No. 602) on samples of Miraj Cotton, 1934-35.	June 1935 ..	0 4 0
182	Spinning Test Report (No. 603) on samples of Nandyal Cotton, 1934-35.	June 1935 ..	0 4 0
183	Spinning Test Report (No. 604) on samples of Surat Cotton, 1934-35.	July 1935 ..	0 4 0
184	Spinning Test Report (No. 606) on samples of Tiruppur Cambodia Cotton, 1934-35.	July 1935 ..	0 4 0
185	Spinning Test Report (No. 607) on samples of African Busoga Cotton, 1934-35.	July 1935 ..	0 4 0
186	Spinning Test Report (No. 608) on samples of Kampala Cotton, 1934-35.	July 1935 ..	0 4 0
187	Spinning Test Report (No. 609) on samples of Hubli Upland Cotton, 1934-35.	July 1935 ..	0 4 0
188	Technological Report on Punjab-American 4F, 1934-35.	July 1935 ..	0 4 0
189	Technological Report on Surat 1027 A.L.F., 1934-35 ..	July 1935 ..	0 4 0
190	Spinning Test Report (No. 612) on samples of Kalagin Cotton, 1934-35.	July 1935 ..	0 4 0
191	Spinning Test Report (No. 613) on samples of Farm Westerns Cotton, 1934-35.	July 1935 ..	0 4 0
192	Technological Report on Jayawant(Kumpta), 1934-35.	Aug. 1935 ..	0 4 0
193	Technological Report on Cambodia Co. 2 (Cambodia 440) 1934-35.	Aug. 1935 ..	0 4 0

TECHNOLOGICAL CIRCULARS.—*concl.*

Circular No.	Title.	Date of Publication.	Price.
			Rs. s. p.
194	Spinning Test Report (No. 620) on samples of Navsari Cotton, 1934-35.	Aug. 1935 ..	0 4 0
195	Spinning Test Report (No. 621) on samples of Upland Cotton, 1934-35.	Aug. 1935 ..	0 4 0
196	Spinning Test Report (No. 624) on samples of Dholleras Cotton, 1934-35.	Sept. 1935 ..	0 4 0
197	Spinning Test Report (No. 626) on samples of Westerns Cotton, 1934-35.	Sept. 1935 ..	0 4 0
198	Spinning Test Report (No. 627) on samples of Surat Cotton, 1934-35.	Sept. 1935 ..	0 4 0
199	Spinning Test Report (No. 628) on samples of Tinnevely Cotton, 1934-35.	Sept. 1935 ..	0 4 0
200	Spinning Test Report (No. 630) on samples of Cambodia Cotton, 1934-35.	Sept. 1935 ..	0 4 0
201	Spinning Test Report (No. 631) on samples of Karunganni Cotton, 1934-35.	Sept. 1935 ..	0 4 0
202	Spinning Test Report (No. 633) on samples of Bijapur Cotton, 1934-35.	Sept. 1935 ..	0 4 0
203	Spinning Test Report (No. 634) on samples of Bagalkote Cotton, 1934-35.	Sept. 1935 ..	0 4 0
204	Spinning Test Report (No. 635) on samples of A. R. Jinja Cotton, 1934-35.	Sept. 1935 ..	0 4 0
205	Spinning Test Report (No. 637) on samples of A. R. Busoga Cotton, 1934-35.	Sept. 1935 ..	0 4 0
206	Spinning Test Report (No. 638) on samples of A. R. Kampala Cotton, 1934-35.	Sept. 1935 ..	0 4 0
207	Spinning Test Report (No. 640) on samples of Kumpta Cotton, 1934-35.	Sept. 1935 ..	0 4 0

TECHNOLOGICAL LEAFLETS.

Leaflet No.	Title.	Date of Publication.
1	Note on the harmful effects of adulterating good quality Indian cottons	October 1932.
2	Note on Green-stained Sind-American cotton	October 1932.
3	Blow-Room Treatment in relation to Leafiness in cotton ..	March 1933.
4	Blow-Room Treatment for a Long-staple cotton	April 1933.