The Journal of the TEXTILE INSTITUTE

Official Journal for Communications (Transactions) released for Publication by the British Cotton Industry Research Association (including its Rayon and Silk Sections), the Wool Industries Research Association, the Linen Industry Research Association and the Technological Laboratory of the Indian Central Cotton Committee

CONTENTS

PROCEEDINGS SECTION
Lancashire Section—Textile Books: The Urgent Needs—Withers P51-P58
Annual Meeting ... ... ... ... ... ... ... ... ... ... ... P59
Presidential Address ... ... ... ... ... ... ... ... ... ... ... P60-61
Review ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... P61
General Items: Institute Diplomas, Institute Membership, Employment Register, Vacancies ... ... ... ... ... ... ... P63-P64

TRANSACTIONS SECTION
9—The Lepidometer—An Instrument for Measuring the Scaliness of Animal Fibres—Speakman, Chamberlain and Menkart ... ... ... ... ... ... ... ... ... ... ... T91-T106
10—The Tensile Behaviour of Raw Cotton and Other Textile Fibres—Meredith ... ... ... ... ... ... ... ... ... ... ... T107-T130

ABSTRACTS SECTION ... ... ... ... ... ... ... ... ... A201-A236

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TEXTILE BOOKS: THE URGENT NEEDS

By J. C. Withers.

Paper delivered to the Lancashire Section of the Textile Institute, Thursday, February 8th, 1945.

Introduction

A visitor to any large technical library in the heart of the textile industries, on discovering the collection of textile books in stock, would be astonished to realise how small a space they occupy. The Textile Institute, for example, has most of the live books in English, but can accommodate them all in one small room. The Shirley Institute has for 24 years pursued the policy of acquiring every book on the cotton, rayon and silk industries that could be secured, whether old or new, and in whatever language, and yet the shelf space now occupied by books—apart from bound volumes of periodicals—is only some 160 feet. By contrast with the magnitude of the industries, the number of technologists engaged in them, and the very wide range of topics that might have been written up in book form, textile literature is meagre indeed.

The present position is aggravated by the general chaotic condition of the book market. Very many books that are by no means obsolete are out of print and unobtainable, and it appears that in some branches of their studies textile students are simply unable to get new books. In the range of advanced and special treatises also, the common experience of a would-be buyer is just frustration and exasperation.

It has frequently been the writer’s duty to advise people on the selection of textile books; sometimes an all-round collection for a small works library or research department; sometimes a few elementary books for young men of the apprentice type; sometimes advanced books on some special theme. Again, it is a part of the writer’s duty to meet requests for books from a large research staff, from technical men in the industry, and, indeed, from the public at large, inquiring through the National Central Library. It is often remarkably difficult to satisfy what would seem to be very reasonable requests. For example, an enquirer asks for “two or three books on the manufacture of string”? Has there ever been one written? And if the manufacture of string may be regarded as a logical extension of thread manufacture, where is there a book on sewing thread? The natural inference would seem to be that on many such topics people with the requisite knowledge have been either too busy or unwilling to place that knowledge on record.

As might be expected, most of the well-known classics have been written by the teachers. men like Barker, Bradbury, Fox, Kilgour, Midgeley, Nisbet, Priestman, Thornley, and Woodhouse, but the output from this source has fallen very low. Since 1930 we have seen in this country only two or three new books by textile teachers. It is regrettable that in their manifold activities
responsible teachers are left with so little time and receive so little encouragement to write books. It is also remarkable that two of the most noteworthy recent contributions to British books on cotton technology have come from the busy research staff of a private firm.

**General Works**

*School books.* It is highly desirable that books on textiles that are to be used by children should be free from any tendency to disparage the industries or to perpetuate false comparisons between the different fibres. Some books tend to give the impression that a mill is not a fit place for juvenile employment. Some modern books still talk of rayons as though no improvements had been made in their properties since 1920. So far as they go, admirable models of school books are the "Peeps at Great Industries," published by the Oxford University Press. It would be a boon to the trade if the separate parts on cotton and wool were brought up to date and supplemented by books on rayon and other fibres and the knitting, dyeing and finishing branches, written with the same accuracy and clarity and illustrated with the same wealth of understandable diagrams.

A common defect of school books is that the attempt to express things in language suitable for children has had really grotesque results.* It must surely be better for the children to see and handle things under the direction of an intelligent teacher. An interesting "Workbook" in which the "Fundamentals of Textiles" can be studied by domestic science pupils has been produced by Eda A. Jacobsen and Helen E. McCullough of the University of Illinois. It can be obtained from Messrs. Chapman & Hall Ltd.

*Books for the layman.* Books that may often be found to represent "Textiles" in public libraries or be called for by the layman, are usually obsolete and dangerously likely to give the impression that no progress has been made this century. For example, the writer has found Ure's "Dictionary of Arts and Manufactures" (1879) and nothing newer, still doing duty in the public library of a seaside resort. A good model of a handy single-volume book to cover all the major fibres and manufactures is Woolman and McGowan's "Textiles," a new edition of which was announced last year. For readers with some knowledge of the industries, and certainly for public libraries in textile towns, the best choice would be the three handbooks (Cotton, Rayon and Wool) published in recent years by Mauersberger and his associates. It would be a great advantage if the publishers would collaborate with British authorities to bring these handbooks out in British editions, in which, for example, "picking" is called "scutching," "filling" is called "weft" and the mule is not dismissed as a museum piece!

*Students' text-books.* Textile students will obviously require a range of text books to deal adequately with the major fibres and processes but there is a demand, created, for example, by the Institute's examination in General Textile Technology, for more elementary "all-in" books. "Cotton Manufacturing" by the Dominion Textile Co., of Canada (1941) covers raw cotton, spinning, winding, sizing, weaving, and cloth analysis, testing and designing in a handy textbook of 436 pages.

*Comprehensive treatises.* Of large works that are still "alive" mention should be made of the "Reference Library" of instruction manuals published by the International Correspondence Schools and the series "Technologie der Textilfasern" edited by R. O. Herzog. Authors' names are not given on the I.C.S. manuals but they are known to be leading technologists in the industry and the instruction given is eminently practical and backed by particularly good diagrams. The manuals required by cotton students can be obtained in a set

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*Here, for example, is the story of rayon from a booklet on clothes published by the American Education Press Inc. Rayon Silk. "Some of your clothes may be made of rayon silk. Cotton and wood are put together. They are made into a thick soup. This soup is put into a machine. The machine has many little holes. The soup goes through the holes. It turns into little silky threads. These threads are woven into rayon. Rayon looks like silk".*
of five bound volumes, but it would be a great advantage if the manuals could be brought up to date and rendered readily accessible to all students. The German handbook, like so many major undertakings of the kind, is not yet complete. About 27 volumes have been issued and on some subjects they are the best sources of information.

The Production and Properties of Fibres

**General.** The classic book for a description of the production and properties of textile fibres is Matthew’s “Textile Fibres, their Physical, Microscopical and Chemical Properties.” The most recent edition is dated 1924 but it appears that a year or two ago Dr. Matthews had planned a new edition. Unfortunately he has passed away. This is one of the books that should not be allowed to die and it is greatly to be hoped that the publishers will bring out a revised edition as soon as possible.

Another general book that has often proved useful is Schilling’s “Die Faserstoffe des Pflanzenreiches” which is really a dictionary of fibre names, giving the botanical names of the parent plants, the sources, and brief data about fibre characters. This would form a useful nucleus of a comprehensive dictionary to include all fibres.

**Cotton.** There are several good books on the production of cotton. Sir George Watt’s “Wild and Cultivated Cotton Plants of the World” (1907) is still the classic, botanically speaking, but needs to be overhauled and brought up to date, especially in the light of modern knowledge of the genetics of the species *Gossypium*. This knowledge has been summarised by S. C. Harland in his “Genetics of Cotton” (1939) the language of which is entirely foreign to that of the spinner though it is for him, ultimately, that the breeding of cotton is designed. There are three fairly recent American books on cotton production, namely “Cotton” by H. B. Brown, (2nd. Edn. 1938), dealing with history, species, varieties, morphology, breeding, culture, diseases, marketing and uses, “Cotton and its Production” by W. H. Johnson (1923), and “Production of Cotton” by G. H. Collings, (1926), but the story of Egyptian cotton as written by W. L. Balls in his “Cotton Plant in Egypt” (1919) needs bringing up to date and a welcome would be given to books on Indian, Russian, S. American and African cottons. A useful type of book would be a dictionary of cottons, giving the botanical, and agricultural particulars, recent statistics of yield, and fibre characters for all known marks of cotton.

**Rayon.** Round about 1925-1930 there was a spurt in books on the production of rayon but it is nearly 14 years since an English text-book appeared and much has happened in the meantime. The most recent substantial book appears to be Götzse’s “Kunstseide und Zellwolle” (1940) which can now be obtained from America in a photo-lithographic printing at a cost of about 6/15/-! It is to be hoped that as soon as the war is over a text-book of similar scope will be produced by British writers. There is also room for a popular book for the layman.

**Silk.** No workers in the silk industry are satisfied with existing English books on the production and qualities of the various silks. The best books, from the scientific point of view, are in Herzog’s series, namely “Die Seidenspinner, ihre Zoologie, Biologie und Zucht,” (1938) by Bock and Pigorini, and “Technologie und Wirtschaft der Seide,” (1920) by Ley and Raemisch. The latest book in English is “Cocoon Silk” by Cansdale (1937) but it has not been well received by critics. The author invited criticism in his preface and it is to be hoped that he will produce a revised edition.

**Wool.** Here again, the most substantial modern books are those in Herzog’s series, namely “Welt-wirtschaft der Wolle” (1922) by Behnse and Genzmer, and “Wollkunde” (1929) by Frölich, Spöttel and Tänzer. The Wool Industries Research Association, however, has produced a few monographs on the types of animal fibres and on particular marks of wool and it may be expected that when the investigations have covered the ground a really good book on wool will soon be forthcoming.
Bast and floss fibres. English books in this field are not so old as in many other sections. Bradbury's "Flax Culture and Preparation" (1921), Oakley's "Long Vegetable Fibres" (1928) and Caldwell's "Preparation and Spinning of Flax Fibre" (1931) are still alive, but do not deal very thoroughly with the actual production of the fibres. In Herzog's series there are separate books on flax, hemp and other hard fibres, and jute. A welcome addition during war-time is Zand's book on Kapok (1941).

Conversion of Fibres into Yarns

There is a general feeling that books on the preparatory and spinning processes have tended in the past to dwell too much on machine details and not enough on the fate and behaviour of the fibre or product passing through the machinery. Professor Morton certainly marked a new departure in 1937 with his "Introduction to the Study of Spinning" and it is to be hoped that books in this new spirit will be taken right through to the advanced stage.

What might be called a working compromise between the old descriptive method and the new scientific approach is represented by two sets of manuals produced recently in the United States. One is sponsored by the Textile Foundation and consists of manuals on (1) cotton opening, cleaning and scutching (1937), (2) cotton carding (1926), (3) drawing frames (1937), (4) cotton combing manual (1938), (5) roving frames (1937), and (6) cotton spinning (1938). These are written by members of the staff of the Textile School, Clemson College, S. Carolina, and are issued in typewriter script. It appears to be the intention to put them to the test of teaching experience and then print them after revision. The other set is for the use of students at Lowell Technical Institute and is also in typewriter style. It includes good manuals on cotton opening and scutching, on cotton carding, and on cotton drawing and roving.

For the advanced technologist, however, there is a need for books that will deal with the forces exerted and endured. Many attempts have been made, for example, to work out the kinematics of twist and the time is not far distant when such problems will find their place in advanced books on spinning. There is a hint of such a treatment here and there in the "Handbuch der Spinner" by Bergmann, revised by Lüdicke (1927), which is the most comprehensive book on spinning, since it covers all the major fibres. It reaches nearly 1,000 pages. Strange to say, however, a scientific worker interested in spinning from this kinematic standpoint would get the best lead at present from "Textile Electrification," a book on electrical driving by Stiel, of the Siemens concern. This came out in German in 1930 and in English in 1933.

For a fundamental, theoretical approach to the problem of the effect of spinning conditions on cotton yarns there is a thesis of 175 pages by Braschler, published in 1935. It would be worth while for some authority to translate and publish this as a monograph.

Preparation of Yarn for Weaving

The late Mr. Nisbet's outstanding contribution to textile technology was his books "The Preliminary Operations of Weaving" but many developments have occurred in winding in the 20 years since they were published. Similarly, Woodhouse's volume on "Preparation and Weaving of Artificial Silk" goes back to 1929. Moreover, both writers treat the subject descriptively and not analytically. A new approach is overdue.

Sizing has been neglected by authors for a very long time. The newest book is a second edition of Kretschmer's "Die Schlichterei in ihrem ganzen Umfang" dated 1927, and the only substantial books in English are still a translation from Kretschmer dated 1911 and Percy Bean's "Chemistry and Practice of Sizing" dated 1921. It is high time that the subject received adequate attention. New sizing materials and antisepsics have taken their places in the industry, with new machines and new devices for controlling the moisture content of the warp, and much more is now known about the amount of size required for good weaving.
Weaving

There are many more books on weaving than on the other mechanical processes, but most of them deal more with the description of loom mechanism than with the operation itself.

The classic is of course Fox’s “Mechanism of Weaving” but 22 years have elapsed since the last edition appeared and it is high time that an up-to-date book on similar lines was produced. It is on weaving that continental authors outstrip our own. There are several large works by French, Italian and German authors. One of the latest, the “Handbuch der Weberei” by Professor Vlček of Brünn (1933), is a masterpiece of machine drawing. Hanton’s “Mechanics of Textile Machinery” (1924) and Wilmot’s “Theory and Electrical Drive of the Loom” (1931) represent the newer scientific approach to the subject. Another new approach is represented by Moberg’s “Cotton Loom-fixer’s Manual” (1942) with its precise instruction for tacklers.

Knitting

The latest British books appear to be the set written for the Leicester College of Technology in the knitting department. They are handy and clear volumes but getting old; the last came out in 1930. Newer developments in knitting are covered very well by M. C. Miller, in the United States, with his “Principles of Knitting” (1931) and “Knitting Full-fashioned Hosiery” (1937).

Lace and Embroidery

Most of the books on lace and embroidery are written from the “art and craft” angle and very few of them give any indication that there is a machine lace industry. “The Lace Book” by Jessie F. Caplin (1932) has a good chapter or two.

Designing

Apart from the artistic productions about textiles, there are several students’ books. Watson’s “Advanced Textile Design” (1925) and his “Textile Design and Colour” (1936) still hold the field, but the book “Yarn Diameters and Cloth Structure” by Woodhouse and Brand (1932), though fairly recent, will need revision in the light of the new science of cloth geometry. A hearty welcome has been given to two American books that give specifications of cloths, indicate the range of cloth particulars (reel, pick and counts) embraced under a given term, and mention the uses of the cloths. One is G. B. Haven’s “Industrial Fabrics” (1942) and the other is Hoye’s “Staple Cotton Fabrics” (1942). It may not be widely known that this very useful book has been supplemented by a “Swatch Book” containing actual cotton fabrics, numbering 261 types.

Chemical and Finishing Processes

The literature on the chemical technology of textiles is fairly extensive but falling sadly out of date in many branches. The time is ripe for a good book on Bleaching, combined with white finishing, the latest being Kind’s “Bleichen der Pflanzenfasern” (1932), which only covers part of the programme. On dyeing there is C. M. Whittaker’s new edition (1942) of his “Dyeing with Coal Tar Dye-stuffs,” and another useful book is “Progrès réalisés dans l’Application des Matières Colorantes,” in two volumes (1937-38) by L. Diserens. Horsfall and Lawrie’s “Dyeing of Textile Fibres” (1927) has been out of print for years and a new edition would be welcomed because the approach to the subject was via the fibre rather than the pure chemistry of the dyes, as is the case with so many of the classics on dyeing. On printing there is the new and expensive edition (1936) of Knecht and Fothergill’s “Principles and Practice of Textile Printing,” but this scarcely mentions any new developments that affect process control. For example, on the subject of the impurities in raw cotton, the only citation is to Schunck’s work in 1891. The reproach that Mercer’s countrymen had nothing to write on Mercerisation since 1903 has happily been removed by J. T. Marsh’s book “Mercerising” (1941).
The subject of finishing is, however, in need of similar revision. It is most difficult to turn up in a book any details about the finishing of a specific cloth, for example, umbrella cloth. The best modern book is "Les Apprêts Textiles," two volumes (1938) by A. Lambrette, and American practice is dealt with in a rather discursive book "Processing and Finishing Cottons," two volumes (1933) by J. F. Monaghan. Scientifically speaking, textile finishing is concerned with the treatment of certain colloids, often with other colloids. This scientific approach is reflected in the book "Kolloid-chemische Grundlagen der Textilveredlung" by Valko of the I. G. Farbenindustrie, a few copies of which reached England just before the outbreak of war. Books on the various branches of Proofing are also hopelessly inadequate, especially in view of wartime developments. Some authority should remedy this defect in the literature as soon as conditions permit.

Testing

As recently as 1922 a book on strength testing appeared that gave no indication at all that humidity mattered! This state of things has of course passed away and there are some small books that do reflect the influence of research. James Lomax's "Textile Testing" appeared in 1937 and J. H. Skinkle's book in American and British editions in 1940. There is a tendency to treat textile microscopy separately from general textile testing and in this field there are books in English by Lawrie (1927), J. M. Preston (1933) and Schwarz (1934). Eventually one such book will include references to the newer staining methods for identifying fibres.

One turns in vain to books on Testing for advice about the planning and equipment of testing laboratories suitable for, say, a private firm, an official Testing House, a teaching institution, and a consultant. On the particular subject of wool quality, there is the late S. G. Barker's "Wool Quality" (1931) which appears to be unobtainable now. It is to be hoped that his old associates will revive the book in the light of their knowledge.

Dictionaries and Encyclopaedias

There are several small dictionaries of technical terms and names of materials but none of them is really adequate. Harmuth's "Dictionary of Textiles" (1920) claims to cover more than 8,500 terms and definitions but needs to be brought up to date. What one would like to see is an all-inclusive work planned on the lines of Thorpe's "Dictionary of Applied Chemistry," and just as our friends the Society of Dyers and Colourists have gained great credit for their splendid production the "Colour Index," one ventures to hope that the Textile Institute might take in hand the planning and production of a great encyclopaedia of textiles.

Those who read foreign textile literature also require more assistance in translations. By far and away the best polyglot dictionaries are volumes 14, 15, 16 in the Schloßmann-Oldenburg series of Illustrated Technical Dictionaries. These have thumb-nail sketches, where necessary, to illustrate the terms in question and give the equivalent expressions in English, German, Russian, French, Italian, Spanish and Catalanian Spanish.

The German editors had the assistance of men like the late Mr. W. Scott-Taggart to check the renderings into English, but, unfortunately, the world wars have hampered the completion of the programme. The existing volumes cover only fibres and their production, spinning, and weaving, and one may venture a wistful hope that some day knitting and the chemical technology of textiles will also be covered.

DISCUSSION

Mr. Smith: Does Dr. Withers favour the revision of existing books or does he favour starting from the beginning and re-writing? Many of the revised books are disappointing. They are a curious blend of old mis-statements plus up-to-the-minute lightning flashes, and it is unsafe to rely on the book as a whole. Are you satisfied that British
technical literature has been fairly represented or is it as poor as I imagine by comparison with German and American literature?

Dr. Withers: I hope I have done justice to British works. I am more and more convinced that it is better to write a new book than to revise an old one. Generally speaking it is far better and far more interesting to the author than I think is the case in Germany and America. That is one reason why the quantity of textile literature is so small. Another reason is the inducement to write a book. As an author of one I can only say that it is not a paying proposition. The financial return is hopeless. There are very few occasions in textiles where a book has paid its author; but that is generally due to the particular subject chosen. If you have one good book on a subject that is all you need. Other subjects need to be written about but there is no inducement. One deterrent to teachers is the knowledge that members of the Research Associations, and sometimes their own students, are in possession of information which in many cases has not been published. No one would like to write a book knowing that those to whom it is addressed, know more. I blame industry for the attitude that the Shirley Institute has to take on the question of publication. It has made it difficult for teachers to do the job they wish to do.

Mr. Barnes: I think that there are far more British than American books and far more British than German, but we have nothing like Hertzog's series. It was a complete scheme whereby textile technology was written up according to a plan. I think we should think out fully a scheme of school books written specifically for the purpose and they should be the right size, price, depth and specialisation of subject. In the past, the teachers' output was high and now it is low. I think we should be the right size, price, depth and specialisation of subject. In the past, the teachers' output was high and now it is low. I think we should think out fully a scheme of school books written specifically for the purpose and they should be the right size, price, depth and specialisation of subject. In the past, the teachers' output was high and now it is low. 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I think we should think out fully a scheme of school books written specifically for the purpose and they should be the right size, price, depth and specialisation of sub...
Mr. Creasey: Some months ago I received from America notification of a dictionary of textile developments. The idea was to pay down $60 and they were going to send a card index system compiled throughout the year by a body of experts. It was a question of filing under their system. I imagine that Dr. Withers has seen the thing. Being rather sceptical about it I didn't invest $60. Has Dr. Withers investigated this sort of thing?

Dr. Withers: I haven't made up my mind about the Americans. The advice I have given to most people attached to the Shirley Institute is that they will get far more for a guinea or two a year in British textile abstracts than from these American services for $60.

Mr. Curtis: I should like to suggest that we adjourn this meeting and have another two or three hours at it. The Government want books and are willing to supply paper for the interests of the boys out there who have missed five years. Books are necessary to them. The Textile Institute should take first steps to get it and I am sure they would be accepted by the Government.

Mr. Smith: The need for books is obvious and I think it is far too big a subject for one individual to tackle. These points will be brought forward in the right quarter.

Dr. Cunliffe: I have great pleasure in proposing a vote of thanks to Dr. Withers. It is obvious from the discussion that Dr. Withers has brought before us a subject of utmost and immediate importance. It is clear from what he has said that there is a great lack of text books in certain directions for certain types of reader. I should just like to refer to one book—S. G. Barker's "Wool Quality." I think that this is illustrative of what some of the speakers have in mind. It covers the subject from an authoritative point of view. It was written by his staff and he edited it. Shirley Institute is an excellent body to do this, but there is room for private firms also. There is a need, I think, for summaries from Shirley Institute and other organisations of work that has already been published. A large number of people have difficulty in reading books and they should be simplified.
Notes and Announcements

Annual Meeting

The thirty-fifth Annual General Meeting of the Institute was held in Manchester on Wednesday, 2nd May, when Mr. T. H. McLaren, the President, was in the chair. After the Secretary had read the notice convening the meeting, and the minutes of the previous meeting had been accepted as a true record, Mr. H. G. Greg, the Chairman of the Council, introduced the Council's Report for 1944. In proposing the adoption of the report, Mr. Greg stressed the many activities which had been maintained during the war period, and indicated that the Council was planning future development so that the Institute would make further progress, and not stand still at the close of hostilities. Mr. R. S. Meredith, who seconded the resolution, said that he hoped that full consideration would be given to the functions of fabrics, as well as to their production. The report was adopted by the meeting. The Revenue Account and Balance Sheet for the same period were proposed for acceptance by Mr. W. Howarth, seconded by Mr. A. Draper, and adopted after the auditor had read his report.

At this point Mr. Greg took the chair. On the proposal of Mr. W. Pritchard, seconded by Mr. H. Ashton, it was unanimously resolved that Mr. T. H. McLaren, of Dundee, be re-elected as President for the ensuing year. Before proposing the resolution Mr. Pritchard said that Mr. McLaren had been a very active President in his first year of office, and that the Institute was grateful for the energetic manner in which Mr. McLaren had carried out his duties.

Mr. McLaren then resumed the chair, and in his reply he thanked the members for their confidence in him, and said that he felt honoured in being called upon to serve as President for an extended term. A copy of Mr. McLaren's reply is given at the end of this report.

Mr. W. Kershaw (Manchester), Mr. W. W. L. Lishman (Todmorden) and Mr. W. H. Webb (Randalstown, N. Ireland) were re-elected as Vice-Presidents for a period of three years, on the proposal of Mr. W. Hardacre, seconded by Mr. W. A. Edwards.

The secretary then read out the result of the ballot and the Chairman announced that the following members had been elected to the Council:

For three years:—

H. Ashton, Rochdale.  J. R. S. Goodall, Stockport.
A. Draper, Salford.  T. H. Robinson, Bingley.
N. C. Gee, Dewsbury.  J. Williams, Nelson.

For one year:—E. M. Walker, Leicester.

Messrs. Lloyd, Piggott & Co., incorporated accountants were elected as auditors of the Institute for one year. The business meeting then closed.

At the luncheon which followed seven guests were entertained: Sir Raymond Streat, Dr. C. J. T. Cronshaw, Dr. J. E. Myers, Dr. F. C. Toy, Mr. F. C. Harwood, Dr. H. Phillips and Mr. C. Paine. After the toast to "The King," Mr. W. Howarth proposed the toast of "Our President," to which Mr. McLaren suitably responded. A toast to "Our Guests" was proposed by Mr. H. G. Greg, and Sir Raymond Streat replied on behalf of the guests.

The Mather Lecture was delivered by Dr. C. J. T. Cronshaw, following the luncheon. The subject was "Design for Industry," and a full report will be given in the next issue of the Journal.
PRESIDENTIAL ADDRESS

Gentlemen.—I must thank you for the honour you have done me in re-electing me your President for another term, and assure you of my continued anxiety to do all I can to further a greater interest in the Institute's activities by all those connected and associated with the great textile industries of this country.

I have had the opportunity of appreciating the immense amount of work done quietly and unobtrusively by your Chairman and Members of Council, and to them we all owe a deep debt of gratitude. I am sure the ordinary member has no idea of the time, patience and trouble which these gentlemen exert to keep the day to day affairs of the Institute moving smoothly.

I have been privileged to be present at meetings during the last year of a few of the district sections of the Institute, and have been much impressed by these enthusiastic gatherings and was glad to note a goodly sprinkling of the younger men. It must always be remembered that it is to youth we must look to keep these great industries afloat and ahead in world competition, and it is well for the younger men to be given their head so long as there are older men of wide experience to guide and encourage them in their fresh ideas.

It is more than ever necessary for heads of businesses to have for consultation men with sound technical training, and before long no business of any standing will, I feel sure, retain its foremost place without such assistance.

The Textile Institute is in the unique position of assisting to maintain a flow of properly trained technical assistants to the industry. By its contacts with the Technical Colleges throughout the country, studies are so framed that on reaching a required standard students may qualify as an Associate or as a Fellow of the Textile Institute. This attainment is the hallmark of a particular level of knowledge which directors and executives of manufacturing firms may accept with confidence when considering candidates for vacancies on their staffs.

This distressing war is surely drawing to a close and we may look forward with confidence to a future in which conduct of business will again be free and unhampered by Controls. Everyone must eagerly anticipate the time when discharges of men and women from the Services will admit businesses again being staffed with their skilled workpeople who have come through these trying years. Alas, many will never return, and those who have made the supreme sacrifice we remember with thankful hearts—such deeds make it possible for us to carry on, and with it the duty of improving the lot of our people by better working conditions and fuller amenities.

Many are the blanks in the executive, manager and foremen ranks due to ravages of war, and these—if the highest efficiency is to be achieved and maintained—must be filled with intelligent and highly trained personnel. All must be encouraged to study the theory of their particular jobs and so make themselves highly efficient technicians.

I make no apology for again referring to the Textile Institute as a neutral meeting ground and for begging all those engaged in these great industries to join together in discussions and planning, where associations can be formed, petty jealousies driven forth and friendships formed—all to the ultimate benefit of the country and the people engaged in them.

It is gratifying to know that the steady increase in membership continues, and I sincerely hope all members will bring home to their friends who are non-members the advantages of membership of the Institute so that the snowball effect of increase in uninterrupted.
Much remains yet to be accomplished and many are the items with which your Council will deal in the future. These problems are intricate and of a controversial nature, and they will require all the help and encouragement you can give them to wade through the great masses of detail which must be considered before a final neat picture is presented to us. Assisting in this work is the Acting Secretary and his staff, to whom, in conclusion, I should like to pay tribute for their zeal and unceasing effort in all matters textile and their un-failing courtesy and help to me.

Gentlemen, I thank you for your confidence in re-electing me President for another term.

Review


The development of colorimetry in this country has been handicapped by the lack of any English textbook setting out clearly the theory and methods of exact colour measurement and specification. This is the more surprising when it is realised that the establishment of colour measurement on a sound scientific basis is mainly due to English and American workers. This book is a successful attempt to meet this need.

As stated in the preface, the main purpose of the book is to describe the principles, methods and applications of the trichromatic system of colour measurement, but other methods are by no means neglected although their relation to this system is emphasised. Before describing this system the underlying physical and physiological principles are discussed, the first two chapters being given to these subjects.

The third chapter is perhaps the most important in the book and gives a very clear exposition of the theory and use of the trichromatic system of colour specification and measurement. Starting from the fundamental experimental fact that any colour can be matched by mixing three radiations of different colour in suitable proportions the idea of the colour equation is developed. The nature of the quantities involved is made quite clear, and the conversion of the colour equation from one set of reference stimuli to another is described in detail. In particular the reference stimuli which form the framework of the system adopted by the International Commission on Illumination (known as the C.I.E. system in this country and the I.C.I. system in America) is fully described, as is also the method of obtaining the colour equation from spectral reflection curves.

Succeeding chapters deal with practical colorimeters and spectrophotometers—including photoelectric instruments—and the use of colour charts. The author considers that colour charts are in many cases the best form of working standards, but that in order to ensure permanence they should, in general, be based on the C.I.E. system.

The final chapter deals with the various applications of colorimetry, including the application to dyestuffs and raw materials of the textile industry. The importance of colorimetry in providing an unambiguous scale of fading is dealt with under the application to paints and pigments from which it would seem that its value has been realised more by the users of these materials than by dyers of textile materials.

A very useful appendix gives details of the standard light sources used in colorimetry (one of which forms the basis of the British Standard for colour matching lamps) and a full set of tables for deducing the colour equation from spectrophotometric data.

The book can be thoroughly recommended to those desirous of knowing what colour measurement can do and what are its limitations. It is to be regretted that this small book, excellent though it is, should, under present conditions cost 30/-.

F. L. Warburton.
General Items

Institute Diplomas

Elections to Fellowship and Associateship have been completed as follows since the appearance of the previous list (April issue of the Journal).

**FELLOWSHIP**

Percy Edward Stanhope, F.R.I.C., Branch Manager, Robinson & Co. Ltd., Ramsbottom (Branch of B.D.A. Ltd.).


**ASSOCIATESHIP**

Thomas Frederick Gibbons, B.Sc., Assistant Technical Examining Officer, Admiralty. (Formerly with Tootal Broadhurst Lee Co. Ltd.).

Richard Scholfield, Laboratory Assistant, British Cotton Industry Research Association, Shirley Institute, Manchester.

Frederick Harry Whyte, B.Sc. (Tech.), Technical Research Assistant, Dunlop Cotton Mills Ltd., Rochdale.

Institute Membership

The following applicants were elected to membership at the May meeting of Council:

**Ordinary.**

Joseph Stanley Barke, 2, Ridgefield, Manchester, 2 (Trade and Technical Journalist and Trade Association Secretary).

Thomas Alfred Booth, c/o Comptroller of Stores, Box 514AA, G.P.O., Sydney, N.S.W., Australia (Textile Inspector).

Herbert Evelyn Brearley, "Brian Royd," Hullen Edge Road, Elland, Yorks. (Blanket Manufacturer, West Vale Works, Greeland, Near Halifax).

James Briscoe, 835, St. Helens Road, Over Hulton, Bolton (Cotton Mill Manager, Cannon Bros. Ltd., Stanley Mills, Jackson Street, Bolton).


Feliks Brodowski, 346, Lytham Road, Blackpool, Lancs. (F/Lt. Polish Air Force).

William McMorrine Brown, 50, Batson Street, Glasgow, S.2 (Inspector of Textiles, Inspectorate of Stores, Ministry of Supply, Room 28, 141, Bath Street, Glasgow, C.2).


Arthur Wilfrid Eley, 59, Mellor Road, Western Park, Leicester (Director, Foister, Clay & Ward Ltd., Great Central Street, Leicester).

Markus Gewing, D.Ph., Belfast Silk & Rayon Ltd., Waterford Street, Belfast (Production Manager).

Wilfrid Victor Herbert, 25, Braunstone Avenue, Leicester (Director and Fabric Factory Manager, Wildt & Co. Ltd., Riverside Works, Western Road, Leicester).

Arthur Stanley Hill, Moorgarth, Hebden Road, Haworth, Keighley (Worsted Spinning Production Manager, Irving Firth & Co. Ltd., Beech Mills, Keighley).

Philip Lees, Park House, Shaw, Near Oldham (Assistant Manager, A. & A. Crompton & Co. Ltd., Park and Woodend Mills, Shaw).

Jack Holmes Limb, 100, Bothwell Street, Glasgow (Textile Engineer, Universal Winding Co., 228, Clyde Street, Glasgow).
Alec Murray, B.Sc., 97, Fountain Place, Alexandria, Dumbartonshire (Chief Chemist, British Silk Dyeing Co. Ltd., Balloch, Dumbartonshire).
Hugh L. Robinson, 168, Station Road, Hendon, London, N.W.4 (Deputy Director, Ministry of Supply, Directorate of Surplus Equipment and Stores, 50, Hans Mansions, Hans Road, London, S.W.3).
Boleslaw Wolkowski, Training Centre of Technical Group Polish Forces, P/74 Edinburgh (Officer in Polish Army).
Harvey Wild, 623, Rochdale Road, Royton, Near Oldham (Cotton Spinning Manager and Director, Park & Sandy Lane Mills Co. Ltd., Schofield Street, Royton, Near Oldham).

Junior.
George Arthur Albiston, 21, Normanby Road, Walkden, near Manchester (Technical Trainee, Lancashire Cotton Corporation, Empress Mill, Ince, Wigan).
Herbert Durkin, 64, Calvert Road, Great Lever, Bolton (Stripper and Grinder, John Harwood & Son, Woodside Mills, Bolton).
William Edward Johnson, 4, Finkle Street, Sowerby Bridge, Yorks. (Student).
Kenneth Knowles, 38, Ellesmere Road, Pemberton, Wigan (Technical Trainee, Lancashire Cotton Corporation, May Mill, Pemberton, Wigan).
Wilfrid Nelson, 28, Benson Street, Bolton, Lancs. (Comber Overlookers' Assistant, Musgraves Spinning Co., Chorley Old Road, Bolton).
Andrew Allen Nicholson, 18, Silvio Street, Belfast, N. Ireland (App. Linen Weaving Factory Manager, Wm. Ewart & Son Ltd., Crumlin Road Factory, Belfast).
Joan Lillian O'Donnell, 8, Acresfield Road, Salford, 6, Lancs. (Free Lance Textile Designer).
Keith Thornton, 6, Grafton Place, Ovenden, Halifax (Student, Halifax Municipal Technical College).

Employment Register
The following announcements are taken from entries in our Register of members whose services are on offer. Employers may obtain full particulars on application:

No. 241—A.T.I., 38 years of age, desires position as Manager or Assistant Manager in the Production of Terry towels and towelling. City and Guilds Full Technological Certificate in Cotton Weaving. Expert knowledge of all branches of the towel trade, plain, fancy, jacquards, etc.

No. 242—A.T.I., 34 years of age, desires administrative post in organising capacity, not necessarily inside mills, nor even on the manufacturing side. Full Technological Certificates in Cotton Spinning, Cotton Weaving, Silk and Rayon Weaving, Silk and Rayon Dyeing. Several years' experience in cotton mills in India, in Weaving and also in spinning, including managerial capacity, specially on work of reorganisation. Also widely read in Economics, Business Administration, Psychology and social questions generally.

No. 243—Member, age 44 years, desires position as Textile Weaving Manager, at home or abroad. City and Guilds Full Technological Certificate Experience in Cotton, Linen, Jute and Rayon, also in factory planning and engineering. Specialist in Sizing for all yarns.
Vacancies

TECHNICAL OFFICER—A firm of chemical manufacturers have a vacancy for a graduate, fully conversant with bleaching problems as applied to cotton, wool, silk and rayon; a knowledge of similar problems related to jute and linen would be an advantage. He must also be conversant with detergents and wetting agents. Duties will involve advising customers and carrying out tests at their plants. The Technical Officer will act as manager of the Research Laboratory and ensure a close liaison between the Laboratory and the Head Office. Salary for a suitably qualified man will be approximately £1,000—£1,250. Applications giving full details of qualifications and experience should be addressed to Box No. 75.

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REPRINTS
Orders should be sent to THE TEXTILE INSTITUTE,
16 St. Mary's Parsonage, MANCHESTER, 3.

A FEW COPIES OF THE FOLLOWING REPRINTS ARE AVAILABLE:—
Current Changes in the Technology of Cotton Spinning—W. L. Balls
The Chemistry of Wool and Related Fibres—J. B. Speakman
Recent Industrial Tendencies. The Substitution of Knowledge and Co-operation for Instant
and Competition—H. G. Hughes.
Comparison of the Cloth Qualities of Continental and Noble Combed Materials—E. Midgley.
Textile Research and Development—Sir Robert T. Pickard. Industrial Leadership—A. P. Young.
Liberal Education and Modern Business—Sir M. E. Sadler.
Loom Requirements in Relation to Artificial Silk—W. Wilkinson.

Price 1/- each Post Free. *Price 2/- each Post Free.
When a wool fibre is rubbed lengthways between finger and thumb, it migrates in the direction of the root end, because the surface is composed of a series of overlapping scales which function like a ratchet. Fibre migration of this type is responsible for the felting of loose wool and the shrinkage of wool fabrics under suitable mechanical conditions in presence of aqueous media. Variations in the scaliness of different wools, i.e. variations in the number of scales per unit length and their degree of projection from the body of the fibre, will clearly have an important bearing on their response to felt­ting and milling processes. Some method of measuring the scaliness of wool fibres is therefore essential if a clear understanding of these processes is to be realised, especially as the rate at which felting and shrinkage take place is affected by the length, fineness and crimpiness of the fibres, as well as by their scaliness.

The only available method of measuring the scaliness of animal fibres is one which was devised some years ago in this laboratory. It consists in mounting fifty fibres in parallel, with the scales all pointing in one direction, to form a miniature violin bow. Several determinations are then made of the angle of tilt necessary to cause the bow to slide, first in the direction of the root ends and then in the direction of the tips, on the surface of a cloth having a trail pile finish. If \( \theta_r \) is the average angle of slip in the direction of the root ends, and \( \theta_t \) the average angle of slip in the direction of the tips, the quantity

\[
S = \frac{\tan \theta_t - \tan \theta_r}{\tan \theta_t}
\]

is taken as a measure of scaliness. Although the method has given useful results, it suffers from a number of defects. The construction of the "violin bows" is extremely tedious, there is no opportunity of studying the properties of individual fibres, and the results are not very closely related to felting and milling, where dynamic and not static friction is operative. Not only so, but the value of the quantity \( S \) as a means of comparing the felting properties of different wools is obscure, because \( \theta_r \) varies from one kind of wool to another.

With such considerations in mind, it was decided to build an instrument, termed a lepidometer, for the purpose of measuring the actual creeping power of individual fibres under a rubbing action. The object of this paper is to describe the instrument and some of the results which have been obtained with its aid in recent studies of milling shrinkage and the unshrinkable finish.
EXPERIMENTAL

Part 1 : Construction of the Lepidometer

The lepidometer was designed to give a standardised imitation of the lengthways rubbing action of finger and thumb in the familiar demonstration of the creeping power of animal fibres. The fibre, with its root end downwards, is placed between two surfaces, which are caused to reciprocate under standard pressure. Fibre travel proceeds until the tension developed in a measuring device, to which the tip end of the fibre is attached, is sufficient to arrest motion, and the maximum tension developed is taken as a measure of scaliness.

The apparatus consists essentially of three parts, viz:

1. the rubbing surfaces and their accompanying driving arrangements.
2. the tension measuring device—a torsion wire and torsion head—and
3. the tension recording mechanism, which is arranged to plot tension-time curves automatically on a revolving drum.

Fig. 1.

The main working parts of the apparatus and their relationship to one another are shown in Fig. 1, which is not drawn to scale, while Figs. 2, 3 and 4 are photographs of the actual apparatus. The latter is driven by a Garrard, type RG/1, electric gramophone motor, which is provided with two driving shafts. The first, running at 78 r.p.m., is used to drive the rubbing surfaces, and the second, which is at right-angles to the first, runs at 6.5 r.p.m. and is used to drive the recording drum. Some variation in the speeds of these shafts can, however, be obtained by means of the centrifugal governor which is fitted to such motors. With the exception of the
driving and cross-shafts, which are of mild steel, all the working parts of the apparatus are made of brass.

(1) The Rubbing Surfaces

The carriers for the rubbing surfaces are square brass plates 1 (20mm. x 20mm. x 3mm.), which are lightly pivoted about horizontal axes 2 in the plane of the plates and near their upper horizontal edges. The pivots for each plate pass through the arms of a horizontal-shaped stirrup 3, which is fastened to a sliding block 4 by means of a single screw passing vertically through a longitudinal slot cut in the leg of the stirrup. A clear illustration of this method of suspending the carriers is given in Fig. 3, one of the sliding blocks being shown tilted clear of its slide so as to allow the stirrup and clamping screw to be seen. This arrangement permits the position of the plates 1 to be adjusted for parallelism as well as for horizontal distance apart, by swivelling the stirrups about the clamping screws.

The sliding blocks 4 are H-section and slide easily without rock on two vertical tracks. They are caused to oscillate relative to each other by means of a link motion 5 and opposed eccentrics 6 (Fig. 2), driven from the main shaft of the motor through the right-angle drive 7, consisting of a brass disc driven by a rubber ring 8 on the cross-shaft 9, which is direct-coupled to the motor shaft through a flexible coupling. The throw of the eccentrics is 1-inch, but the actual amplitude of oscillation of the rubbing surfaces can be varied over a wide range by changing the point of attachment of the eccentric rod to the lever 10, which is provided with a number of holes for this purpose. The rate of oscillation (number of strokes per minute) can be varied by using the right-angle drive as an infinitely-variable gear, final adjustments being made with the motor governor.

Pressure is applied to the rubbing surfaces by means of the lever arms 11 and the sliding bobweights 12. The arms are attached at right-angles to the backs of the carriers 1, at their centres, and pass through clear holes drilled in the sliding blocks. By multiplying the weight of the bobs 12 by their distance from the point of attachment of the levers, the additional pressure due to the bobs—termed bobweight leverage—can be calculated. The stops 13 (Fig. 3), which are pivoted on the sliding blocks, are used to control the vertical motion of arms 11 and thus the side-swing of the carriers.

The actual surfaces by which the fibre is rubbed are built up by cementing a pad of felt or rubber (10mm. x 10mm. x 2mm.) to the centre of each carrier by means of shellac. A strip of the chosen friction material, 1-cm. wide, is stretched over each pad in a vertical direction, and is held top and bottom by light clamping bars screwed to the edges of the carrier as shown in Fig. 3. Care is taken to keep the strip under uniform and standard tension. The purpose of the pads is to increase the resilience of the surfaces and facilitate embedding of the fibres; in addition, they make a slight departure from exact parallelism less important than would be the case if rigid surfaces were used.

(2) The Tension-Measuring Device

For the purpose of measuring scaliness, the fibre is mounted by folding a 1-cm. square of gummed paper in half, moistening the gummed surfaces, introducing the tip end at right-angles to the fold, and then pressing the gummed surfaces together. A small hole is then pierced in the paper mount, so that the latter can be slipped on to the light glass hook 14 (Fig. 1) attached to the phosphor-bronze ribbon or braided silk cord 15, which passes over part of the circumference of the torsion head 16. This is a light ebonite wheel mounted on a brass axe to which the torsion wire is attached. For the latter high-tensile steel wire, 0.005 inches in diameter, is used, the 15 cm. length being attached to the brass blocks 17 (Fig. 2), with the torsion head in the middle. The tension in the wire is adjusted by means of two thumbscrews, one of which (18) is visible in Figs. 2 and 4. The axle of the
torsion head carries a light aluminium pointer 19 and adjusting weights 20 and 21. By means of the latter, the centre of gravity of the whole system can be made to coincide with the axis of the wire and torsion is then the only restoring force; alternatively, the sensitivity of the instrument can be reduced by lowering the weight 21, when the restoring force is a combination of torsion and deadweight loading.

During scaliness determinations, movement of the suspended system is damped by a small vane moving in a vessel 22 which contains castor oil. The vane is a small square of mica cemented to the end of an aluminium rod which runs backwards from the axle of the torsion head, parallel to the torsion wire and immediately below it, to near the back anchorage of the wire, where it bends downwards into the castor oil.

(3) The Tension-Recording Mechanism

As the forces acting on the suspended system are small, no recording mechanism which involves the slightest friction is permissible. Either photographic recording or some type of intermittent recorder must be used, and in order to avoid the complications of optical methods, a simple thread recorder was chosen. Its main features are shown in Fig 4.

The recording drum 23 is driven from the slow shaft of the motor through two pairs of worm gears 24, the speed being so reduced that the drum makes one revolution in approximately 20 minutes (circumferential speed 7.3 mm. per minute). The end of the pointer 19 (Fig. 1) is flattened horizontally and the edge of the flattened portion filed to an obtuse knife-edge. Between the pointer and the drum, and some 2 to 3 mm. from the latter, is stretched vertically the inked thread of fine sewing silk 25. Its exact position relative to the drum is adjustable and the best position is ascertained by trial. The thread, which is endless, passes over guide pulleys at the ends of arms 26, and round a tension pulley and an inking roller in the box 27. This roller, which has a felt covering saturated with recording ink, is driven by the belt 28 from a pulley on the slow motor shaft, so that the thread travels continuously while the apparatus is working.

During measurements of scaliness, the pointer is chopped sharply down at timed intervals on to the inked thread and the drum by the chopper bar 29. This bar, which would otherwise be pressed against the drum by the tension spring 30, is held off by the push-rod 31 actuated by the circular cam 32. The cam is shown in phantom in Fig. 4 so as not to hide the gear-drive behind it. On its periphery are cut six semi-circular notches, and each time a notch passes the end of the push-rod the chopper-bar drives the pointer on to the drum with a force governed by the tension in the spring 30. Each contact is of short duration and the rate of travel of the inked thread is sufficiently slow not to interfere with the precision of the record. With six notches in the cam there are 40 contacts per minute and a satisfactory record of the rate of development of tension by the rubbed fibre is thus obtained.

For the purpose of fixing the recording paper, the drum 23 can be drawn off its spindle, without disturbing either thread, pointer or chopper-bar, by removing the thumb-nut 33. As it is seldom necessary to rub a fibre for more than 30 seconds, up to 40 tests can be recorded on one sheet of paper, and under suitable conditions—coarse, straight, dry fibres—50 fibres may be tested in one hour without undue strain.

The instrument is calibrated by suspending weights from the hook 14 and noting the elevation of the pointer as it records on the revolving drum 23. When torsion is supplemented by deadweight loading, the tension scale is linear up to an angular movement of the pointer of about 60°, as may be seen from the typical calibration curve of Fig. 5.

Scaliness measurements can be made in liquids as well as in air, because the two strips of friction material curve apart above the felt or rubber back-
ing, as shown in Fig. 1, to form a recess in which about 0.5 c.c. of liquid can be accommodated. If solutions are used, errors due to changes in concentration by evaporation of water are avoided by removing some of the old solution at intervals by means of filter paper and adding a few more drops. Fibres examined under these conditions are, of course, allowed to come to equilibrium with the solution before being transferred to the apparatus for measurements of scaliness.

Selection of Rubbing Surfaces

The requirements which must be fulfilled by any material which is to serve as the rubbing surface are that it should be reproducible and available in standard form; that it should be thin, flexible and able to slide on itself without undue friction; and that it should possess suitable abrasion characteristics.

Of a large number of materials examined, very few fulfilled most of these requirements and none was found entirely satisfactory for all types of fibre under the various possible conditions of use. Oiled silk and closely woven nylon fabrics were suitable for use with coarse fibres, but the mounting of the surfaces so as to ensure reproducible results was difficult. Rubberised cotton (macintosh fabric) surfaces did not slide over each other satisfactorily. None of the fabrics could be used with merino fibres because they slid into grooves in the material and thereafter did not move. The difficulty persisted even when the fabric was cut on the bias.

Cellophane and cellulose ester films grooved badly in contact with the fibres, and the same fault made it impossible to use chamois and other kinds of leather. Unplasticised polystyrene film was too brittle, but a film of polyvinyl chloride, which was too sticky dry, gave satisfactory results in presence of soap solution. Most of the available specimens of natural and synthetic rubbers were too tacky, and only the following three materials were found suitable for general use:

(a) Sheet rubber containing an acid-soluble filler. This material, which was the only one available at the beginning of the investigation, was used in most of the following work, and is referred to as "carbonate-filled" rubber.

(b) Polythene film, which suffers rapid wear with dry fibres, but is satisfactory in presence of liquids.
Sheet rubber filled with barium sulphate. Like polythene, but for a different reason—excessive friction when dry—the rubber was usable only with liquids.

The performance of these materials is illustrated by the tension-time curves of Fig. 6, where the first sharp rise on the curves, usually represented by a few widely-spaced dots, has been reinforced for purposes of photography. Curve \( A \) was given by a human hair fibre on carbonate-filled rubber surfaces in presence of soap solution*, and curve \( B \) by a similar fibre on polythene surfaces, again in presence of soap solution. Curves of type \( B \) are also obtained with sulphate-filled rubber. In curve \( A \) the sharp rise is succeeded by a rapid and then a slower fall, presumably owing to the action of the carbonate-filled rubber in wearing down the scales. Since the level of curve \( B \) is independent of the time of rubbing, after the sharp initial rise, it seems probable that neither the fibre nor the polythene surfaces suffered any significant amount of wear during the test. The alternative, that all the wear took place before maximum tension was attained, was eliminated by microscopic examination of rubbed fibres.

For this purpose, the hypochlorite-methylene blue staining technique of Whewell and Woods* was used with the root ends of Lincoln wool fibres, which had been purified by extraction with alcohol and ether. The behaviour of wool on rubber and polythene is similar to that of human hair, and wool was preferred because of the absence of pigment. Each fibre was rubbed for 40 seconds in air, or in soap solution after 3 hours’ immersion, under the conditions specified in Table 1. As the mean maximum tension varied from one set to another, the sensitivity of the lepidometer was adjusted to give the same mean length of fibre travel in each case. The central part (about 1.5 cms.) of the rubbed portion of each fibre was removed, soap-treated fibres being extracted with alcohol before staining.

The rubbed lengths of fibre were allowed to stand for 15 minutes at room temperature in 50 ccs. of sodium hypochlorite solution (pH 10.6) containing 0.6g. of available chlorine per litre. After being washed in five changes of distilled water for one minute each time, the fibres were immersed in 50 ccs. of methylene blue solution (0.4g. per litre) for 5 minutes, washed 5 minutes in running water and finally dried between filter papers. They were then cut up into 2-mm. lengths, which were mounted on a microscope slide in liquid paraffin, examined, and grouped into five classes according to the extent of staining. The results are given in Table 1, the mean score given in the last column being calculated in the usual manner.

Table 1

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of fibres</th>
<th>Percentage of fibres in class</th>
<th>Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>104</td>
<td>30.8 55.8 11.4 2.0 0.0</td>
<td>0.85</td>
</tr>
<tr>
<td>Immersed in soap solution for 3 hours</td>
<td>110</td>
<td>27.3 54.6 18.1 0.0 0.0</td>
<td>0.91</td>
</tr>
<tr>
<td>Carbonate-filled rubber, dry</td>
<td>77</td>
<td>2.6 55.8 32.5 9.1 0.0</td>
<td>1.48</td>
</tr>
<tr>
<td>Carbonate-filled rubber, dry</td>
<td>69</td>
<td>2.9 50.4 33.4 4.3 0.0</td>
<td>1.39</td>
</tr>
<tr>
<td>Carbonate-filled rubber, soap</td>
<td>86</td>
<td>8.1 50.0 40.8 1.1 0.0</td>
<td>1.35</td>
</tr>
<tr>
<td>Polythene, soap</td>
<td>73</td>
<td>16.4 71.3 12.3 0.0 0.0</td>
<td>0.96</td>
</tr>
</tbody>
</table>

* b.l = bobweight leverage.

* A 0.2 per cent. solution of anhydrous sodium oleate was used throughout the investigation.
It is obvious that fibres rubbed by polythene surfaces suffer very much less damage than fibres rubbed by carbonate-filled rubber surfaces, and since the staining test is extremely sensitive, there can be no doubt that the rise of the tension to a high value, which is independent of the time of rubbing, is characteristic of negligible wear on the fibres. Conversely, the sharp maximum on curve A is clearly due to the rapidity with which the scales are abraded by carbonate-filled rubber, and it is doubtful whether the maximum tension developed is a true measure of scaliness. As, however, the fibre travels through the nip of the surfaces during the initial rapid increase in tension, abrasion should not be serious until the true maximum tension is attained and movement ceases. If this view is correct, the maximum tension developed on carbonate-filled rubber surfaces may well be a true measure of scaliness.

The consistent use of a material giving curves of type B would obviously be ideal for the measurement of scaliness, but no one material can give such curves with all fibres because they vary considerably in their resistance to abrasion. Among materials which are similar to animal fibres in abrasiveness, the choice must therefore be between those which are more and those which are less abrasive; if more abrasive, the fibres are worn; if less abrasive, the material is grooved. This does sometimes happen with polythene and the tension then rises to a value which remains constant for a short time before rising indefinitely. In practice, therefore, the rubbing surfaces must act abrasively on the fibres, but materials with only a slight abrasive action are selected in order to ensure that the maximum tension developed is a true measure of scaliness. It must, however, be noted that abrasive surfaces have the special advantage of allowing the abrasion-resistance of fibres to be studied at the same time as their scaliness is measured.

**Reproducibility of Results**

For determinations of scaliness, the rate of rubbing is normally maintained at 78 strokes per minute. Strict control of the rate is, however, unnecessary, as may be seen from the data of Table 2, which were obtained with New Zealand Romney fibres on carbonate-filled rubber surfaces in air.

<table>
<thead>
<tr>
<th>Rate of rubbing (strokes/minute)</th>
<th>Number of fibres</th>
<th>Mean maximum tension (g.)</th>
<th>Coefficient of variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>50</td>
<td>0.76 ± 0.03*</td>
<td>24.0</td>
</tr>
<tr>
<td>40</td>
<td>50</td>
<td>0.81 ± 0.03*</td>
<td>28.9</td>
</tr>
</tbody>
</table>

* Standard error.

On the other hand, the pressure applied to the rubbing surfaces must be strictly controlled if reproducible results are to be obtained. The results of Table 3 were obtained with the root ends of Lincoln wool fibres on polythene surfaces in presence of soap solution.

<table>
<thead>
<tr>
<th>Bobweight leverage (g.cm.)</th>
<th>Number of fibres</th>
<th>Mean maximum tension (g.)</th>
<th>Coefficient of variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>40</td>
<td>1.32 ± 0.04*</td>
<td>18.4</td>
</tr>
<tr>
<td>108</td>
<td>40</td>
<td>3.07 ± 0.07</td>
<td>14.8</td>
</tr>
<tr>
<td>150</td>
<td>40</td>
<td>4.45 ± 0.10</td>
<td>14.2</td>
</tr>
<tr>
<td>228</td>
<td>40</td>
<td>5.65 ± 0.21</td>
<td>23.1</td>
</tr>
<tr>
<td>327</td>
<td>40</td>
<td>6.98 ± 0.22</td>
<td>20.2</td>
</tr>
</tbody>
</table>

* Standard error.
It is obvious that the maximum tension developed is profoundly affected by variations in bobweight leverage. At the two highest pressures used, there is some grooving of the polythene surfaces, and excessive pressure was therefore avoided in all subsequent work.

Data illustrating the consistency of the results obtained with different pairs of surfaces of the same material are given in Table 4. The root ends of Lincoln wool fibres were used and the rubbing surfaces were backed with felt pads. As the horizontal distance apart of the surfaces was not the same for different pairs of experiments, comparison of the results outside the pairs is not permissible.

Table 4

<table>
<thead>
<tr>
<th>Test</th>
<th>Conditions of measurement</th>
<th>Number of fibres</th>
<th>Mean maximum tension (g.)</th>
<th>Coefficient of variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carbonate-filled rubber, dry</td>
<td>90</td>
<td>1.31 ± 0.05*</td>
<td>34.5</td>
</tr>
<tr>
<td></td>
<td>b.l = 166 g.cms.</td>
<td>50</td>
<td>1.34 ± 0.06</td>
<td>33.5</td>
</tr>
<tr>
<td>2</td>
<td>Carbonate-filled rubber, water</td>
<td>40</td>
<td>3.21 ± 0.15</td>
<td>29.6</td>
</tr>
<tr>
<td></td>
<td>b.l = 166 g.cms.</td>
<td>50</td>
<td>3.23 ± 0.16</td>
<td>35.5</td>
</tr>
<tr>
<td>3</td>
<td>Carbonate-filled rubber, soap</td>
<td>50</td>
<td>1.97 ± 0.08</td>
<td>30.2</td>
</tr>
<tr>
<td></td>
<td>b.l = 108 g.cms.</td>
<td>49</td>
<td>1.99 ± 0.08</td>
<td>27.5</td>
</tr>
<tr>
<td>4</td>
<td>Carbonate-filled rubber, soap</td>
<td>50</td>
<td>2.78 ± 0.13</td>
<td>32.5</td>
</tr>
<tr>
<td></td>
<td>b.l = 189 g.cms.</td>
<td>50</td>
<td>2.75 ± 0.15</td>
<td>39.5</td>
</tr>
<tr>
<td>5</td>
<td>Polythene, soap, no bob- weights</td>
<td>41</td>
<td>1.07 ± 0.04</td>
<td>24.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
<td>1.12 ± 0.06</td>
<td>32.1</td>
</tr>
</tbody>
</table>

* Standard error.

In obtaining the results of Test 3, the calibration of the instrument was altered from 37.8 mm./g. in the first experiment to 22.1 mm./g. in the second. Over the range examined, therefore, the maximum tension developed is independent of the length of travel of the fibres. The results of Test 4 are specially interesting because the felt backing of the surfaces in the first experiment had been used previously with about 500 fibres, whereas new felt pads, as well as new surfaces, were employed in the second experiment.

An attempt was made to study the durability of the surfaces by calculating the (quadratic) regression of maximum tension on fibre number, but the results were unsatisfactory because of the small number of observations and their variability. Comparison of the means of successive tens, combined with visual examination of the used surfaces, did, however, show that carbonate-filled rubber could be used satisfactorily with up to at least 150 fibres in air. In soap solution the material began to deteriorate after 70 to 80 fibres had been examined, and polythene surfaces were unreliable after testing 50 to 60 fibres. Fortunately, no more than 40 to 50 fibres need be tested to give a reliable mean, as is shown in Table 4, and the poor resistance of the surfaces to wear is therefore of no serious consequence.

It will be noticed that the reproducibility of the coefficient of variation is smaller than that of the mean maximum tension, probably owing to slight variations in the parallelism of the surfaces. Nevertheless, valuable information has been obtained by using this factor as a measure of the uniformity of chemical treatments.

Part 2: Typical Uses of the Lepidometer

(1) Milling/Shrinkage

Other things being equal, the rate of shrinkage of wool fabrics in a milling machine is more rapid in presence of acid or alkali (up to at least pH 10) than in water, and the beneficial effect of these reagents has been referred to their action in modifying the elastic properties of the fibres.
By breaking down the salt linkages between the main peptide chains of wool, acids and alkalis facilitate deformation of the fibres, thus promoting the fibre-travel responsible for shrinkage. The fibres migrate in much the same way as an earthworm crawls, i.e. by alternate extension and contraction, and acids are superior to alkalis as milling agents because they are without effect on the disulphide bonds between the main peptide chains of wool. Ease of deformation is obtained without interference with the power of recovery from deformation. Alkalis, on the other hand, attack the disulphide bonds, and if the pH value of the solution is too high, milling is impeded because the increased ease of deformation of the fibres is outweighed by the greater difficulty of recovery from deformation. Confirmation of these views, and proof of the importance of the elastic properties of wool fibres in relation to milling shrinkage, have been obtained in the discovery of two methods of making wool fabrics unshrinkable by increasing the resistance of the fibres to deformation without modifying their scaliness. There is, however, a possibility that acids and alkalis may facilitate milling shrinkage by modifying the scaliness, as well as the elastic properties, of the fibres. Whewell and his collaborators, using the "violin bow" method, have measured the scaliness of wool fibres in solutions of acid and alkali, as well as in water, with the following results:

<table>
<thead>
<tr>
<th>Medium</th>
<th>Scaliness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrochloric acid (pH 1)</td>
<td>29.4</td>
</tr>
<tr>
<td>Water</td>
<td>23.5</td>
</tr>
<tr>
<td>2% Borax solution (pH 9.24)</td>
<td>21.5</td>
</tr>
</tbody>
</table>

In agreement with the effect of acids in promoting milling shrinkage, the scaliness of wool fibres is greater at pH 1 than in water, possibly because the swelling which accompanies salt linkage breakdown affects the prominence of the scales. Alternatively, the effectiveness of the scales in promoting fibre-travel may depend on their elastic properties, if the free edges have the degree of flexibility which has been envisaged by Rudall. The reduced scaliness of the fibres in borax solution is unexpected but can hardly be discussed without data for the rate of shrinkage of fabric in water and in borax solution. In the light of these observations, however, it seemed desirable to measure the scaliness of wood fibres in media of varying pH.
\( \text{pH} \) as soon as the lepidometer was constructed\(^{13} \). The rate of shrinkage of all-wool flannel in the same media was also determined in a model milling machine\(^9 \), so that the significance of variations in scaliness in relation to milling shrinkage might be assessed.

(a) Scaliness. Human hair was examined on polythene surfaces backed with pads of sulphate-filled rubber. After extraction with alcohol and ether, a bundle of fibres was soaked overnight in 50 ccs. of the appropriate buffer solution at room temperature. Single fibres were removed at intervals, mounted, and introduced between the polythene surfaces, which were kept wet with the buffer solution throughout the determinations.

The results are given in Table 5, illustrated by Fig. 7.

<table>
<thead>
<tr>
<th>Buffer</th>
<th>( \text{pH} )</th>
<th>Number of fibres</th>
<th>Mean maximum tension (g.)</th>
<th>Coefficient of Variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{CH}_3\text{COONa + HCl} )</td>
<td>1.22</td>
<td>39</td>
<td>0.55 ± 0.02</td>
<td>22.9</td>
</tr>
<tr>
<td></td>
<td>2.21</td>
<td>80</td>
<td>0.45 ± 0.02</td>
<td>35.0</td>
</tr>
<tr>
<td></td>
<td>3.39</td>
<td>37</td>
<td>0.39 ± 0.02</td>
<td>33.4</td>
</tr>
<tr>
<td></td>
<td>5.14</td>
<td>40</td>
<td>0.39 ± 0.02</td>
<td>30.0</td>
</tr>
<tr>
<td>( \text{KH}_2\text{PO}_4 + \text{NaOH} )</td>
<td>5.85</td>
<td>40</td>
<td>0.40 ± 0.02</td>
<td>24.6</td>
</tr>
<tr>
<td></td>
<td>6.98</td>
<td>40</td>
<td>0.41 ± 0.02</td>
<td>26.3</td>
</tr>
<tr>
<td></td>
<td>7.87</td>
<td>40</td>
<td>0.41 ± 0.02</td>
<td>26.0</td>
</tr>
<tr>
<td>( \text{H}_3\text{BO}_3 + \text{NaOH} )</td>
<td>8.10</td>
<td>40</td>
<td>0.40 ± 0.02</td>
<td>35.3</td>
</tr>
<tr>
<td></td>
<td>9.07</td>
<td>38</td>
<td>0.38 ± 0.02</td>
<td>32.9</td>
</tr>
<tr>
<td></td>
<td>9.98</td>
<td>40</td>
<td>0.42 ± 0.02</td>
<td>33.1</td>
</tr>
<tr>
<td>( \text{Na}_2\text{CO}_3 + \text{HCl} )</td>
<td>10.52</td>
<td>40</td>
<td>0.47 ± 0.02</td>
<td>21.6</td>
</tr>
<tr>
<td></td>
<td>11.36</td>
<td>40</td>
<td>0.47 ± 0.02</td>
<td>32.4</td>
</tr>
<tr>
<td>( \text{Na}_2\text{HPO}_4 + \text{NaOH} )</td>
<td>11.29</td>
<td>41</td>
<td>0.57 ± 0.02</td>
<td>23.3</td>
</tr>
<tr>
<td></td>
<td>12.06</td>
<td>40</td>
<td>0.46 ± 0.02</td>
<td>23.0</td>
</tr>
</tbody>
</table>

* Standard error.

Similar, though less reliable, results were obtained with the root ends of Lincoln wool fibres in the same series of buffer solutions, using polythene surfaces with backings of felt. In these experiments, the felt as well as the polythene surfaces was wetted with buffer solution, and the precision of the results may have been affected by the swelling of the felt, particularly in strongly alkaline solutions.

From Fig. 7 it is obvious that the scaliness of the fibres increases with fall of \( \text{pH} \) below 4, and there can be no doubt that the increased rate of shrinkage of wool fabrics in acid media is due to increased scaliness, as well as to modified elastic properties of the fibres, though the two factors may be related as has already been suggested. Above \( \text{pH} \) 9, too, the scaliness of the fibres first increases and then, above \( \text{pH} \) 11, decreases. The reality of the fall in scaliness at high \( \text{pH} \) values is emphasised by the data obtained with fibres in phosphate buffers. In the light of these results, it seemed possible that the increased rate of shrinkage of wool fabrics in media of moderate alkalinity might also be due to increased scaliness as well as to modified elastic properties. Similarly, although the \( \text{pH} \) values for maximum scaliness and maximum rate of shrinkage in alkaline media\(^1 \) are not identical, it is possible that the ineffectiveness of strongly alkaline media as milling agents is connected with reduced scaliness as well as with impaired elastic properties. Attention must, however, be called to the fact that specific ion effects are noticeable with the carbonate and phosphate buffers at \( \text{pH} \) 11. Even more marked specific ion effects were noted in acid media, using phthalate buffers, but the data are omitted from Table 5 which, apart from
the phosphate buffers at \( pH \) 11-12, is confined to buffers which appear to be comparable with one another. The existence of specific ion effects made it necessary, however, to study the rate of shrinkage of fabric in the buffer solutions used in measurements of scaliness, before any satisfactory conclusions regarding the connection between scaliness and milling shrinkage could be reached.

(b) Shrinkage. Determinations of the rate of shrinkage at different \( pH \) values were carried out in a model milling machine with strips of fabric having the following characteristics:

- **Warp:** 28s Yorkshire skeins, with 14.5 turns/inch twist; 34 ends/inch.
- **Weft:** 28s Yorkshire skeins, with 10.0 turns/inch twist; 31 picks/inch.
- **Weave:** Plain. **Weight:** 5.2 ozs./square yard.

Alcohol-soluble matter, determined by Soxhlet extraction, 1.5 per cent. on the dry weight.

Two areas, each 30 cms. by 20 cms., were marked out in coloured cotton on each strip of cloth, which measured 200 cms. by 38 cms. After being conditioned at 65 per cent. relative humidity and 22.2°C., the strip was weighed, soaked overnight in 3 litres of the appropriate buffer solution, centrifuged, and re-weighed after the areas of the marked rectangles had been re-determined. The cloth was then introduced into the milling machine and the ends sewn together. When the machine was started, sufficient of the solution in which the cloth had been soaked was added to bring the total weight up to twice the air-dry* weight. Milling was allowed to proceed for 30 minutes, 5 c.c. lots of water being added after 10 and 20 minutes' milling and temperature readings being taken in the usual manner. The thermostat was maintained at 19°C. and the mean temperature of the cloths was 20° ± 1°C. At the end of the milling period the cloth was weighed and the areas of the marked rectangles re-measured. The resulting data are given in Table 6, which includes the \( pH \) values of the solutions in equilibrium with the cloths, determined by means of the glass electrode.

### Table 6

<table>
<thead>
<tr>
<th>Buffer</th>
<th>( pH )</th>
<th>Weight of cloth (g.)</th>
<th>Percentage shrinkage in</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Air-dry</td>
<td>After centrifuging and adding solution</td>
<td>After milling</td>
</tr>
<tr>
<td><strong>CH\textsubscript{3}COONa + HCl</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.40</td>
<td>132</td>
<td>264</td>
<td>262</td>
<td>31.8</td>
</tr>
<tr>
<td>2.08</td>
<td>131</td>
<td>262</td>
<td>261</td>
<td>29.0</td>
</tr>
<tr>
<td>3.22</td>
<td>128</td>
<td>256</td>
<td>253</td>
<td>26.6</td>
</tr>
<tr>
<td>3.78</td>
<td>129</td>
<td>258</td>
<td>259</td>
<td>24.9</td>
</tr>
<tr>
<td>4.13</td>
<td>131</td>
<td>262</td>
<td>262</td>
<td>25.4</td>
</tr>
<tr>
<td>4.98</td>
<td>129</td>
<td>258</td>
<td>255</td>
<td>25.0</td>
</tr>
<tr>
<td><strong>KH\textsubscript{2}PO\textsubscript{4} + NaOH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.13</td>
<td>132</td>
<td>264</td>
<td>262</td>
<td>21.8</td>
</tr>
<tr>
<td>6.90</td>
<td>132</td>
<td>264</td>
<td>264</td>
<td>19.1</td>
</tr>
<tr>
<td>8.05</td>
<td>133</td>
<td>266</td>
<td>267</td>
<td>14.7</td>
</tr>
<tr>
<td><strong>H\textsubscript{3}BO\textsubscript{3} + NaOH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.03</td>
<td>132</td>
<td>264</td>
<td>263</td>
<td>17.5</td>
</tr>
<tr>
<td>9.02</td>
<td>130</td>
<td>260</td>
<td>252</td>
<td>18.5</td>
</tr>
<tr>
<td>9.80</td>
<td>128</td>
<td>256</td>
<td>258</td>
<td>18.6</td>
</tr>
<tr>
<td><strong>Na\textsubscript{2}CO\textsubscript{3} + HCl</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.96</td>
<td>128</td>
<td>256</td>
<td>255</td>
<td>14.9</td>
</tr>
<tr>
<td>10.52</td>
<td>131</td>
<td>262</td>
<td>264</td>
<td>13.5</td>
</tr>
<tr>
<td>10.82</td>
<td>129</td>
<td>258</td>
<td>261</td>
<td>11.3</td>
</tr>
</tbody>
</table>

Area shrinkage is shown as a function of \( pH \) in Fig. 8. Below \( pH \) 4 the degree of shrinkage increases steadily with fall of \( pH \), in keeping with the increasing scaliness shown in Fig. 7, and it seems clear that acids have the

* Throughout this paper, the term "air-dry" implies conditioning at 65 per cent. relative humidity and 22.2°C.
twofold function in milling of increasing the scaliness of the fibres and reducing their resistance to deformation. Whereas scaliness is sensibly independent of pH between pH 4 and 9, however, the degree of shrinkage decreases steadily with rise of pH above pH 6, after remaining approximately constant between pH 4 and 6. That the extent of shrinkage should fall at pH values above 6, despite the constancy of scaliness up to pH 9 and the rise between pH 9 and 11, is a further proof of the importance of the elastic properties of wool fibres in relation to milling shrinkage.

![Graph](image)

Fig. 8

Attention must now be drawn to the fact that the curve of Fig. 8 at pH values above 6, is unlike the earlier curve which showed milling shrinkage to be independent of pH between pH 4 and 8, then to increase up to pH 10, and finally to fall. The earlier results were, however, obtained with unbuffered solutions, and their validity has been confirmed in further experiments with such solutions in the model milling machine. As the data are unrelated to the present investigation, they need not now be discussed.

(2) The Unshrinkable Finish

(a) Wet Chlorination. When wool fibres are treated with an aqueous solution of chlorine, the disulphide bonds between the main peptide chains are broken and the attacked structure swells and gelatinises, especially in alkaline solutions. The gelatinous layer on and under the scales is believed to be responsible for the unshrinkability of chlorinated wool\(^1\), and it seemed probable that the lepidometer might usefully be employed to study the relationship between the scaliness of fibres chlorinated to varying degrees and the degree of unshrinkability of corresponding fabrics. Observations of this type have already been made by Whewell and his collaborators\(^1\), using the "violin bow" method of determining scaliness, and the purpose of the following work was simply to demonstrate that the lepidometer could be used with equal success and greater convenience to study the reaction between wool and reagents which are calculated to promote unshrinkability by superficial attack on the fibres. In addition, it was hoped that the lepidometer
would have the special advantage of allowing the uniformity of chlorination to be assessed, because the fibres are examined individually instead of in groups of sixty.

The root ends of Lincoln wool fibres were used for scaliness measurements. After the fibres had been purified by extraction with alcohol and ether, a bundle was attached by means of sewing cotton to a 5g. (air-dry) square of all-wool flannel, which had likewise been purified by extraction and possessed the following characteristics:

Warp: 28s Yorkshire skeins, 34 ends per inch.
Weft: 28s Yorkshire skeins, 34 ends per inch.
Weave: Plain. Weight: 5.4 ozs./square yard.

A rectangle, 10 cms. × 15 cms., was marked out on the square of flannel to facilitate subsequent measurement of its degree of unshrinkability after chlorination. For this purpose, each sample was immersed at room temperature in 50 ccs. of M/20 potassium hydrogen phthalate solution (pH 4) containing 0.1 per cent. Teepol as wetting agent. Sodium hypochlorite solution (50 ccs.) of the appropriate concentration was then added, with constant stirring, over a period of 10 minutes, and the treatment was allowed to proceed for a further 5 minutes after the addition had been completed. At the end of this time the amount of unabsorbed chlorine was estimated by removing aliquots of the solution for titration with sodium thiosulphate. The treated pattern, with its attached fibres, was immersed for 5 minutes in 500 ccs. of 1 per cent. sodium bisulphite solution, and then for 5 minutes in 500 ccs. of 0.5 per cent. sodium bicarbonate solution, before being washed in running water overnight. The fabric was finally centrifuged and allowed to dry in room air.

After the Lincoln fibres had been detached, all the treated samples, together with a control, were milled together by hand in warm 5 per cent. soap solution. The shrinkages of the treated samples are shown as percentages of the shrinkage of the untreated sample in Table 7, which includes values for the scaliness of the treated and untreated Lincoln fibres. Scaliness measurements were made on carbonate-filled rubber surfaces with backsings of felt, using a bobweight leverage of 108 g. cms. The fibres were examined dry and in soap solution. In the latter case, both the felt pads and the rubber surfaces were wetted with soap solution, in which the fibres were allowed to stand for two hours before use.

### Table 7

<table>
<thead>
<tr>
<th>Chlorine absorbed (g./100g. wool)</th>
<th>Scaliness in soap solution</th>
<th>Scaliness in air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrinkage in area</td>
<td>Number of fibres</td>
<td>Mean max. tension (g.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>—</td>
<td>49</td>
<td>1.99 ± 0.08*</td>
</tr>
<tr>
<td>0.98</td>
<td>50</td>
<td>1.18 ± 0.08</td>
</tr>
<tr>
<td>1.96</td>
<td>43</td>
<td>0.43 ± 0.05</td>
</tr>
<tr>
<td>2.94</td>
<td>49</td>
<td>0.27 ± 0.02</td>
</tr>
<tr>
<td>3.84</td>
<td>53</td>
<td>0.30 ± 0.02</td>
</tr>
<tr>
<td>5.88</td>
<td>50</td>
<td>0.21 ± 0.01</td>
</tr>
</tbody>
</table>

* Standard error.

As the amount of chlorine absorbed by the wool increases, the shrinkage of the treated patterns decreases, and so does the scaliness of the fibres in air and in soap solution. Decreased scaliness is undoubtedly the cause of unshrinkability in the case of chlorinated wool, but it is interesting that complete unshrinkability should be realised before scaliness is entirely elimin-
ated. It must, however, be noted that the shrinkages of the treated patterns were determined after a limited period of milling. When milling is prolonged, chlorinated fabric undergoes rapid contraction after preliminary expansion, as would be expected from the scaliness measurements. Data illustrating this phenomenon were obtained with a chlorinated length of the flannel used in the preceding experiments. A 47.5g (air-dry) sample measuring 38 cms. x 75 cms., with a 2.5g. (air-dry) control, was wetted out at room temperature in 1500 ccs. of M/20 potassium hydrogen phthalate solution (pH 4) containing 0.1 per cent. Teepol. Sodium hydrochlorite solution (500 ccs.) containing 3.0g. available chlorine per litre (3 per cent. on the weight of the wool) was added over a period of 10 minutes with constant stirring. Treatment was continued for a further 5 minutes and the cloth was then immersed in 1 litre of 1 per cent. sodium bisulphite solution for 5 minutes, followed by 5 minutes in 1 litre of 0.5 per cent. sodium bicarbonate solution and overnight washing in running water. The control pattern, on being handmilled with soap in the usual way, expanded 5.8 per cent, whereas an untreated pattern milled at the same time gave an area shrinkage of 44.2 per cent. When the main length of chlorinated fabric was milled with soap in the model milling machine, however, pronounced shrinkage was ultimately obtained. Untreated, chlorinated and two other lengths of flannel were sewn together and milled at 20°C., using 135 ccs. of a 5 per cent. soap solution with a total weight of 100g. wool. During milling, water was added from time to time to compensate for loss by evaporation. The areas of marked rectangles on the patterns were measured at intervals, and shrinkage data for the untreated and chlorinated patterns are given in Table 8.

<table>
<thead>
<tr>
<th>Time of Milling (hours)</th>
<th>Percentage shrinkage of Untreated fabric</th>
<th>Chlorinated fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length</td>
<td>Width</td>
</tr>
<tr>
<td>0.25</td>
<td>10.9</td>
<td>5.3</td>
</tr>
<tr>
<td>0.58</td>
<td>18.8</td>
<td>16.9</td>
</tr>
<tr>
<td>1.00</td>
<td>26.2</td>
<td>22.8</td>
</tr>
<tr>
<td>1.75</td>
<td>34.2</td>
<td>29.3</td>
</tr>
<tr>
<td>2.25</td>
<td>40.0</td>
<td>30.2</td>
</tr>
<tr>
<td>3.00</td>
<td>40.2</td>
<td>32.2</td>
</tr>
<tr>
<td>4.00</td>
<td>42.7</td>
<td>33.3</td>
</tr>
<tr>
<td>5.00</td>
<td>42.7</td>
<td>33.3</td>
</tr>
<tr>
<td>6.00</td>
<td>44.4</td>
<td>33.8</td>
</tr>
<tr>
<td>7.50</td>
<td>44.4</td>
<td>34.8</td>
</tr>
</tbody>
</table>

Reverting to the data of Table 7, it is obvious that the lepidometer data do provide a measure of the uniformity of treatment of the fibres. The coefficient of variation rises rapidly as the amount of absorbed chlorine increases up to 2 per cent. Beyond this point the coefficient falls, especially in soap solution, suggesting that the primary irregularity of treatment with small amounts of chlorine is smoothed out when more chlorine is used. As was expected, therefore, the lepidometer can be used to assess the uniformity of treatments calculated to make wool unshrinkable, as well as for the purpose of elucidating the precise cause of unshrinkability in any particular case.

(b) Cross-linkage Formation. As has already been indicated, fabrics are incapable of undergoing milling shrinkage unless some or all of the component fibres possess a surface scale structure, are easily deformed, and possess the power of recovery from deformation. Conversely, it has been argued that an unshrinkable finish might be conferred on wool fibres by
modifying their elastic properties instead of by the customary method of attacking the surface scale structure. In agreement with this deduction, a high degree of unshrinkability has been imparted to wool fabrics by polymerising ethylene sulphide and other monomers within the fibres so as to increase their resistance to deformation. A simpler method of modifying the elastic properties of wool fibres in the manner required for unshrinkability is, however, to increase the number of stable cross-linkages between the peptide chains. Among agents known to be capable of cross-linking animal fibres, by far the most effective are mercuric acetate and benzoquinone. Both compounds were found to be capable of making wool fabrics unshrinkable, but in order to show that unshrinkability is due to changes in the elastic properties of the fibres, it became necessary to demonstrate that their scaliness was unaltered. The lepidometer was employed for this purpose with fibres prepared in the following manner.

(i) *Mercuric acetate.* The root ends of Lincoln wool fibres were first purified by extraction with alcohol and ether, and a bundle of fibres was then attached by means of sewing cotton to a 2.5g. (air-dry) sample of the all-wool flannel described on p. After the flannel had been immersed in 100 ccs. of a 0.1M solution of mercuric acetate in 0.1M acetic acid for 1 hour at 25°C., it was rinsed in three changes of 500 ccs. of distilled water over a period of 1 hour. The Lincoln fibres were then removed for measurements of scaliness, while the treated pattern was milled with an untreated pattern by hand for 15 minutes in 5 per cent. soap solution. The shrinkages of both patterns are given in Table 9, which includes the results of scaliness determinations. Fifty fibres were examined in each case, using carbonate-filled rubber surfaces, provided with backings of felt, and a bobweight leverage of 220 g.cms. For measurements in soap solution, both the felt pads and the rubber surfaces were wetted with soap in the usual way.

<table>
<thead>
<tr>
<th>Material</th>
<th>Shrinkage in area (%)</th>
<th>Scaliness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>In soap solution</td>
</tr>
<tr>
<td></td>
<td>Mean maximum tension (g.)</td>
<td>Coefficient of variation (%)</td>
</tr>
<tr>
<td>Untreated</td>
<td>37.1</td>
<td>4.30 ± 0.15*</td>
</tr>
<tr>
<td>Treated</td>
<td>3.4</td>
<td>4.69 ± 0.14</td>
</tr>
</tbody>
</table>

* Standard error.

The scaliness of wool fibres is clearly unaffected by treatment with mercuric acetate, and the unshrinkability which it imparts to woven fabric must be referred to the modified elastic properties of the fibres.

(ii) *Benzoquinone.* A 2.5g. (air-dry) pattern of flannel, with a bundle of purified Lincoln fibres attached, was treated for 48 hours at 50°C. with 100 ccs. of a 1 per cent. solution of benzoquinone in a 5 per cent. (v/v) solution of alcohol in a pH 5 phthalate buffer solution. After treatment, the pattern and its attached fibres were washed in running water for 24 hours. The fibres were then detached for scaliness measurements, while the pattern was milled with an untreated pattern by hand for 15 minutes in 5 per cent. soap solution. The shrinkages of both patterns are given in Table 10, which includes the results of scaliness determinations on the Lincoln fibres. The latter were examined under the same conditions as before, except that the bobweight leverage was 108 g.cms.
Like mercuric acetate, benzoquinone does not affect the scaliness of wool fibres, and the unshrinkability which it confers on woven fabric must be referred to the modified elastic properties of the fibres.

The preceding illustrations, drawn from the work of this laboratory on milling shrinkage and the unshrinkable finish, will, it is hoped, serve to demonstrate the general utility of the lepidometer.

SUMMARY

An instrument, termed a lepidometer, has been constructed for the purpose of measuring the scaliness of animal fibres by determining the maximum tension developed when single fibres are suspended, root end downwards, from a tension-measuring device, and rubbed between rubber or polythene surfaces. Measurements can be carried out in air or in aqueous solutions, and the general utility of the instrument has been demonstrated by examples drawn from work on milling shrinkage and the unshrinkable finish.

The authors are indebted to the International Wool Publicity and Research Secretariat for grants in aid of the investigation, and to Dr. C. S. Whewell for permission to use some of his unpublished results.

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Received 6/11/44.

Textile Chemistry Laboratory,
Leeds University.
10—THE TENSILE BEHAVIOUR OF RAW COTTON AND OTHER TEXTILE FIBRES

By Reginald Meredith,
(British Cotton Industry Research Association)
(Copyright by the Textile Institute).

CONTENTS.

(1) INTRODUCTION ................................................................. T107
(2) FIBRE CHARACTERS MEASURED .............................................. T109
   (a) Fineness ............................................................... T109
   (b) Strength .............................................................. T109
   (c) Extensibility ......................................................... T110
   (d) Yield stress and strain ........................................... T110
   (e) Work of rupture ................................................... T110
   (f) Variation within a sample ....................................... T111
(3) MATERIALS TESTED AND SAMPLING METHODS .......................... T111
(4) EXPERIMENTAL METHODS ................................................... T112
   (a) Weighing the fibres ................................................. T112
   (b) Recording the load-extension curves ........................... T113
(5) MEASUREMENTS ON THE STRESS-STRAIN CURVES ........................ T114
(6) DISCUSSION OF RESULTS .................................................. T115
   (a) Cottons ............................................................... T115
   (b) Bast and other vegetable fibres ................................ T116
   (c) Rayons .............................................................. T116
   (d) Silk, nylon and Vinyon ........................................... T119
   (e) Wool, hair and casein fibres .................................... T120
   (f) Comparison of different fibres ................................ T121

TABLES I TO IX ................................................................. T124-128

APPENDIX I. Densities of Textile Fibres ............................... T128

APPENDIX II. Data for Stress-Strain Curves of Various Fibres .... T129

(1) INTRODUCTION

Fibres are used for their several purposes according to empirical knowledge of their utility, gained in long experience; it is only recently that sufficient has been learnt about the properties of the different fibres to enable one fibre to be substituted for another with a reasonable hope of success. Even to-day the data on the properties of fibres are scattered through the literature, and the conditions under which these properties have been determined vary greatly. If the conditions are not controlled there can be no valid comparison of properties, for the mechanical properties of fibres depend on the degree of purification, mechanical history, relative humidity and temperature of the surrounding air, on the test length, and on the rate of loading. Thus, for example, the strength of a silk filament depends on whether it is in the raw or in the degummed state; an increase in the relative humidity of the air causes the strength of cotton to rise but that of wool to fall; the strength of a fibre decreases as the test length increases because in a longer length of fibre there is a greater chance of a weak place occurring; and it is well known that the quicker a material is ruptured, the greater is its apparent strength. Since the effects of the above conditions are sometimes very large and varied it is essential to compare different fibres under the same conditions. This has been done in this paper, the conditions adopted being a length of 1 centimetre, a relative humidity of 65 per cent., a temperature of 20° C. and a rate of loading of 10 grams per denier per minute.

Before the new data to be presented are considered, a very brief review of the literature on the strength of fibres will be given. It is fortunate that the strength of the cotton fibre is little affected by the relative humidity between 60 and 100 per cent. Most observers appear to have selected
1 centimetre as the test length so there only remain the rate of loading and type of instrument to cause any large variations. Almost all the tests made at the Shirley Institute between 1920 and 1930 were made on a modified O'Neill instrument with water or ammonium nitrate solution to condition the air surrounding the fibre. Balls's magazine hair tester has been used in addition to the O'Neill instrument by Indian workers, whilst the German technologists prefer the Schopper or the Krais-Keyl instrument.

In order to compare results for different cottons the specific strength has been evaluated by dividing the mean breaking load by the mean fibre weight per unit length, and plotted against the fineness or inverse fibre weight per unit length. The data obtained by most observers agree among themselves, but those given by Schwab appear to be low on the average, as also do those of Barritt for Sea Island and Sakel cottons tested wet on Balls's magazine tester. There is a positive correlation between specific strength and fineness in general, with Maarad and Punjab-American 289F cottons consistently weak for their fineness whereas Peruvian cottons are relatively strong. Strength data for the bast fibres are scarce but from the few results available flax, hemp, ramie and sisal appear to have approximately the same strength whilst jute is appreciably weaker.

There are numerous results for rayon in the literature and a summary with references to original sources is given by Weltzien. From the collected results the finer viscose rayons are seen to have a strength of about 2-5 grams per denier for 1½-denier and 2-0 grams per denier for 3-denier rayons. The acetate rayons have an average strength of 1-4 grams per denier and the cuprammonium rayons about 2-0 grams per denier.

Of the synthetic fibres, nylon is outstanding with its remarkable elastic properties. It can be made in any denier within wide limits and has a specific strength of from 4 to 7 grams per denier and an extension at break of from 20 to 30 per cent, depending on the amount the filament has been stretched in production. Typical present day values are 5 grams per denier and 20 per cent, extension. Vinyon is another synthetic fibre which can be made to give a range of strengths from 1 to 4 grams per denier; the higher the strength, the lower is the extensibility. Glass gives by far the strongest textile fibre but it is, of course, very brittle. A strength of 12 grams per denier with an extension at break of 5 per cent, is about average for present day production. Complete data on the effect of fineness, test length and rate of loading on the strength and extension of glass fibres are given by Anderegg.

A large part of the present work is concerned with cotton, rayon and silk although for purposes of comparison it has been extended to samples of bast fibres, wools and synthetic products. Some 58 samples in all have been tested, consisting of 15 cotton, 8 bast fibre, 17 rayon, 4 silk, 3 wool and 11 miscellaneous.

It is hoped that the results may be useful to the technologist who seeks to build fabrics for special purposes, although it is realised that the number of samples tested is limited and the properties measured are few. The advantage of making tests on the fibres themselves is that information is obtained about the properties of the material without the complication of yarn or fabric structure. The disadvantage is the great variability of single fibres, which necessitates a large number of tests to obtain a significant result. Stress-strain curves have been obtained for all the samples and should be useful in many ways.
(2) FIBRE CHARACTERS MEASURED

Although the relation of stress to strain is the main characteristic studied in this paper it is necessary to describe the fibre by such geometrical characteristics as length and fineness for they affect not only the test results but also the application of the data to specific problems. For example, a fine wool can be spun into a much finer yarn than a coarse wool so that the former would have a soft handle although there would be little difference in specific strength.

(a) Fineness

The fineness is one of the factors which determines the finest count of yarn that can be spun; it affects the stiffness and lustre of the yarn. The inverse of the fibre weight per unit length has been used as a measure of fineness, for it is much easier to weigh a given length of fibre than to measure its diameter at many points and find the average. The denier, i.e., the weight in grams of 9,000 metres of the fibre was chosen as the general unit for expressing fineness.

In the case of cotton the fineness is affected by the maturity of the hairs in the sample and the "intrinsic fineness" ($\varphi$) has been calculated to compare all cottons at an arbitrary degree of maturity. The "effective length" in thirty-seconds of an inch has been measured on cotton only, to describe the sample more completely in terms that are familiar to the industrialist.

(b) Fibre Strength

The strength of a textile material is usually taken as the first criterion of quality. It is especially important in mechanical fabrics such as conveyor belts, canvases, tyre fabrics, etc. In order to compare the strengths of fabrics of different dimensions it is simpler to compare the ratios of strength to weight rather than the ratios of strength to area of cross-section. The force required to rupture a fibre is termed the breaking load ($F$) and it is usually expressed in grams. For a particular kind of fibre it depends on many factors such as area of cross-section, test length, and relative humidity.

The ratio of breaking load to fibre weight per unit length (or denier) is considered the most significant measure of strength for the comparison of different fibres. Since this quantity has the dimensions of a length it is often called the "breaking length" and it may be expressed in units of kilometres or hanks. The term "breaking length," however, is rather difficult for the general reader to grasp, and the term "specific strength" ($S$), which will be used henceforward, is preferred. The specific strength is expressed in grams per denier throughout, but the units may be changed to kilometres if necessary by multiplying the number of grams per denier by 9. The engineer's usual measure of ultimate tensile stress in kg.mm.$^{-2}$ is obtained by multiplying the specific strength in grams per denier by nine times the density in grams per c.c. This neglects the cross-sectional contraction which can be taken into account, approximately, by multiplying the breaking stress by $(1+E)$, where $E$ is the fractional extension at break.

A table of densities collected from the literature is given in Appendix I to enable this to be done. It would be as well to point out that the breaking stresses so obtained refer to the average cross-section of the fibre and not to the cross-section at the weakest portion where and when the fibre breaks.

Since the variation of strength with rate of loading is approximately the same for all fibres it is immaterial what rate of loading is used so long as it is the same for all fibres. We have used a rate of loading as near as possible to 10 grams per denier per minute. At the time when these tests were made it was only possible to vary the rate of loading in steps so that the rate of loading was not exactly 10 grams per denier per minute for each sample. However, a correction has been made to all the load measurements so that they correspond to a constant rate of loading of exactly 10 grams per denier per minute.
This has been done by using the fact that an increase in rate of loading of ten times will produce an increase in strength of 10 per cent., or expressed mathematically,

\[ \frac{F}{F_{10}} = 1 + 0.1 \log_{10} \left( \frac{R}{R_{10}} \right) \]

where \( F \) = load at any given rate of loading \( R \), and \( F_{10} \) = load at a standard rate of loading, \( R_{10} \). The value of \( R \) is the quotient of the known rate of loading in grams per minute and the average denier of the sample tested.

(c) Extensibility

The extensibility is a very characteristic quality of a fibre, indicating the nature of the forces that resist deformation of the fibre structure. The relatively inextensible fibres have well-oriented structural units which cannot be displaced very far from their initial positions before the strain falls on the main chemical bonds. The highly extensible fibres have long-chain molecules which are either oriented at random or capable of unfolding without disturbing the main structure.

Under the heading of extensibility we have to distinguish between the extension at break or breaking extension \( E \) and the stress-strain modulus.

The extension at break is the amount by which a fibre will stretch before rupture and it is expressed as a percentage of the initial test length. The values of the extension at break have not been corrected for the small differences in rate of loading because experience indicates that they are unaffected at least over the small range which is here involved.

Most of the stress-strain curves show an initial part where the stress is proportional to the strain and for this part of the curve it has been possible to measure the "initial Young's modulus" which is the ratio of stress to strain and can be regarded as the stress required to double the length of the specimen. The initial Young's modulus has been expressed in units of grams per denier to conform with the strength results. It can be used, for example, to compare the stresses set up when various fibres are stretched by the same small amount.

(d) Yield Stress and Strain

The stress-strain curves have many varied shapes for different fibres. Certain fibres show a sudden increase in extension for a small increase in stress after the initial portion where stress is proportional to strain. The place where this occurs is sometimes called the yield point although the effect usually takes place over a region of extension. The yield point is taken as that point where the tangent to the curve is parallel to the line joining the start and finish. The advantage of this method is its applicability to almost any shape of curve and it has the definite physical meaning that beyond the yield point so defined the fibre extends at a greater rate than on the average.

There are, of course, certain cases where there may be two tangents which satisfy the above conditions or where the values for yield strain are higher than would appear from a visual examination of the stress-strain curve and the significance of the yield point has to be considered individually for each of these cases. The direct criterion of yield is to unload the fibre just after the yield point and see how much it recovers, but that goes beyond the scope of this paper.

The significance of the yield point is that if a fibre is stretched beyond this point it will not show complete immediate recovery, although it may creep back slowly to its original length. This phenomenon is important in winding rayon, for example, where over-stretching may cause subsequent lustre defects in the finished fabric. The yield stress is expressed in grams per denier and the yield strain as a percentage.

(e) Work of Rupture

It is interesting to compare the amount of work required to rupture different fibres. This is represented by the area enclosed by the stress-strain
curve and the strain axis and would be half the product of the breaking load and breaking extension if Hooke's law were obeyed. The stress-strain curves for textiles depart considerably from a linear relation but the idea of work of rupture as one half the product of load and extension at break can be retained by introducing a "work factor" which is the ratio of the actual work of rupture to the product of load and extension at break. Thus, for a material obeying Hooke's law, the "work factor" is 0.5; if the actual work of rupture is less than half the product of load and extension at break, the "work factor" is less than 0.5 and, similarly, if the actual work of rupture is greater than half the product of load and extension at break, the "work factor" is greater than 0.5. The work of rupture is thus given by (work factor) x (load at break) x (extension at break), and has been expressed in gm. cm. per denier for a 1 cm. length of fibre. Obviously, the work of rupture is proportional to the length of fibre tested.

The work of rupture measures the ability of a fibre to absorb energy, i.e., to withstand a sudden shock. It happens that strong fibres are usually inextensible and vice-versa, so that a relatively weak fibre may have a higher work of rupture than a very strong fibre.

(f) Variation within a Sample

When considering such a variable material as a textile fibre, it is important to know how much variation there is in any measured quantity. For example, one fibre which is very regular but slightly weaker than a more irregular fibre may give a stronger yarn.

The variability of a quantity can be expressed by the coefficient of variation which is calculated by statistical methods. It is the standard deviation expressed as a percentage of the mean. From these coefficients we can easily see which are the more regular fibres. The coefficient of variation can also be used to estimate the effect of test length on the strength of a sample of fibres because the increase in strength for a given decrease in the test length is roughly proportional to the coefficient of variation.

The standard error is another quantity which is easily obtained from the standard deviation on dividing by the square root of the number of observations of a given quantity. It enables the reliability of a mean to be estimated or the significance of the difference between two means to be established. Thus, the probability is 20 to 1 in favour of the true mean being within plus or minus three times the standard error. Similarly, if the difference between two means is greater than twice the square root of the sum of the squares of the standard errors of the two means, then the probability is 20 to 1 in favour of the difference being real. For example, the strength of one Punjab American cotton is 2.92 ± 0.18 grams per denier, whilst that of another is 3.37 ± 0.18 grams per denier, but since the difference is less than twice \[\sqrt{0.18^2 + 0.18^2},\] the difference is not statistically significant.

The correlation coefficient is another statistical quantity which is useful for comparing the degree of relationship between two variable quantities. A numerical value of +1 indicates a perfect positive relation between the two quantities, a value of zero indicates no relationship at all and a value of -1 indicates that as one variable increases, the other decreases in perfect relationship.

(3) MATERIALS TESTED AND SAMPLING METHODS

The object of this paper is to compare certain physical properties of a large range of textile fibres. This means that the samples chosen should be as representative as possible. In Table I all the samples except the cottons are described by a name, with a few notes on their origin or preparation. There are eight samples of bast fibre which include flax, jute, hemp, and ramie. In selecting samples from the multitude of varieties of jute and hemp, it was considered desirable to include their botanical names. Apart from the common hemp (Cannabis sativa), there are two others which are
The tensile behaviour of raw cotton

quite abundant, namely, Sunn or Bombay hemp (*Crotalaria juncea*) and Manila hemp (*Musa textilis*), but these were found to be too coarse for our instrument and had to be omitted. The last two samples included under the sub-heading “bast fibres” were seed-hairs used for lifebelts and thermal insulation; they are too smooth and weak to be spun into yarn.

Seventeen samples of rayon were tested and included viscose, basified viscose, acetate, cuprammonium and nitro rayon. Four of the samples may be classed in the category of stretched rayons. The series of four Celanese samples have suffered different degrees of stretch during manufacture, but were not necessarily all made from the same mixing. The staple fibres were chosen in the raw state to avoid alteration in the shape of some of the stress-strain curves which takes place when the staple fibre is converted into yarn.

Three samples of silk were chosen to represent the three main silk-producing countries and a sample of wild Tussah silk was included. One fine, one medium and one coarse wool were chosen to see whether there was any marked variation due to fineness. Information on length, fineness and maturity is provided in Table II for 15 samples of raw cotton which were chosen to cover the usual range of fineness for commercial varieties.

Good sampling is essential in fibre tests so that the few fibres tested shall be representative. The fibres were usually either in the raw state or in yarn and the method of sampling depended on whether the fibre was of short staple, long staple or continuous.

For raw cotton and short-staple fibres the sample, weighing about 50 grams, was first divided into four quarters. Next, tufts were taken at random from each quarter and each of these halved four times, discarding right and left-hand halves alternately, so producing 16 wisps from each quarter. Each of the four sets of 16 wisps was combined into four tufts which were “doubled and drawn” between fingers and thumb before dividing each tuft into four parts and recombining corresponding quarters of each tuft to form four new tufts. Each of these was then “doubled and drawn” individually before taking a quarter of each and mixing well to form a sample. This sample was combed with a steel comb to remove short fibres and the very long fibres were removed with a pair of tweezers, leaving the sample to be used.

When the sample consisted of long-staple fibres such as wool or waste silk, the procedure was to select six fairly substantial tufts at random from various parts. These tufts were then individually reduced, well mixed, combed and cut, then ten fibres taken from a wisp abstracted from each tuft. Continuous filament yarn was dealt with by cutting six 2-cm. lengths at appreciable intervals along the yarn, and selecting ten fibres without bias from each tuft to form the sample. The ultimate fibres of linen yarn were easily separated but occasionally there were fibre bundles which were detected by examination under the microscope and separated with forceps. The hemp and jute yams consisted of fibre bundles which could not usually be reduced to ultimates by mechanical means; any extraneous fibre was removed before weighing.

The number of fibres tested was 50 per sample of cotton and the bast fibres and 25 per sample of rayon, silk, wool and synthetic fibres, which are more regular. This number excluded grip breaks and was not very large because the main interest lay in the load-extension curve which is sufficiently defined by this number of curves.

(4) EXPERIMENTAL METHODS

(a) Weighing the Fibres

The fineness or denier of a fibre was determined on a microbalance which consisted essentially of a fine phosphor-bronze strip fixed in a horizontal position at one end and loaded with the fibre at the other (see Fig. 1). The
deflection of the strip, which is proportional to the weight of the fibre, was observed with a micrometer eyepiece.

A length of 2 cms. was removed from the centre of the final sample with a cutting tool consisting of two razor blades clamped to a brass spacing block. It is important that the fibres should be straight, parallel and under enough tension to remove the natural crimp. Six pinches were carefully abstracted with tweezers and the first ten fibres taken from the right-hand side of each pinch were weighed. If the fibres were not selected systematically, the resulting group would be biased towards the heavy side owing to the tendency to pick up the more rigid and more easily observed fibres. The zero reading was noted before and after each weighing and the individuality of the fibres preserved by placing them in order under glass slides on a black velvet pad.

Two microbalances were used, one (A) very sensitive, for weighing single fibres whose mean fibre weight did not exceed $500 \times 10^{-8}$ grams per centimetre, and a second (B) 5 times less sensitive, for weighing heavier single fibres or small groups of finer fibres. They were calibrated against a microbalance (C) of the same type, but lower sensitivity, which was itself calibrated with a standard weight. The method of calibrating the finer microbalance (A) consisted of weighing a 2-cm. length of 33-denier 10-filament nylon yarn on the directly calibrated microbalance (C), then separating the filaments and weighing these individually on the finer balance. To calibrate the less sensitive balance (B), five 1-cm. lengths of 30-denier nylon yarn were weighed together on the directly calibrated microbalance (C) and then separately on microbalance (B). The sensitivities of the microbalances (A) and (B) were $16 \times 10^{-8}$ grams per division (mm.) and $86 \times 10^{-8}$ grams per division (mm.) respectively.

(b) Recording the Load-Extension Curves

The apparatus used for determining the load-extension curve of a fibre was an autographic load-extension recorder described by Cliff, with several minor improvements. The load was applied to the specimen by the rotation of a spiral spring and the load-extension curve was recorded photographically in rectilinear co-ordinates. The load calibration was effected by suspending weights from the top grip and noting the number of revolutions of the spiral spring required to bring the arm holding the grip back to its horizontal equilibrium position. The maximum load which could be recorded depended on the torsional modulus of the spiral spring. The spring normally used had a range of 15 grams and it gave a constant rate of loading of 0.30 gram per
second. For coarse wool, ramie, etc., stronger springs had to be used and consequently the actual rate of loading in grams per second was higher, but the rate of loading in grams per denier per minute was of the same order of magnitude for all the fibres tested.

The optical system was adjusted to give a linear magnification of the extension of the specimen. It was normally about $12 \times$ but by using the inner grip on the loading arm, this was increased five-fold to about $60 \times$. To measure this magnification and hence calculate the extension calibration factor, a Pye travelling telescope was set up before the instrument and the movement of the top grip observed through the telescope while the corresponding position of the spot of light on the recording bromide paper was noted. The maximum extension which could be recorded was 80 per cent. on a 1-cm. test length.

To mount a fibre to a length of 1 cm., it was laid along the centre of a special card mount and secured at each edge by a small drop of wax, melted by a hot glass rod or needle. Care was taken to avoid heat tendering of the fibre and it was mounted straight with just sufficient tension to remove any kinks. Everett's No. 1 wax (M.P. 57° C.) was generally used for mounting all except the very strong fibres; it does not harden so quickly as shellac (M.P. 120° C.), but it produces fewer grip breaks on regular fibres such as nylon. For the strong bast fibres, it was necessary to use shellac to prevent yielding of the mountant. Necol cellulose cement was used for such fibres as vinyon, which softens at 60° C.; one end was mounted and left for one hour to set before mounting the other end.

A load-extension curve was made by clamping the mounted fibre between the grips, cutting away the sides of the mount, and then, starting with the fibre just taut, the load was increased at a constant rate until the fibre ruptured. The testing was carried out in a room in which the relative humidity was controlled at 65 ± 2 per cent., and the temperature at 20 ± 2° C.

(5) MEASUREMENTS ON THE STRESS-STRAIN CURVES

The load-extension curves were measured by means of a glass graticule divided into millimetre squares. The load and extension at break and at the yield point (if any) were measured for each curve and the mean values found for each sample. The yield point was taken at that point where the tangent to the curve was parallel to the line joining the start and finish.

Typical stress-strain curves for each sample have been determined by choosing five curves with strength, extension and yield point nearest the mean values, taking the load for each curve at 20, 40, 60, 80 and 100 per cent. of the corresponding breaking extension, and finding the mean for the five curves. The mean breaking load and mean breaking extension of these five curves were adjusted to the corresponding mean values for the sample and the intermediate values worked out by proportion. The absolute measures of the yield values were incorporated in the curves. This method was used because it preserves the characteristic shape of the curve better than taking the mean load for all the curves at fixed percentages of the breaking extension.

Almost all the stress-strain curves commence with a linear portion for which an "initial Young's modulus," i.e., ratio of stress to strain, can be evaluated. In order to obtain a true mean value for this quantity for each sample, it is necessary to calculate the ratio of stress to strain for each fibre and then find the mean.

The work of rupture was measured for each sample by means of an Amsler planimeter and the "work factor" calculated as the ratio of the measured work of rupture to the product of load at break and extension at break.
(6) DISCUSSION OF RESULTS

The mean values of fineness, strength and extension at break, together with the initial Young's modulus, yield stress and yield strain (if any), work of rupture and work factor are recorded in Tables III to VII. The standard errors for fineness, breaking load, specific strength and extension at break are also included in these tables.

(a) Cotton

The cottons range from superfine Sea Island to coarse Indian, and they have been placed in Table III in the order Sea Island, Egyptian, American, African and Indian. There is a tendency for coarser fibres to have a higher breaking load but not in proportion to their area of cross-section. The specific strength shows a large increase with increasing fineness so that the long, fine cottons are considerably stronger for the same weight than short, coarse cottons. The extension at break varies from 5 per cent. to 10 per cent., with a mean of 7.3 per cent., and shows no correlation with fineness. These observations are in agreement with the results obtained by Clegg, Schmidhäuser, Brown, Mann and Peirce, and Morton, but the strengths given by Schwab for tests at 65 per cent. R.H. appear to be low.

The correlation coefficients \( r \) for intrinsic fineness \( \varphi \), effective length \( L \) and specific strength \( S \) are

\[
(p, L), r = 0.89; \quad (\varphi, S), r = 0.80; \quad \text{and} \quad (L, S), r = 0.83
\]

so that there is a fairly good relationship between \( S \) and \( \varphi \) and between \( S \) and \( L \), with little to choose between them. The Ishan and Tanguis cottons are coarse for their effective lengths and show high breaking loads with a specific strength corresponding to their effective length. A relatively high strength for Peruvian cottons was found by other workers. The Tanganyika cotton was very immature and gave a low specific strength. Giza 7 cotton stands out as a cotton which is strong both in relation to its length and fineness, whereas Maarad is weak in both comparisons.

The mean values of the correlation coefficients for individual fibre weight \( H \), breaking load \( F \), specific strength \( S \), and extension at break \( E \) are

\[
(H, F), r = 0.38; \quad (F, E), r = 0.58; \quad (E, H), r = 0.22; \quad (H, S), r = -0.20.
\]

Thus, in general, there is some correlation between breaking load and fibre weight within a variety, fair correlation between load and extension at break and no correlation between fibre weight and breaking extension nor between fibre weight and specific strength. From the observed lack of relationship between specific strength and fibre weight within a variety, we deduce that the specific strength of a small sample whose mean fibre weight differs from that of the bulk sample will not differ much from that which would have been obtained from the latter. The correlation between fibre weight and breaking load within a variety has been recorded by previous workers (who used mean fibre weight and mean breaking load of small samples), as 0.35 (Brown, Mann and Peirce), and 0.59 for 90 and 45 Indian cottons (Turner and Venkataraman), which can be compared with our mean value of 0.38.

When the mean strength, etc., were calculated, the fibres which ruptured at the place where they were gripped were neglected and the first 50 results free from grip breaks were used. Some data for these grip breaks were collected and they showed that the number of grip breaks per sample of 50 good breaks averaged 12 per cent. There are three possible causes of grip breaks, namely, damage at the grip (heat tendering, skew mounting, etc.), naturally-occurring weak places, and weakening of a very regular fibre by the restraining action of the grip. Now, some 5-6 per cent., or roughly half of the grip breaks had breaking loads greater than the mean, so the conclusion was drawn that the low values of strength which may be due to damaged fibres (at the grip) are balanced roughly by the high values resulting from regular fibres weakened by the grip.
The average specific strength of the grip breaks was 6.7 per cent, less than normal, so that if grip breaks were included in the normal mean, the strength would be lowered on the average by only $6.7 \times 0.12 = 0.8$ per cent, which is insignificant. Therefore, it is unnecessary to neglect grip breaks when a large number of cotton fibres are tested by the technique described above, and this means that a bundle of fibres can be weighed en masse before testing, with a great saving of time.

The average fibre-weight of the grip breaks was very close to that of the normal means (only 1.3 per cent, less), so that thin and thick fibres were equally affected. The extension at break was not appreciably different, being only 1.7 per cent, greater than normal.

In order to avoid confusion, only five stress-strain curves have been drawn in Figure 2, but the end points for the remaining samples are shown. All the cottons give similar curves consisting of a linear portion after the "crimp" has been removed by a stress of 0.03 gram per denier, then a transition region at about 0.3 to 0.9 gram per denier before the curve assumes a definite concavity to the stress axis. The inflexion in the stress-strain curve can be detected in the curves for Sakel cotton given by Brown, Mann and Peirce, and it is present to some extent in all the stress-strain curves of native cellulose fibres. Those individual curves which proceed far enough before rupture approach a modulus of elasticity which appears to be independent of the type of cotton. Owing to the more pronounced curvature of the stress-strain curves for the more extensible cottons, they have a lower "work factor" than average. The initial Young's modulus increases considerably with fineness, being almost twice as large for Sea Island as for Indian cotton.
More detailed information on the relation of the elastic properties of raw cotton to its length, fineness, maturity and structure will be given in another paper concerned only with cotton.

(b) Bast and other Vegetable Fibres

The testing of bast fibres presents several difficulties, arising from their structure. In the first place, for example, hemp fibres consist of bundles of ultimate cells tenaciously held together, the size of the bundles depending on the stage to which retting has been taken. If one is concerned with the relationship of fibre strength to yarn strength, then the fibre bundles must obviously be tested. On the other hand, for reinforcement of plastics the strength of the ultimate cells is more appropriate. These ultimates would be too small to be tested under the standard conditions laid down above, yet the fibre bundles are often too coarse to be tested with the present apparatus (e.g., Manila hemp). The procedure adopted here was to examine the flax and ramie fibres to ensure that only ultimates were tested, and to remove only stray fibrils from the jute and hemp fibre bundles. The test results are recorded in Table IV.

The sample of line flax had a higher specific strength than the tow flax, a result also obtained by Slattery,\textsuperscript{13} whose actual strengths, however, were lower than our values. An average strength of 3·5 grams per denier for the two samples of jute is close to the 3·6 to 3·8 grams per denier quoted by Barker\textsuperscript{13} and about the same as that of Egyptian cotton. Hemp fibres appear to be almost as strong as flax fibres, our value of 5·2 grams per denier for Russian hemp agreeing with the 5·0 grams per denier for hemp quoted by Barker\textsuperscript{13}.

The two samples of ramie had been treated by the Sabner process\textsuperscript{14,15} to remove almost all the intercellular substances and to isolate single cells. According to this process, the ramie fibre may have more than 98 per cent. of its gum removed by subjecting it in batches of less than 50 lb. in one vessel six times to the following treatment. Boil for less than 30 minutes in less than 0·5 per cent. caustic alkali, run off the liquor and squeeze, rinse with water and if desired, treat with weak acid, run off the liquor and rinse with water. A very high strength of 6·7 grams per denier was obtained, comparable with 6·5 and 6·8 grams per denier recorded in the literature\textsuperscript{14,15} for similarly treated fibre. The specific strength and extensibility increase as the fibre is purified by treatment in 2 per cent. caustic soda solution.

Kapok and akund were weak compared with other vegetable fibres; they are normally used as a packing material for life-jackets, heat and sound insulation.

Owing to the low extensibility of the bast fibres, their work of rupture is comparatively low in spite of their high strength. All the bast fibres except ramie gave a stress-strain curve which was almost linear and, consequently, the "work factor" was 0·5. The samples of ramie gave a slightly S-shaped stress-strain curve.

(c) Rayons

When considering the elastic properties of rayons it must be realised that they are determined to a large extent by the manufacturing process and only careful control will ensure that any two samples produced by one manufacturer are the same. Nevertheless, it is possible to obtain a general idea of the behaviour of the different kinds of rayon by considering a large number of samples from many sources. In order to specify the rayons more precisely, their 2 per cent. fluidities in cuprammonium solution have been given in Table V, together with their mean fineness, strength, extension at break, etc.

The fineness of the rayon samples varied considerably, depending on the method of manufacture. Generally, the stretched rayons had fine filaments and they were strong and relatively inextensible. The ordinary rayons of low denier showed a smaller extension at break than those of high denier.
The specific strengths of the rayons varied from 1.0 to 6.7 grams per denier, with the majority between 1 and 3 grams per denier. With the exception of Seraceta (high extension) and the stretched fibres, the extension at break lay generally between 15 per cent. and 25 per cent. The stretched rayons gave greatly increased strength with correspondingly reduced extension at break. Data from the literature for the strength and extension at 65 per cent. R.H. of some 70 samples of viscose rayon, 10 samples of acetate rayon and 10 samples of cuprammonium rayon were plotted and the average values calculated. The average strength and extension at break of viscose rayon were 2.5 grams per denier and 17 per cent. for 1.4-denier rayon and 2.0 grams per denier and 20 per cent. for 3-denier rayon. Our values for ordinary viscose rayons are about the same. The cuprammonium rayons appear to have strength and extension at break very similar to the viscose rayon. Our mean values of 1.3 grams per denier and 29 per cent. for ordinary acetate rayon are in agreement with the values 1.4 grams per denier and 30 per cent. recorded in the literature for ten samples.

The initial Young's modulus varied from 26 grams per denier for Seraceta to 183 grams per denier for Celanese FS9, with most of the values for ordinary viscose rayon from 50 to 80 grams per denier. Much of the extension of ordinary rayons is not recoverable and the values of stress and strain at the yield point are of more practical value than the strength and extension at break. The yield stress for ordinary rayons varied between 0.6 and 0.9 gram per denier, whilst that of stretched rayons was considerably higher.
The viscose, cuprammonium and nitro rayons gave a yield strain of approximately 2 per cent., whilst for acetate rayon it was between 3 and 4 per cent. The "work factor" for rayons showed a definite tendency to increase with extension at break.

The stress-strain curves of these rayons are shown in Figure 3, where it is at once apparent that high strength is associated with low extensibility and vice-versa. The gap between normal and stretched rayons could be bridged by a product such as high-tenacity Tenasco rayon. There are one or two points of interest. For example, Acetate Fibro and Seraceta follow the same curve for most of the way; both Fibro and Acetate Fibro appear to rupture at a lower extension than the corresponding continuous filament materials, viscose and Seraceta; and the Strong Fibro is only a little stronger than the ordinary Fibro but it has an appreciably higher yield point. There are several papers in the literature which give stress-strain curves for rayon, but the test conditions are often so diverse as to make comparison impracticable.

(d) Silk, Nylon and Vinyon

In Table VI the results for four samples of silk, two samples of nylon and two samples of Vinyon are recorded. The fine Chinese silk showed higher specific strength, yield stress and initial Young's modulus than the Japanese and Italian silks, and they in turn showed higher values than the coarser Tussah silk. The sample of Italian silk, which gave a lower fluidity than the other samples, had a relatively high breaking extension of 31 per cent. and its stress-strain curve (Fig. 4) was intermediate in type between that of the finest silk, with a gradual increase in rate of extension after the Hooke's law region (stress proportional to strain) and that of the coarse Tussah silk, with a sudden increase in rate of extension after the Hooke's law part.

Denham and Lonsdale made a comprehensive series of tests on degummed Italian and Canton silk; they used a test length of 5 cm., with a constant rate of extension of 1.9 per cent. per second, which should give...
almost the same results as our tests and this was found to be so except for the initial Young’s modulus for which we obtained slightly higher values. The strength and extension at break of degummed Japanese silk recorded in a laboratory report of the British Silk Research Association agree closely with our values.

The samples of nylon were stronger than natural silk but they had about the same extension at break. Although there are apparently two yield points for nylon, there is no doubt that the second one is to be taken as the point where the structure has been irreparably deformed. It will be noticed that the initial Young’s modulus is much lower for nylon than for silk. Both nylon and silk are eminently suitable for parachutes because of their high work of rupture which allows them to absorb the energy of a sudden impact.

(e) Wool, Hair and Casein Fibres

The results for wool, mohair, camel hair and casein fibre will now be considered. The three samples of combed wool show no significant change of specific strength with fineness, although the coarse wool has nearly seven times the breaking load of the fine wool (see Table VII). This conclusion is confirmed by results scattered through the literature for 31 samples of wool ranging in fineness from 2 to 41 denier. These same samples indicate that the extension at break increases slightly with decreasing fineness so that our value for 36’s wool is exceptional. Camel hair has a very similar extension at break to wool but it is appreciably stronger. The three samples of casein fibre, namely Casein (English), Lanital (Italian) and Aralac (American) show very similar strengths, which are, however, only just more than half the average value for wool. Their mean extensions at break vary from 25 per cent. to 60 per cent., but most of this is not recoverable and this fact should be realised when comparing these fibres with natural wool.

The coefficient of variation of the specific strength of wool is usually less than that of the breaking load, indicating a good correlation between fibre weight per unit length and breaking load. This is especially marked for camel hair, where the coefficient is 63 per cent. for breaking load against 23 per cent. for specific strength. The casein fibres do not appear to be much more regular in properties than the natural wools. The great variability in extension of the casein fibres is indicated by the high values for the coefficients of variation, which range from 53 to 98 per cent.

When the stress-strain curves for wool, hair and casein fibres (Fig. 5) are examined it will be immediately seen that those for the fine and medium wools commence with a short curved portion, concave to the stress axis; this is due to the inherent crimp in these samples which was not removed by the very small initial tension used to bring the fibres just taut. Otherwise, these curves agree in their general characteristics, such as shape and higher yield stress for coarser fibres, with those obtained by Speakman, who investigated the effect of humidity, temperature and rate of loading on the stress-strain curve of Cotswold wool. Mohair and camel hair have a greater yield stress than the coarsest wool and about the same initial Young’s modulus. The modulus and yield stress for the casein fibres correspond to those for the fine 64’s wool. Some stress-strain curves for casein fibre, both wet and at 65 per cent. R.H., are given by Heim; our value of yield stress agrees with his but we found very little increase in stress was required to rupture the fibre whereas Heim’s curves show 100 per cent. increase. The values of yield strain measured for the casein fibres are affected by the extraordinary shape of the stress-strain curve which makes the point of contact of the measuring tangent vary with the extension at break. Judged from the stress-strain curves, the yield strain is approximately the same for all three casein fibres. The high work of rupture for camel hair is no doubt fully utilised when this material is used as cord in driving belts.
Fig. 5. Stress/Strain Curves for Wool, Hair and Casein Fibres.

(f) Comparison of Different Fibres

In order to obtain a general comparison of the main textile fibres, a collection of average values of fineness, strength, etc., has been made in Table VIII.

Considering the strength of the different fibres, we note that ramie, stretched viscose rayon and flax hold first place, followed in order by nylon, hemp, silk, jute, cotton, viscose and acetate rayons, wool and casein fibre. Of course, it is possible to obtain nylon stronger than the best flax, or Sea Island cotton stronger than some silks. The extension at break is low for the bast fibres, with stretched viscose rayon and cotton next, followed by ordinary viscose rayon, silk, nylon and acetate rayon and ending with the highly extensible wool and casein fibres. Generally speaking, the strongest fibres are least extensible but this does not apply to silk or nylon which, consequently, show a high work of rupture well above that of any other fibres.

From the column headed "initial Young's modulus" it is seen that the bast fibres and stretched viscose are least extensible, with moduli ranging from 245 to 165 grams per denier; that is, to stretch these materials by 1 per cent. would require a stress of from 2·45 to 1·65 grams per denier. Silk
follows at 92 grams per denier, then viscose rayon and cotton, with average values of 65 and 55 grams per denier, respectively. A group of most easily extended fibres is formed by acetate rayon, nylon, wool and casein, with moduli from 31 to 23 grams per denier.

Viscose rayon, acetate rayon, wool and casein show similar yield stresses ranging from 0.6 to 0.8 gram per denier. Nylon gives a very high yield stress according to the criterion used, and "elasticity" tests which will be described in a later paper show that this high figure is not misleading.

In Figure 6 a selection of stress-strain curves has been plotted, ranging from the strong, relatively inextensible flax to the weak and plastic casein fibre. Silk and nylon are conspicuous by their combination of high strength and extensibility. If the stress-strain curve is concave to the stress axis, the
vinyon. The casein fibres certainly show an enormous variation in extension at break but the low value for vinyon is the mean of two widely different values. It should be pointed out that the coefficients of variation for individual samples may vary considerably as shown by their standard errors. It will be noted that the variation in specific strength is a little less than that in breaking load in every case except for nylon. The high variation in the breaking extension of nylon is due to the plastic flow after the yield point is exceeded; similarly for casein.

This concludes a brief survey of some of the tensile properties of the main textile fibres. Much more work remains to be done to determine the effect of humidity and temperature on these properties. Most of the samples described above have been subjected to a repeated loading test to measure their ability to recover from strain and these results are reported in the following paper.

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Table I
Description of Samples, other than Cottons

**BAST AND OTHER VEGETABLE FIBRES.**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Reference No.</th>
<th>Effective length, (\frac{1}{4}) in</th>
<th>Fibre weight, (10^8) gm./cm.</th>
<th>Immaturity, N-D</th>
<th>Intrinsic fineness, (\varphi)</th>
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</thead>
<tbody>
<tr>
<td>St. Vincent, V135</td>
<td>M 10</td>
<td>66</td>
<td>101</td>
<td>42-18</td>
<td>55-5</td>
</tr>
<tr>
<td>Montserrat</td>
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<td>149</td>
<td>58-18</td>
<td>41-3</td>
</tr>
<tr>
<td>Sakel, pure strain</td>
<td>X/284</td>
<td>48</td>
<td>132</td>
<td>55-9</td>
<td>48-0</td>
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<tr>
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<td>46</td>
<td>142</td>
<td>62-4</td>
<td>47-7</td>
</tr>
<tr>
<td>Maarad</td>
<td>SS 55</td>
<td>51</td>
<td>144</td>
<td>65-7</td>
<td>47-0</td>
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<tr>
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<td>SS 54</td>
<td>43</td>
<td>152</td>
<td>60-10</td>
<td>42-6</td>
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<tr>
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<td>SS 45</td>
<td>38</td>
<td>185</td>
<td>69-6</td>
<td>37-5</td>
</tr>
<tr>
<td>Texas</td>
<td>SS 49</td>
<td>33</td>
<td>203</td>
<td>46-20</td>
<td>27-8</td>
</tr>
<tr>
<td>Upland</td>
<td>(\frac{1}{2}) in</td>
<td>31</td>
<td>237</td>
<td>63-12</td>
<td>27-5</td>
</tr>
<tr>
<td>Tanguis</td>
<td>C 43</td>
<td>42</td>
<td>214</td>
<td>61-5</td>
<td>31-3</td>
</tr>
<tr>
<td>Ishan</td>
<td>SS 88</td>
<td>39</td>
<td>272</td>
<td>60-9</td>
<td>23-9</td>
</tr>
<tr>
<td>Punjab-American, 4F</td>
<td>SS 70</td>
<td>31</td>
<td>191</td>
<td>39-14</td>
<td>29-5</td>
</tr>
<tr>
<td>Punjab-American, 4F</td>
<td>Type 90</td>
<td>29</td>
<td>219</td>
<td>68-7</td>
<td>31-1</td>
</tr>
<tr>
<td>Oomras</td>
<td>SS 145</td>
<td>27</td>
<td>278</td>
<td>63-11</td>
<td>23-5</td>
</tr>
<tr>
<td>Bengals</td>
<td>C 1108</td>
<td>25</td>
<td>340</td>
<td>77-6</td>
<td>21-1</td>
</tr>
</tbody>
</table>

**Table II**
Data from Combined Stapling Tests on Cotton

<table>
<thead>
<tr>
<th>Sample</th>
<th>Reference No.</th>
<th>Effective length, (\frac{1}{4}) in</th>
<th>Fibre weight, (10^8) gm./cm.</th>
<th>Immaturity, N-D</th>
<th>Intrinsic fineness, (\varphi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscoe, 1(\frac{1}{4}) den.</td>
<td>Courttauld's viscose rayon, unbleached, received 1938.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 den.</td>
<td>Courttauld's A quality viscose rayon, received 1938.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paracor</td>
<td>Courttauld's low fluidity viscose rayon, received 1941.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tenasco</td>
<td>Courttauld's low fluidity viscose rayon, received 1941.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durali</td>
<td>Courttauld's very fine stretched viscose rayon, 1941.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fibro</td>
<td>Courttauld's viscose rayon, 1(\frac{1}{4}) in. staple, 1935.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong Fibro</td>
<td>Courttauld's viscose rayon, 1(\frac{1}{4}) in. staple, 1940.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetate Fibro</td>
<td>Courttauld's acetate rayon, 1(\frac{1}{4}) in. staple, 1940. Ac. acid 53-25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seraca</td>
<td>Courttauld's continuous filament acetate rayon, 1938. Ac. acid 55.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Celenase</td>
<td>British Celenase continuous filament acetate rayon, 1941.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Celenase F4</td>
<td>Stretched continuous filament acetate rayon, 1941. Ac. acid 52.1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Celenase, FS6</td>
<td>Stretched and saponified, 1941. Acetic acid yield 0.8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Celenase, FS9</td>
<td>Cont. fil. acetate rayon, 1941. Acetic acid yield 1.2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bemberg</td>
<td>Continuous filament cuprammonium rayon, received 1938.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ouborg nitro</td>
<td>Continuous filament nitrocellulose rayon, received 1928.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rayolanda, I and II</td>
<td>Basified viscose rayon staple, received 1941.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SILKS, NYLON AND VINYLON.**

**CHINESE.**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Degummed filament—cultivated silks.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italian</td>
<td>Degummed filament—wild silk.</td>
</tr>
<tr>
<td>Japanese</td>
<td>Degummed filament—cultivated silks.</td>
</tr>
</tbody>
</table>

**Nylon, I and II.**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Delusted American 66 nylon from 30-denier yarn, 1940.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinyon, I</td>
<td>From green dyed yarn, received 1941.</td>
</tr>
<tr>
<td>Vinyon, II</td>
<td>From warp thread of fabric, received 1941.</td>
</tr>
</tbody>
</table>

**WOOL, HAIR, CASEIN.**

<table>
<thead>
<tr>
<th>Wool, 64's</th>
<th>Raw 64's Australian Botany—fine.</th>
</tr>
</thead>
<tbody>
<tr>
<td>56's</td>
<td>Raw 56's Australian Crossbred—medium.</td>
</tr>
<tr>
<td>36's</td>
<td>Raw 36's New Zealand Crossbred—coarse.</td>
</tr>
</tbody>
</table>

**Mohair**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Raw 7's Turkey, from Angora goat.</th>
</tr>
</thead>
</table>

**Camel hair**

<table>
<thead>
<tr>
<th>Sample</th>
<th>From 3-fold 5's cord.</th>
</tr>
</thead>
</table>

**Casein**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Courttauld's casein fibre, received 1941.</th>
</tr>
</thead>
</table>

**Lanital**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Italian casein fibre, Rome Exhibition, 1937.</th>
</tr>
</thead>
</table>

**Aralac**

<table>
<thead>
<tr>
<th>Sample</th>
<th>American casein fibre from milk, received 1940.</th>
</tr>
</thead>
</table>
### Table III
Mean Fineness, Strength, Extension, etc., of Cotton Fibres

<table>
<thead>
<tr>
<th>Sample</th>
<th>Reference No.</th>
<th>Fineness, denier</th>
<th>Breaking load, grams</th>
<th>Specific strength, gms./den.</th>
<th>Breaking extension, %</th>
<th>Initial Young's modulus, gms./den.</th>
<th>Work of rupture, gm.cm./den.</th>
<th>Work factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Vincent, V135</td>
<td>M 10</td>
<td>0.90 ± 0.03</td>
<td>4.95 ± 0.22</td>
<td>5.11 ± 0.22</td>
<td>6.80 ± 0.29</td>
<td>82</td>
<td>0.169</td>
<td>0.49</td>
</tr>
<tr>
<td>Montserrat</td>
<td>X/E 2434</td>
<td>1.33 ± 0.05</td>
<td>5.57 ± 0.39</td>
<td>4.20 ± 0.24</td>
<td>7.10 ± 0.36</td>
<td>76</td>
<td>0.146</td>
<td>0.49</td>
</tr>
<tr>
<td>Sakel</td>
<td>X/2B4</td>
<td>1.18 ± 0.04</td>
<td>5.35 ± 0.38</td>
<td>4.61 ± 0.29</td>
<td>7.82 ± 0.46</td>
<td>65</td>
<td>0.177</td>
<td>0.47</td>
</tr>
<tr>
<td>Sakel</td>
<td>2B</td>
<td>1.20 ± 0.04</td>
<td>5.15 ± 0.38</td>
<td>4.81 ± 0.29</td>
<td>7.65 ± 0.38</td>
<td>67</td>
<td>0.185</td>
<td>0.47</td>
</tr>
<tr>
<td>Maarad</td>
<td>SS 55</td>
<td>1.29 ± 0.04</td>
<td>4.84 ± 0.28</td>
<td>3.12 ± 2.03</td>
<td>6.80 ± 0.41</td>
<td>59</td>
<td>0.128</td>
<td>0.45</td>
</tr>
<tr>
<td>Giza 7</td>
<td>SS 64</td>
<td>1.37 ± 0.05</td>
<td>5.66 ± 0.48</td>
<td>4.06 ± 0.31</td>
<td>6.86 ± 0.53</td>
<td>69</td>
<td>0.133</td>
<td>0.46</td>
</tr>
<tr>
<td>Uppers</td>
<td>SS 45</td>
<td>1.66 ± 0.07</td>
<td>6.00 ± 0.36</td>
<td>3.65 ± 0.22</td>
<td>7.10 ± 0.42</td>
<td>57</td>
<td>0.121</td>
<td>0.46</td>
</tr>
<tr>
<td>Texas</td>
<td>SS 49</td>
<td>1.80 ± 0.07</td>
<td>4.92 ± 0.35</td>
<td>2.80 ± 0.20</td>
<td>7.19 ± 0.42</td>
<td>50</td>
<td>0.096</td>
<td>0.48</td>
</tr>
<tr>
<td>Upland</td>
<td>T in.</td>
<td>2.11 ± 0.07</td>
<td>5.78 ± 0.33</td>
<td>2.87 ± 0.18</td>
<td>7.14 ± 0.35</td>
<td>49</td>
<td>0.098</td>
<td>0.48</td>
</tr>
<tr>
<td>Punjab-American, 4F</td>
<td>SS 70</td>
<td>1.70 ± 0.07</td>
<td>4.86 ± 0.32</td>
<td>2.92 ± 0.18</td>
<td>6.90 ± 0.40</td>
<td>50</td>
<td>0.094</td>
<td>0.47</td>
</tr>
<tr>
<td>Punjab-American, 4F</td>
<td>Type 90</td>
<td>1.94 ± 0.07</td>
<td>6.50 ± 0.36</td>
<td>3.37 ± 0.18</td>
<td>8.46 ± 0.43</td>
<td>51</td>
<td>0.129</td>
<td>0.45</td>
</tr>
<tr>
<td>Tanguis</td>
<td>C 43</td>
<td>1.90 ± 0.08</td>
<td>5.73 ± 0.41</td>
<td>3.18 ± 0.18</td>
<td>8.19 ± 0.57</td>
<td>61</td>
<td>0.119</td>
<td>0.46</td>
</tr>
<tr>
<td>Ishan</td>
<td>SS 88</td>
<td>2.38 ± 0.07</td>
<td>8.71 ± 0.54</td>
<td>3.67 ± 0.15</td>
<td>9.61 ± 0.42</td>
<td>42</td>
<td>0.154</td>
<td>0.44</td>
</tr>
<tr>
<td>Oomras</td>
<td>SS 145</td>
<td>2.45 ± 0.10</td>
<td>5.61 ± 0.46</td>
<td>2.40 ± 0.17</td>
<td>6.08 ± 0.38</td>
<td>47</td>
<td>0.071</td>
<td>0.49</td>
</tr>
<tr>
<td>Bengals</td>
<td>C 1108</td>
<td>2.92 ± 0.10</td>
<td>5.86 ± 0.45</td>
<td>2.09 ± 0.14</td>
<td>5.60 ± 0.44</td>
<td>44</td>
<td>0.057</td>
<td>0.49</td>
</tr>
</tbody>
</table>

### Table IV
Mean Fineness, Strength, Extension, etc., for Bast and other Vegetable Fibres

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fineness, denier</th>
<th>Breaking load, grams</th>
<th>Specific strength, gms./den.</th>
<th>Breaking extension, %</th>
<th>Initial Young's modulus, gms./den.</th>
<th>Work of rupture, gm.cm./den.</th>
<th>Work factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flax I</td>
<td>1.68 ± 0.09</td>
<td>10.6 ± 0.9</td>
<td>6.59 ± 0.45</td>
<td>3.27 ± 0.15</td>
<td>202</td>
<td>0.108</td>
<td>0.50</td>
</tr>
<tr>
<td>Flax II</td>
<td>2.62 ± 0.11</td>
<td>13.5 ± 0.9</td>
<td>5.64 ± 0.27</td>
<td>2.76 ± 0.13</td>
<td>204</td>
<td>0.078</td>
<td>0.50</td>
</tr>
<tr>
<td>Jute 1</td>
<td>1.6 ± 0.14</td>
<td>47.6 ± 2.9</td>
<td>3.76 ± 0.23</td>
<td>1.88 ± 0.08</td>
<td>201</td>
<td>0.035</td>
<td>0.50</td>
</tr>
<tr>
<td>Jute II</td>
<td>1.7 ± 0.03</td>
<td>54.6 ± 3.6</td>
<td>3.31 ± 0.34</td>
<td>1.73 ± 0.12</td>
<td>190</td>
<td>0.030</td>
<td>0.50</td>
</tr>
<tr>
<td>Russian hemp</td>
<td>3.13 ± 0.22</td>
<td>10.3 ± 1.6</td>
<td>5.21 ± 0.34</td>
<td>2.58 ± 0.15</td>
<td>203</td>
<td>0.066</td>
<td>0.49</td>
</tr>
<tr>
<td>Sisal hemp</td>
<td>8.84 ± 0.34</td>
<td>48.9 ± 2.9</td>
<td>5.30 ± 0.28</td>
<td>1.85 ± 0.06</td>
<td>286</td>
<td>0.049</td>
<td>0.50</td>
</tr>
<tr>
<td>Ramie No. 11</td>
<td>6.23 ± 0.06</td>
<td>42.4 ± 1.3</td>
<td>6.77 ± 0.22</td>
<td>3.64 ± 0.12</td>
<td>169</td>
<td>0.115</td>
<td>0.47</td>
</tr>
<tr>
<td>Ramie No. 12</td>
<td>4.59 ± 0.15</td>
<td>30.5 ± 1.6</td>
<td>6.74 ± 0.34</td>
<td>3.84 ± 0.12</td>
<td>161</td>
<td>0.119</td>
<td>0.47</td>
</tr>
<tr>
<td>Kapok</td>
<td>0.55 ± 0.02</td>
<td>0.91 ± 0.05</td>
<td>1.75 ± 0.10</td>
<td>1.22 ± 0.07</td>
<td>143</td>
<td>0.011</td>
<td>0.50</td>
</tr>
<tr>
<td>Akund</td>
<td>1.12 ± 0.05</td>
<td>2.60 ± 0.18</td>
<td>2.40 ± 0.17</td>
<td>1.56 ± 0.09</td>
<td>154</td>
<td>0.019</td>
<td>0.50</td>
</tr>
</tbody>
</table>
Table V
Mean Fineness, Strength, Extension at Break, etc., of Rayons

Conditions: 65% R.H.; 20° C.; 1-cm. test length; rate of loading, 10 gms./den./min.; 25 tests per sample.

<table>
<thead>
<tr>
<th>Approx. denier</th>
<th>Sample</th>
<th>Fluidity, poise</th>
<th>Fineness, denier</th>
<th>Breaking load, grams</th>
<th>Specific strength, gms./den.</th>
<th>Breaking extension, %</th>
<th>Initial Young's modulus, gms./den.</th>
<th>Yield point</th>
<th>Stress, gms./den.</th>
<th>Strain, %</th>
<th>Work of rupture, gm.cm./den.</th>
<th>Work factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Viscose ...</td>
<td>8.5</td>
<td>1.54 ± 0.07</td>
<td>3.15 ± 0.13</td>
<td>2.05 ± 0.01</td>
<td>27.2 ± 0.4</td>
<td>54</td>
<td>0.65</td>
<td>2.02</td>
<td>0.45</td>
<td>0.346</td>
<td>0.62</td>
</tr>
<tr>
<td>5</td>
<td>Viscose ...</td>
<td>9.7</td>
<td>4.72 ± 0.23</td>
<td>8.21 ± 0.40</td>
<td>1.76 ± 0.04</td>
<td>27.0 ± 1.0</td>
<td>48</td>
<td>0.64</td>
<td>2.20</td>
<td>0.73</td>
<td>0.290</td>
<td>0.62</td>
</tr>
<tr>
<td>2</td>
<td>Paracor</td>
<td>4.4</td>
<td>2.41 ± 0.02</td>
<td>5.69 ± 0.19</td>
<td>2.41 ± 0.08</td>
<td>23.6 ± 1.4</td>
<td>67</td>
<td>0.73</td>
<td>1.91</td>
<td>0.352</td>
<td>0.352</td>
<td>0.62</td>
</tr>
<tr>
<td>2</td>
<td>Tenasco...</td>
<td>4.9</td>
<td>2.10 ± 0.05</td>
<td>6.34 ± 0.30</td>
<td>3.07 ± 0.12</td>
<td>16.9 ± 0.7</td>
<td>68</td>
<td>0.74</td>
<td>1.65</td>
<td>0.256</td>
<td>0.256</td>
<td>0.50</td>
</tr>
<tr>
<td>2</td>
<td>Durafl ...</td>
<td>2.4</td>
<td>0.255 ± 0.01</td>
<td>1.39 ± 0.09</td>
<td>5.52 ± 0.38</td>
<td>5.8 ± 0.3</td>
<td>176</td>
<td>1.42</td>
<td>0.91</td>
<td>0.169</td>
<td>0.169</td>
<td>0.53</td>
</tr>
<tr>
<td>2</td>
<td>Fibro</td>
<td>9.5</td>
<td>1.48 ± 0.03</td>
<td>3.33 ± 0.05</td>
<td>2.29 ± 0.03</td>
<td>15.7 ± 0.4</td>
<td>74</td>
<td>0.77</td>
<td>1.88</td>
<td>0.213</td>
<td>0.213</td>
<td>0.59</td>
</tr>
<tr>
<td>3</td>
<td>Strong Fibro</td>
<td>9.7</td>
<td>1.20 ± 0.03</td>
<td>2.88 ± 0.13</td>
<td>2.41 ± 0.10</td>
<td>12.8 ± 0.7</td>
<td>83</td>
<td>0.85</td>
<td>1.52</td>
<td>0.196</td>
<td>0.196</td>
<td>0.63</td>
</tr>
<tr>
<td>3</td>
<td>Acetate Fibro</td>
<td>11.4</td>
<td>2.81 ± 0.06</td>
<td>2.93 ± 0.08</td>
<td>1.05 ± 0.03</td>
<td>27.7 ± 0.9</td>
<td>26</td>
<td>0.58</td>
<td>4.02</td>
<td>0.210</td>
<td>0.210</td>
<td>0.71</td>
</tr>
<tr>
<td>3</td>
<td>Seraceta</td>
<td>9.3</td>
<td>3.45 ± 0.02</td>
<td>4.46 ± 0.12</td>
<td>1.28 ± 0.04</td>
<td>35.6 ± 1.5</td>
<td>27</td>
<td>0.65</td>
<td>3.77</td>
<td>0.304</td>
<td>0.304</td>
<td>0.67</td>
</tr>
<tr>
<td>3</td>
<td>Celanese</td>
<td>10.6</td>
<td>0.96 ± 0.02</td>
<td>1.37 ± 0.05</td>
<td>1.43 ± 0.05</td>
<td>23.7 ± 1.5</td>
<td>41</td>
<td>0.84</td>
<td>3.23</td>
<td>0.244</td>
<td>0.244</td>
<td>0.72</td>
</tr>
<tr>
<td>3</td>
<td>Celanese F4</td>
<td>10.1</td>
<td>1.59 ± 0.02</td>
<td>6.11 ± 0.21</td>
<td>3.86 ± 0.15</td>
<td>5.5 ± 0.3</td>
<td>145</td>
<td>1.60</td>
<td>1.46</td>
<td>0.222</td>
<td>0.122</td>
<td>0.87</td>
</tr>
<tr>
<td>3</td>
<td>Celanese FS6</td>
<td>11.1</td>
<td>1.11 ± 0.03</td>
<td>5.30 ± 0.22</td>
<td>4.79 ± 0.24</td>
<td>5.1 ± 0.2</td>
<td>152</td>
<td>1.10</td>
<td>0.86</td>
<td>0.119</td>
<td>0.119</td>
<td>0.49</td>
</tr>
<tr>
<td>3</td>
<td>Celanese FS9</td>
<td>7.1</td>
<td>1.05 ± 0.03</td>
<td>6.96 ± 0.51</td>
<td>6.65 ± 0.48</td>
<td>6.4 ± 0.4</td>
<td>183</td>
<td>1.28</td>
<td>0.77</td>
<td>0.216</td>
<td>0.216</td>
<td>0.51</td>
</tr>
<tr>
<td>1</td>
<td>Bemberg</td>
<td>3.0</td>
<td>1.35 ± 0.04</td>
<td>2.45 ± 0.06</td>
<td>1.84 ± 0.05</td>
<td>22.6 ± 1.7</td>
<td>68</td>
<td>0.68</td>
<td>1.87</td>
<td>0.283</td>
<td>0.283</td>
<td>0.68</td>
</tr>
<tr>
<td>5</td>
<td>Obourg nitro</td>
<td>17.0</td>
<td>5.49 ± 0.20</td>
<td>8.70 ± 0.35</td>
<td>1.58 ± 0.03</td>
<td>17.4 ± 0.6</td>
<td>47</td>
<td>0.66</td>
<td>1.88</td>
<td>0.175</td>
<td>0.175</td>
<td>0.64</td>
</tr>
<tr>
<td>4</td>
<td>Rayolanda I</td>
<td>—</td>
<td>4.29 ± 0.11</td>
<td>11.3 ± 0.41</td>
<td>2.60 ± 0.08</td>
<td>13.9 ± 0.8</td>
<td>62</td>
<td>0.96</td>
<td>2.13</td>
<td>0.212</td>
<td>0.212</td>
<td>0.69</td>
</tr>
<tr>
<td>4</td>
<td>Rayolanda II</td>
<td>—</td>
<td>4.45 ± 0.09</td>
<td>9.35 ± 0.30</td>
<td>2.12 ± 0.06</td>
<td>17.8 ± 0.9</td>
<td>56</td>
<td>0.81</td>
<td>2.29</td>
<td>0.230</td>
<td>0.230</td>
<td>0.61</td>
</tr>
</tbody>
</table>
### Table VI

**Mean Fineness, Strength, Extension at Break, etc., of Silk and Synthetic Fibres**

Conditions: 65% R.H.; 20° C.; 1-cm. test length; rate of loading, 10 gms./den./min.; 25 tests per sample.

<table>
<thead>
<tr>
<th>Approx. denier</th>
<th>Sample</th>
<th>Fineness, denier</th>
<th>Breaking load, grams</th>
<th>Specific strength, gms./den.</th>
<th>Breaking extension, %</th>
<th>Initial Young's modulus, gms./den.</th>
<th>Yield point</th>
<th>Work of rupture, gm.cm./den.</th>
<th>Stress, gm./den.</th>
<th>Strain, %</th>
<th>Work factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chinese silk</td>
<td>0.87 ± 0.04</td>
<td>4.53 ± 0.24</td>
<td>5.20 ± 0.20</td>
<td>23.1 ± 1.5</td>
<td>117</td>
<td>2.21</td>
<td>3.38</td>
<td>0.800</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>1½</td>
<td>Italian silk</td>
<td>1.37 ± 0.04</td>
<td>6.87 ± 0.22</td>
<td>5.02 ± 0.07</td>
<td>31.0 ± 1.3</td>
<td>76</td>
<td>1.35</td>
<td>2.55</td>
<td>0.975</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Japanese silk</td>
<td>1.45 ± 0.04</td>
<td>6.26 ± 0.16</td>
<td>4.36 ± 0.10</td>
<td>23.4 ± 0.7</td>
<td>83</td>
<td>1.76</td>
<td>3.28</td>
<td>0.677</td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>2½</td>
<td>Tussah silk</td>
<td>2.57 ± 0.07</td>
<td>10.5 ± 0.44</td>
<td>4.16 ± 1.7</td>
<td>36.6 ± 1.8</td>
<td>55</td>
<td>1.09</td>
<td>2.82</td>
<td>0.841</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Nylon I</td>
<td>3.26 ± 0.06</td>
<td>16.0 ± 1.0</td>
<td>4.90 ± 0.06</td>
<td>25.9 ± 0.6</td>
<td>23</td>
<td>4.29</td>
<td>18.7</td>
<td>0.684</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Nylon II</td>
<td>3.10 ± 0.05</td>
<td>17.8 ± 3</td>
<td>5.76 ± 0.08</td>
<td>26.8 ± 1.3</td>
<td>38</td>
<td>4.85</td>
<td>13.8</td>
<td>1.032</td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td>1½</td>
<td>Vinyon I</td>
<td>1.65 ± 0.05</td>
<td>3.67 ± 0.07</td>
<td>2.17 ± 0.05</td>
<td>35.9 ± 0.4</td>
<td>28</td>
<td>0.76</td>
<td>4.30</td>
<td>0.434</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>1½</td>
<td>Vinyon II</td>
<td>1.26 ± 0.04</td>
<td>3.07 ± 0.04</td>
<td>2.51 ± 0.09</td>
<td>23.0 ± 1.0</td>
<td>38</td>
<td>0.79</td>
<td>2.83</td>
<td>0.346</td>
<td>0.60</td>
<td></td>
</tr>
</tbody>
</table>

### Table VII

**Mean Fineness, Strength, Extension, etc., for Wool and Casein**

Conditions: 65% R.H.; 20° C.; 1-cm. test length; rate of loading, 10 gms./den./min.; 25 tests per sample.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fineness, denier</th>
<th>Breaking load, grams</th>
<th>Specific strength, gms./den.</th>
<th>Breaking extension, %</th>
<th>Initial Young's modulus, gms./den.</th>
<th>Yield point</th>
<th>Work of rupture, gm.cm./den.</th>
<th>Stress, gm./den.</th>
<th>Strain, %</th>
<th>Work factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool, 64's</td>
<td>3.94 ± 0.14</td>
<td>5.14 ± 0.24</td>
<td>1.28 ± 0.06</td>
<td>42.5 ± 2.2</td>
<td>26.1</td>
<td>0.64</td>
<td>5.0</td>
<td>0.350</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>Wool, 56's</td>
<td>12.0 ± 0.6</td>
<td>18.8 ± 1.4</td>
<td>1.59 ± 0.09</td>
<td>42.9 ± 1.5</td>
<td>24.1</td>
<td>0.70</td>
<td>5.1</td>
<td>0.424</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>Wool, 36's</td>
<td>26.8 ± 0.7</td>
<td>35.1 ± 3.0</td>
<td>1.29 ± 0.08</td>
<td>29.8 ± 3.2</td>
<td>33.9</td>
<td>0.83</td>
<td>3.6</td>
<td>0.301</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td>Mohair</td>
<td>10.9 ± 0.8</td>
<td>14.2 ± 0.8</td>
<td>1.44 ± 1.0</td>
<td>30.0 ± 2.5</td>
<td>39.4</td>
<td>0.88</td>
<td>3.4</td>
<td>0.301</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>Camel hair</td>
<td>9.55 ± 3.3</td>
<td>16.1 ± 1.9</td>
<td>1.79 ± 0.08</td>
<td>39.4 ± 1.9</td>
<td>33.3</td>
<td>1.06</td>
<td>4.0</td>
<td>0.520</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>Casein</td>
<td>3.30 ± 0.10</td>
<td>2.35 ± 0.16</td>
<td>0.72 ± 0.05</td>
<td>25.6 ± 4.3</td>
<td>24.1</td>
<td>0.55</td>
<td>3.8</td>
<td>0.161</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>Lanital</td>
<td>3.67 ± 0.16</td>
<td>2.60 ± 0.15</td>
<td>0.72 ± 0.04</td>
<td>36.5 ± 7.1</td>
<td>25.7</td>
<td>0.61</td>
<td>4.6</td>
<td>0.235</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>Aralac</td>
<td>5.34 ± 0.34</td>
<td>4.13 ± 0.28</td>
<td>0.70 ± 0.03</td>
<td>59.3 ± 6.3</td>
<td>19.5</td>
<td>0.62</td>
<td>6.3</td>
<td>0.391</td>
<td>0.84</td>
<td></td>
</tr>
</tbody>
</table>
### Table VIII

Average Values for Different Fibres

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Fineness, den.</th>
<th>Specific strength, gm./den.</th>
<th>Breaking extension, %</th>
<th>Initial Young’s modulus, gm./den.</th>
<th>Yield stress, gm./den.</th>
<th>Yield strain, %</th>
<th>Work of rupture, gm. cm./den.</th>
<th>Work factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>1.7</td>
<td>3.5</td>
<td>1.8</td>
<td>55</td>
<td>0.73</td>
<td>1.0</td>
<td>0.11</td>
<td>0.47</td>
</tr>
<tr>
<td>Flax</td>
<td>2.2</td>
<td>6.1</td>
<td>3.4</td>
<td>203</td>
<td>1.27</td>
<td>1.0</td>
<td>0.09</td>
<td>0.50</td>
</tr>
<tr>
<td>Hemp</td>
<td>3.0</td>
<td>5.2</td>
<td>3.2</td>
<td>203</td>
<td>1.27</td>
<td>1.0</td>
<td>0.07</td>
<td>0.49</td>
</tr>
<tr>
<td>Jute</td>
<td>15</td>
<td>3.5</td>
<td>1.8</td>
<td>195</td>
<td>1.27</td>
<td>1.0</td>
<td>0.03</td>
<td>0.50</td>
</tr>
<tr>
<td>Ramie</td>
<td>5.4</td>
<td>6.7</td>
<td>1.8</td>
<td>145</td>
<td>1.27</td>
<td>1.0</td>
<td>0.12</td>
<td>0.47</td>
</tr>
<tr>
<td>Viscose rayon</td>
<td>2.3</td>
<td>2.1</td>
<td>2.1</td>
<td>65</td>
<td>0.73</td>
<td>1.0</td>
<td>0.26</td>
<td>0.62</td>
</tr>
<tr>
<td>Stretched rayon</td>
<td>0.8</td>
<td>5.6</td>
<td>5.8</td>
<td>170</td>
<td>1.27</td>
<td>1.0</td>
<td>0.17</td>
<td>0.51</td>
</tr>
<tr>
<td>Acetate rayon</td>
<td>2.4</td>
<td>1.3</td>
<td>2.1</td>
<td>31</td>
<td>0.68</td>
<td>3.7</td>
<td>0.25</td>
<td>0.70</td>
</tr>
<tr>
<td>Silk</td>
<td>1.2</td>
<td>4.9</td>
<td>2.1</td>
<td>85</td>
<td>1.8</td>
<td>3.2</td>
<td>0.82</td>
<td>0.65</td>
</tr>
<tr>
<td>Nylon</td>
<td>3.2</td>
<td>5.3</td>
<td>2.1</td>
<td>26</td>
<td>20</td>
<td>4.6</td>
<td>0.86</td>
<td>0.61</td>
</tr>
<tr>
<td>Wool</td>
<td>14</td>
<td>1.4</td>
<td>2.1</td>
<td>38</td>
<td>0.7</td>
<td>4.5</td>
<td>0.26</td>
<td>0.68</td>
</tr>
<tr>
<td>Casein</td>
<td>4.1</td>
<td>0.7</td>
<td>2.1</td>
<td>25-60</td>
<td>0.6</td>
<td>4.9</td>
<td>0.26</td>
<td>0.86</td>
</tr>
</tbody>
</table>

### Table IX

Average Values of the Variation within a Sample for Different Fibres

<table>
<thead>
<tr>
<th>Sample</th>
<th>Coefficient of Variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fineness</td>
</tr>
<tr>
<td>Cotton</td>
<td>24</td>
</tr>
<tr>
<td>Bast fibres</td>
<td>24</td>
</tr>
<tr>
<td>Rayon</td>
<td>12</td>
</tr>
<tr>
<td>Silk</td>
<td>17</td>
</tr>
<tr>
<td>Nylon</td>
<td>9</td>
</tr>
<tr>
<td>Vinyon</td>
<td>16</td>
</tr>
<tr>
<td>Wool</td>
<td>21</td>
</tr>
<tr>
<td>Casein</td>
<td>23</td>
</tr>
</tbody>
</table>

### APPENDIX I

Densities of Textile Fibres

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Density, gm./c.c.</th>
<th>Reference</th>
<th>Fibre</th>
<th>Density, gm./c.c.</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>1.52</td>
<td>49</td>
<td>Nitrocellulose rayon</td>
<td>1.54</td>
<td>52</td>
</tr>
<tr>
<td>Flax</td>
<td>1.50</td>
<td>50</td>
<td>Acetate rayon</td>
<td>1.33</td>
<td>50</td>
</tr>
<tr>
<td>Hemp</td>
<td>1.48</td>
<td>50</td>
<td>Silk (degummed)</td>
<td>1.35</td>
<td>53</td>
</tr>
<tr>
<td>Jute</td>
<td>1.48</td>
<td>50</td>
<td>Nylon</td>
<td>1.14</td>
<td>50</td>
</tr>
<tr>
<td>Ramie</td>
<td>1.52</td>
<td>50</td>
<td>Vinyon</td>
<td>1.35</td>
<td>54</td>
</tr>
<tr>
<td>Kapok</td>
<td>1.47</td>
<td>51</td>
<td>Wool</td>
<td>1.32</td>
<td>50</td>
</tr>
<tr>
<td>Viscose rayon</td>
<td>1.52</td>
<td>50</td>
<td>Mohair</td>
<td>1.32</td>
<td>50</td>
</tr>
<tr>
<td>Cuprammonium rayon</td>
<td>1.52</td>
<td>50</td>
<td>Camel hair</td>
<td>1.32</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Casein</td>
<td>1.30</td>
<td>50</td>
</tr>
</tbody>
</table>
## APPENDIX II

Data for Stress-Strain Curves of Various Fibres

(First line gives stress in grams per denier; second line gives corresponding strain in %)

### Sample.

<table>
<thead>
<tr>
<th>Cotton</th>
<th>Stress (g/den)</th>
<th>Strain (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Vincent, V135 M10</td>
<td>1.02</td>
<td>1.86</td>
</tr>
<tr>
<td>Montserrat X/E 2434</td>
<td>0.83</td>
<td>2.72</td>
</tr>
<tr>
<td>Uppers SS 45</td>
<td>0.72</td>
<td>1.26</td>
</tr>
<tr>
<td>Punjab-American SS 76</td>
<td>0.56</td>
<td>1.42</td>
</tr>
<tr>
<td>Ishan SS 88</td>
<td>0.64</td>
<td>1.42</td>
</tr>
</tbody>
</table>

### Bast and other Vegetable Fibres

<table>
<thead>
<tr>
<th>Flax I</th>
<th>Stress (g/den)</th>
<th>Strain (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flax II</td>
<td>1.14</td>
<td>2.25</td>
</tr>
<tr>
<td>Jute I</td>
<td>0.55</td>
<td>1.10</td>
</tr>
<tr>
<td>Jute II</td>
<td>0.56</td>
<td>1.33</td>
</tr>
<tr>
<td>Russian hemp</td>
<td>0.54</td>
<td>1.07</td>
</tr>
<tr>
<td>Ramie No. 11</td>
<td>0.73</td>
<td>1.45</td>
</tr>
<tr>
<td>Ramie No. 12</td>
<td>0.77</td>
<td>1.64</td>
</tr>
<tr>
<td>Kapok</td>
<td>0.54</td>
<td>0.49</td>
</tr>
<tr>
<td>Akund</td>
<td>0.31</td>
<td>0.62</td>
</tr>
</tbody>
</table>

### Rayon, Filaments and Staple

<table>
<thead>
<tr>
<th>Viscose 1½ den.</th>
<th>Stress (g/den)</th>
<th>Strain (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscose 5 den.</td>
<td>0.42</td>
<td>0.76</td>
</tr>
<tr>
<td>Paracor</td>
<td>0.43</td>
<td>0.75</td>
</tr>
<tr>
<td>Tenasco</td>
<td>0.66</td>
<td>6.9</td>
</tr>
<tr>
<td>Durafl D</td>
<td>0.26</td>
<td>3.24</td>
</tr>
<tr>
<td>Fibro</td>
<td>0.83</td>
<td>2.3</td>
</tr>
<tr>
<td>Strong Fibro</td>
<td>0.58</td>
<td>1.39</td>
</tr>
<tr>
<td>Acetate Fibro</td>
<td>0.39</td>
<td>1.15</td>
</tr>
<tr>
<td>Seraceta</td>
<td>0.53</td>
<td>0.85</td>
</tr>
<tr>
<td>Celanese</td>
<td>0.70</td>
<td>0.98</td>
</tr>
<tr>
<td>Celanese F4</td>
<td>1.7</td>
<td>9.5</td>
</tr>
<tr>
<td>Celanese FS6</td>
<td>1.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Celanese FS9</td>
<td>1.0</td>
<td>2.1</td>
</tr>
<tr>
<td>Bemberg</td>
<td>0.61</td>
<td>1.4</td>
</tr>
<tr>
<td>Obourg Nitro</td>
<td>0.68</td>
<td>1.40</td>
</tr>
<tr>
<td>Rayolanda (I)</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Rayolanda (II)</td>
<td>1.0</td>
<td>0.7</td>
</tr>
</tbody>
</table>
### Appendix II—continued

#### Sample

**SILK, NYLON AND VINYON**

<table>
<thead>
<tr>
<th>Material</th>
<th>Stress (kg/cm²)</th>
<th>Strain (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese silk</td>
<td>1.52</td>
<td>3.24</td>
</tr>
<tr>
<td>Italian silk</td>
<td>1.3</td>
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#### WOOL, HAIR AND CASEIN FIBRES

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<tr>
<th>Material</th>
<th>Stress (kg/cm²)</th>
<th>Strain (%)</th>
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<td>Wool, 64s</td>
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<td>0.78</td>
</tr>
<tr>
<td>Wool, 56s</td>
<td>8.5</td>
<td>17.0</td>
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<tr>
<td>Wool, 36s</td>
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<td>Mohair</td>
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<tr>
<td>Camel hair</td>
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<tr>
<td>Casein</td>
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<td>Lanital</td>
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Received 27/12/44
1—FIBRES AND THEIR PRODUCTION

(B)—ANIMAL

Eri Silk: Production in Assam. H. K. Nandi. Indian Farming, 1944, 5, 365-366. Eri silk is obtained from cocoons of the caterpillars of Attacus ricini which feed on the leaves of the castor plant known as era in Assam. The rearing of eri is a very popular cottage industry among the people of the Assam Valley, and it is most widely practised in the Mikir Hills. Notes are given on the methods of rearing. Eri silk is very hard and more durable than other types of silk or cotton yarn. It cannot be reeled as each layer of the cocoon gives only about 8-10 yards of yarn. This is the result of the peculiar formation of the cocoon, one end of which is left open for the emergence of the moth. The cocoons are boiled before spinning, and soda, wood ashes or soap may be used as clarifying agents. The ratio of cocoon to fibre is 4:3 and the yarn is not appreciably affected by the type of the food plant, i.e. either the white or red type of castor, but the latter is more suitable. The cocoons are white or brown, the colour being independent of the colour of the caterpillars or the type of food plant. Eri cloth is popular for clothing in Assam, and eri silk is used for making mosquito curtains in some places. Large quantities of eri cocoons and silk are exported to Calcutta, Bhutan and the Punjab.

Silk: Production in England. Lady Hart Dyke. Silk and Rayon, 1945, 19, 43, 67. It is claimed that stock bred from eggs sent from Cyprus is suitable for sericulture in England, and that the associated occupation of rearing mulberry bushes is an attractive opportunity for girls of the Land Army. Lady Hart Dyke's establishment at Lullingstone, Kent, has recently provided eggs and mulberry seed for a new centre at the Cistercian Monastery, Roscrea, Eire.

Grades of Wool from Wyoming Corriedales, Columbias and Panamas. R. H. Burns. Natl. Wool Grower, 1944, 34, No. 11, 14. Details are given of the grades of wool produced by Corriedale ewes and rams, Columbia ewes and Panama rams in Wyoming. Reference is made to the author's table showing the standard, predominating and occasional grades of wool occurring in the breeds of sheep which are of particular interest to Wyoming wool growers (these Abs., 1943, A109).


Sheep Shearing. J. H. Hitchcock. New Zealand J. Agric., 1944, 69, 445-452. Methods of overhauling shearing gear are discussed, with special reference to the grinding of combs and cutters. The different holds and technique used are illustrated and described, and the fundamental rules of shearing enumerated.

(C)—VEGETABLE

loam in west Tennessee. Where land was bedded but not flat-broken, the yields were favourable to 6-in. bedding. Ploughing preparatory to bedding was profitable on rich land, but distinctly unprofitable on poor land. Early ploughing was notably superior under level planting and early ploughing and early bedding gave appreciably better yields at both 3- and 6-in. preparation depths. Good cultivation on poor land resulted in yields averaging nearly 30 per cent. larger than were obtained under no cultivation, whilst on rich land yields averaged the same from both practices.

**Broom Fibre: Production.** F. Tobler. *Faserforschung, 1943, 16, 81-93* (through *Chem. Zentr., 1943, ii, 1337 and Chem. Abstr., 1945, 39, 195*). The author collates information on the mode of growth of the broom, the nature of the branches, retting, fibre content, etc., from his own and other investigations and shows that it is possible to breed branches relatively rich in fibre and to process the material so as to make economic utilisation possible. Methods for improving the yield and fibre content and fibre recovery on a practical economical basis are reported.

**Punjab-American Normal and Tirak Cotton Plants: Comparison of Growth Trends.** R. H. Dastur and A. Ahad. *Indian J. Agric. Sci., 1944, 14, 152-160.* A report is given of a study of the growth characteristics of the 4F Punjab-American cotton plant on normal soil and on soil where *tirak* occurred. A depression was observed in the relative growth rate of plants on sandy loams with saline subsoil in the months of September and October. On light sandy soil the relative growth rate was higher than that of the plants on normal sandy loams during the early stages of growth. Similar differences were found in the net assimilation rate of plants on these soils. The percentage distribution of dry matter in bolls was higher on normal sandy loams than on soils where *tirak* occurred. The percentage of dry matter in the bolls was least on light sandy loams with sodium clay in the subsoil. Growth of the bolls of *tirak*-affected plants ceased after the 28th day stage. No increase in the dry matter of the whole boll occurred after that stage. Lint, however, continued to increase in weight even in *tirak*-affected plants up to the 49th day stage. In the case of normal bolls growth continued up to the 49th day stage in all parts. The dry matter per boll on *tirak*-affected plants was nearly one half of the dry matter per boll on normal plants. The volume, length and diameter of bolls from *tirak*-affected plants were less than those of bolls of normal plants. *Tirak*-affected bolls contained less moisture and fewer seeds and a much higher percentage of immature seeds than normal bolls.

**Cotton: Ginning; Preventing Press Damage.** U.S. Dept. Agr. Leaflet 244, 1944, 8 pp. (through *Exp. Sta. Rec., 1945, 92, 122*). During the pressing of cotton at gins, over-weight and irregularly packed bales cause undue stress on the tramper and press, and cause costly and untimely breakdowns. It is suggested that cotton growers should send to the gin only quantities of seed cotton that will produce bales weighing from 450 to 550 lb. The ginner can divide lots of seed cotton on wagons or trucks in such a way as to gin uniform-weight bales when there are two or more bales from the same farm, and he can encourage the grower to provide some kind of partition for keeping cotton for each bale separate on the wagon or truck. During ginning, the lint must be evenly distributed in the press box in order to prevent rolling or heavily-sided bales. The kicker speed and action should be adjusted to synchronize with the action of the tramper and give uniform distribution of the cotton within the press box. Since the moisture content of cotton varies throughout the ginning season, the kicker should be watched closely and changed from time to time to meet varying conditions. A new design of press-box dog mechanism developed primarily to avoid the formation of dog ridges in gin bales that cause the bales to cut during compression has been found to be effective in providing uniform distribution of the cotton through the bale box. The mechanism consists of two prismatic plates, one for each side of the box, hinged and pivoted for rotation within an opening along the upper part of the sides of the press box, and means for rotating the plates into horizontal position to retain the cotton in the bale box during the tramping operation and to return the plates to vertical position during the pressing period.

studied, 1910-43, the acreage response to the price of cotton adjusted for changes in prices paid by farmers for all commodities was on two distinct planes, the regression equation being \( X_t = 25.568 + 0.683 X_t \) for 1910-24 and \( X_t = 33.238 + 0.888 X_t \) for 1925-33. The elasticity of response was approximately the same in both periods. The elasticity of supply for acreage varied from 0.1 to 0.3 at different levels of price. The first-difference analysis for 1911-33 showed that a 1-cent change in price was followed by a change of approximately 880,000 acres. During periods of acreage control by the Agricultural Adjustment Administration, normal acreage-price relationships failed to hold. Changes in southern agriculture, such as further development of oil-bearing crops, feed crops and livestock, and possibly tobacco, may alter previous relationships.


Glass Fibres: Production and Utilisation. Silk J. Rayon World, 1944, 21, No. 247, 32, 33, 41; No. 248, 52-53. A broad review is given of the modern production of glass filaments, continuous and staple fibre, their physical properties, and applications.

Tantalum Rayon Spinnerets: Perforating. C. C. Downie. Silk and Rayon, 1945, 19, 88-91. An illustrated account is given of methods for perforating tantalum cups for use as spinnerets. The usual method is to punch a series of bulges in the metal, grind down the projections and finish the holes with a punching needle. The cup is mounted on an anvil under the punching machine and a low-power binocular microscope is set up for frequent inspection of the work. The mechanical properties of tantalum sheet are recorded.

Rayon Filaments: Stretch Spinning. Silk and Rayon, 1945, 19, 317-320, 325. Modern methods for the production of strong rayon filaments by stretching at some stage during spinning are reviewed and discussed on the basis of micellar orientation.

"Ardil" Fibre and Fabrics: Production. Imperial Chemical Industries Ltd. Silk and Rayon, 1945, 19, 30-31, 99; Textile Manufacturer, 1945, 71, 27, 31. An announcement is made of the conclusion of the first stage of experimental work on the production of "Ardil" fibre from ground-nut protein, and its spinning, weaving and knitting. Illustrations are provided of the product at various stages and a list is given of spinners and weavers in the wool districts, knitters, dyers and finishers who collaborated in the developments. Mixtures of "Ardil" and viscose rayon have also been spun and the yarns made into knitted and woven fabrics.

Patents

Rayon Cakes: Treatment with Liquids. Courtaulds Ltd. and D. C. F. Devos. B.P. 567,528 of 27/5/1943:19/2/1945. A method of treating one or more cakes of artificial thread with liquids, comprises inserting in the cakes a soft, flexible perforated sheath of rubber or like elastic material that offers substantial resistance to the passage of liquid, and supplying the treating liquid at the surfaces of the sheath remote from the cakes at such a pressure that liquid is forced through the sheath and thence to and through the cakes. The cakes may be assembled on a tubular perforated holder over which is placed a perforated soft permeable sheath of rubber or like elastic material, the size and number of the perforations in the sheath being considerably less than the size and number of perforations in the holder.

Alginate Threads: Production. Courtaulds Ltd. and R. B. Hall. B.P. 597,641 of 1/9/1942:26/2/1945. A process for the manufacture of threads by projecting an aqueous solution of alkali alginate into a suitable coagulating bath and then treating the thread in the form of helices on a thread-advancing device, is characterised by the use of a coagulating bath and other treating liquids which are free from oil and one or more of which contains a small proportion of a cationic or non-ionogenic wetting-out agent, e.g. lauryl pyridinium sulphate, cetyl pyridinium chloride and the non-ionogenic water-
soluble compounds obtainable by the action of ethylene oxide on an aliphatic alcohol or carboxylic acid containing more than 8 C atoms.

**Enzyme Preparation: Production.** Commonwealth Council for Scientific and Industrial Research. Australian P.118,850 of 7/9/1944. Wheat bran, inoculated with an aqueous suspension of spores of a mould of the species *Aspergillus flavus-oryzae*, is incubated for 2-5 days at 20°-30° C.; the bran is then extracted with water and the culture filtered to obtain the extract. This can be used for recovering wool from skin (see following abstract), for degumming silk and for desizing textiles. The residue from the extraction process contains ergosterol, which, when exposed to sunlight or to ultra-violet radiation, yields material rich in vitamin-D.

**Wool: Recovering from Skin Pieces.** Commonwealth Council for Scientific and Industrial Research. Australian P.118,851 of 7/9/1944. Skin pieces or damaged skins are treated with an aqueous protease extract to dissolve or partly dissolve the skin substance and recover the wool. The protease may be of the mould type (see preceding abstract) or papain. If a mould extract is used, the skin pieces, preferably immersed in water, are heated to 65°-75° C. for 1/2-2 hr. to shrink the skin collagen; after cooling, they are digested at 35°-45° C. for one or more days, an extract of pH 7 giving optimum activity; the wool is washed in water and scoured in the usual way. A papain extract is prepared by adding 0.2-0.4 parts by weight of papain powder to 100 parts by weight of water. Pre-treatment to shrink the collagen is unnecessary if digestion with papain is carried out at 65° C. or more.

2—CONVERSION OF FIBRES INTO FINISHED YARNS

**(A)—Preparatory Processes**

**Rayon Staple: Processing on Cotton Machinery.** Southern Textile Association. *Textile World*, 1944, 94, No. 11, 135-137. Extracts are given of papers read at conferences. (1) R. M. Jones reviews developments in Saco-Lowell machines for carding and drafting rayon staple, including the "3 over 4" roving frame with three lines of top rollers and four bottom rollers, the middle top roller resting in the V-space between the 2nd- and 3rd-bottom rollers. This arrangement provides more positive control and the frame is suitable for drafts of 6 to 45 with 1-inch cotton to 2j-inch rayon staple. (2) R. J. McConnel refers to the Whitin Co.'s Bi-coil draw-frame as offering great economies in floor space and cost. (3) E. H. Dreher discusses the optimum relation between denier and staple length. In 1-00 and 1.25 den., greatest yarn strength is reached at 1 & 1/4 ins.; in 1.50 den. at 2 1/2 ins., and in 3.5-5 den. at 2 1/3 ins. (4) F. S. Culpepper reports on suitable procedures in drawing and spinning.

**Blending Hoppers: Application.** *Textile Recorder*, 1945, 62, January, 40-41. A brief explanation is given of the advantages of the American system of feeding cotton from the bales to a set of four blending hoppers in parallel. Each hopper may operate on a different mark or type of cotton, and is set in accordance with the bale density in question.

**Cotton: Carding.** E. B. Grover. *Textile Research*, 1944, 14, 403. Tentative conclusions and observations reached in research on cotton carding at the U.S. Textile Research Institute include the following: (1) Considerable increases in card production per unit are feasible without detrimental effects on the quality of the product; (2) yarn strengths are not impaired significantly as a result of increased card speeds; (3) yarn character or appearance is affected only to a moderate degree by increases in card speeds; (4) neppiness is affected more by the condition of the raw material than by changes within the card; (5) cotton of high fibre strength will result in good processing and strong yarn; (6) fibre strengths are not impaired by increased card speeds; (7) average fibre lengths by weight remain unchanged over wide ranges of card speeds; (8) waste removal can be controlled at least to a limited extent to allow high production without serious deterioration in the quality of the product; (9) peak power demand charges are not increased by the use of high over-all card speeds; (10) further investigation is needed and will be made on the effect of front knife plate settings.
Noble Combing: Dabbing Mechanism. *Wool Rec.*, 1945, 67, 149-150. The importance is stressed of the correct functioning of the dabbing brush in producing a top free from neps, slubs, etc. and noil. The double balanced dabbing motion reciprocates at a high speed without excessive vibration. The wear of the bristles on the heel of a dabbing brush is exceptionally rapid, but the life of the brush can be lengthened by adjusting the stroke to suit different wools.

W.

Post-War Woollen Carding Machines. G. Marshall. *Wool Rec.*, 1945, 67, 276-278. The relative merits are discussed of wood and iron for the construction of woollen carding machines. For a high rate of production and a high level of efficiency, the iron machine is preferred, except possibly for very low and greasy materials. For normal English practice an iron set using a 2-part arrangement with 1 Scotch feed is suitable. The tendency is to use more swifts with fewer workers per part. Peralta burr and thread crushers give greater freedom from sliver trouble when incorporated in a part of the machine and not followed immediately by an intermediate feed. A more efficient type of Garnett breast is desirable than is usual on the Continental machine. A set suitable for practically all types of material could be made up of scribbler composed of Garnett breast (about 40 in. diameter, fitted with 3 or 4 pairs of workers and strippers, a fancy (card wire) and a doffer), followed by 2 swifts each with 36 in. doffers, 4 or 5 pairs of workers and strippers according to the type of material, and a Peralta placed between the first part doffer and the second part swift; the intermediate feed would be a Scotch feed, and this could be followed by a carder with 1 or 2 swifts of the same dimensions as the scribbler swifts. One machine 72 in. wide may have the productive capacity of 2 old-type machines 60 in. wide.

W.

(B)—Spinning and Doubling

Cotton Mill Waste: Reduction. F. L. Asbury. *Textile World*, 1944, 94, No. 11, 123-125. Measures taken at the Avondale Mills, Alabama, to induce operatives to prevent undue waste are briefly reviewed. One plan is to keep posted on a notice board the current market value of hard and soft types of cotton waste. Posters are also used to stress the connection between accidents and loose objects allowed to lie on the floor, or the monetary value of such articles as bobbins.

C.

Spinning Mill Operatives: Work Assignment. F. H. Gunther and M. Gross. *Textile World*, 1944, 94, No. 12, 92-93. The writers describe with examples the principles by which the spinner's task may be calculated from a knowledge of the number of "ends down" per 1,000 spindles per hour and the running time of a creelued bobbin of roving, on the assumption that 15 per cent. of idle time is allowed. A table shows typical times and frequencies for performing various operations in the spinning of 32s combed warp yarn.

C.

Carding and Spinning Rooms: Staffing. *Textile Recorder*, 1945, 62, January, 42-43. The writer reviews the possibilities of reducing staffing difficulties by (1) the introduction of high-draft spinning (coupled with more efficient carding and the use of large sliver cans), (2) rearranging the work of doffing in the ring room, and (3) grouping the operatives in the mule department into (a) experienced machine minders, (b) juniors and other males in training, and (c) auxiliary male and female labour.

C.

Cotton Mill: Re-organisation. *Textile Recorder*, 1945, 62, February, 38-39, 62. A spinning mill manager offers suggestions for increasing the production per man-hour by known improvements in the blowroom, carding, drawframe and speed-frame processes, spinning, winding and beaming. He claims, however, that Government support is the main requirement, including favourable labour supply and export policies and a different measure of taxation.

C.


C.

Silk Waste: Spinning on Woollen Machinery; Electrification Difficulties. H. Marsden. *Textile Manufacturer*, 1945, 71, 29. Commenting on the paper by H. N. Sykes, the writer feels that other factors should be considered before accepting the suggestion that fibres can be readily electrified by ionized air. Methods for countering ‘static’ troubles are mentioned.

Woollen Mule Spinning: Reducing Machine Stoppages. ‘Overlooker.’ *Text. Rec.*, 1945, 62, No. 742, 44. Essential stoppages, e.g. creeling, doffing and changing from one lot to another, can be reduced by careful organisation. Practical hints are also given for reducing irregular stoppages due to broken ends (caused frequently by inefficient carding and condensing, and occasionally by incorrect setting of the mule, especially of the scroll), broken spindle bands, mechanical breakdown (caused principally by inadequate oiling and cleaning of the headstock), and lack of care of driving belts and ropes.

Patents

Carding Engine Taker-in Control Member. British Cotton Industry Research Association and J. Locke. B.P.567,499 of 23/4/1943:16/2/1945. A device for obtaining an improved cleaning action in the taker-in region of a carding engine comprises a control member constructed to provide an enclosed space below the striking face of the dish plate, and having an upper surface which faces the on-coming stream of material from the striking face, which surface is disposed at an acute angle to the taker-in so as to form a converging wedge towards the taker-in, and a striking edge forming a second striking surface below such space disposed at an obtuse angle to the striking face of the dish plate. This member controls the position round the arc of the surface of the taker-in at which material not actually caught in the teeth of the taker-in is projected into the air space below the taker-in. The control member may be shaped differently or placed in different positions so as to give a control position to suit different requirements. Co-operating with the control member is a collecting member which takes the place of the known form of taker-in undercasing or grid. This collecting member joins the cylinder undercasing at its upper end, is provided with a suitably shaped nose piece at the lead-in end, and is adjustable at both ends as regards its distance from the taker-in surface.

Carding Engine Stripping or Fly Comb. Platt Brothers & Co. Ltd. and H. Turner. B.P.567,511 of 21/9/1943:16/2/1945. A stripping or fly comb for woollen, worsted waste or cotton carding engines is characterised in that the teeth of the comb, outwardly from the centre, are inclined inwardly. According to one embodiment of the invention the comb has the known straight or V-teeth over a predetermined length only in the centre of the length of the comb blade, the teeth to the right and left hand of such predetermined length whilst of V-shape being inclined inwardly from the right and left hand for the remaining or outer portions of the blade, so that the varyingly disposed teeth act on the web as it leaves the doffer. According to another embodiment the teeth are inclined at progressively increasing angles.

3—CONVERSION OF YARNS INTO FABRICS

(A)—PREPARATORY PROCESSES


Magazine-end Cone Creel: Count Changing in Warping. Universal Winding Co. *Textile Recorder*, 1945, 62, February, 58, 70. An illustrated description is given of the operations involved in changing counts in warping on a high-speed magazine cone creel without much delay and without the need to thread the expansion comb or drop wires again. The new cones are mounted on extra holders on the creel and the old cones are swung out. Each old end is then broken, joined to a new end, merely by twisting, and the new cone is swung into place. The twisted ends are drawn through the comb and drop wires and the old yarn is cut off. The warper is then started again and the old cones are removed. A 4-lb. cone of yarn holds enough yarn for three full beams.
Conversion of Yams into Fabrics


1. The use of magnesium. Magnesium castings cost 10-20 times as much as grey cast iron, but have higher shock resistance, and are good for machining. There are, however, many disadvantages, including a tendency to smudge textiles.

2. The use of plastics. Apart from the high cost of the dies and moulds required for fabricating loom parts in plastics, experience with handwheels, dobby sheaves, pickers and dust covers has been unsatisfactory.

3. The picking motion. It is said that about 1,000 picking motions have been patented in the United States since 1850. An electromagnetic motion has been developed with which the loom operates very quietly at half the normal speed, but the motor is excessively big and the increased cost for the loom and for power are prohibitive. Hydraulic and pneumatic means have also been considered, but do not offer much prospect of success. High-speed photography is used in studies at the loom.

4. Motors and drives. The fly-wheel effect of the moving parts of the loom, their weights, centres of mass, radii of gyration about some fixed centre, and velocity during the loom cycle have been measured and better loom drives and motors are foreshadowed.

5. Electronics. Electronic relays have been tried in stop motions and weft feelers, but they suffer from inductance defects which often make them slower in action than mechanical devices.

Cross-border Jacquard: Application for Large Patterns. Silk and Rayon, 1945, 94, 92-94. An illustrated description is given of a typical 400's double lift, double cylinder, 120-sett Jacquard and its timing and setting for use as a cross-border machine for large patterns.


Silk Tappet Looms: Setting and Working. Silk J. Rayon World, 1945, 21, No. 248, 47-48, 56. Practical hints are given on the setting and working of the warp beam, back rest, healds, reed, take-up, tappets and under motion of looms for weaving typical plain silk fabrics.


(a) tying 11 warps of about 2,000 ends each of 20s cotton yarn in 8 hours, including the time required for clamping the threads and pulling the tied ends through the healds and reed;

(b) tying 60,000 ends per day of rayon warps on wide beams;

(c) replacing a warp of 5,000 ends in a Jacquard loom in one hour. (It appears to be a development of the invention of S. C. Fleischer, B.P. 413,855 of 2/6/1033.)


(D)—Knitting

Circular Knit Patterns: Calculation. H. D. Buck. *Textile World*, 1944, 94, No. 11, 119-121. The author describes, with examples, how to work out designs on circular knitting machines with cut pressers or pattern wheels of the Brinton type. The basic consideration is the prime factors of the number of needles in the cylinder. Thus, with 730 needles, the only practicable
field is $2 \times 5 = 10$ needles, whereas a cylinder with 728 needles offers the possibility of field widths of 2, 7, 13, and their multiples 8, 14, 26, 28, 32, 52, and 56 needles. 

(G)—FABRICS

Textile Fabrics: Designing. Silk and Rayon, 1945, 19, 322, 324. With the help of some typical examples (illustrated) the writer explains the scope for the designer in various branches of the textile industries, with special reference to the knowledge of cloth construction and weaving that the designer should possess. 

PATENTS.

Knitting Device. W. Miesch-Gerber and K. Schoenenberger (Erlenbach, Switzerland). B.P.567,394 of 13/4/1943:13/2/1945. A device for the manufacture of knitted fabrics is characterised in that parts of the framework located on opposite sides of the opening that serves as a seating for a needle and carrying the members for supporting the stitches are each provided with two rows of members of different size, one of the rows being capable of being brought into the operative position instead of the other row by simply reversing the part of the framework by which they are carried. 

Tape Condenser Surface Winding Drum: Mounting, Traversing and Driving. Platt Brothers & Co. Ltd., G. J. Prosser and C. L. Watts. B.P.567,539 of 8/9/1943:19/2/1945. Means for mounting, traversing and driving surface winding drums and their bobbins of textile condensers, comprise bearing means for each surface drum slidably mounted on the bobbin frame, means for imparting sliding movement to the bearings for axial movement of the drums, means for moving the bobbins axially simultaneously with their drums and driving means for rotating the surface drums in all positions of axial movement. Bearings are provided for each surface drum, slidably mounted on brackets carried by the bobbin frame, and the bobbin carrier brackets are mounted on a shaft carried by the slideable bearings for axial movement therewith. The drums are connected in pairs for simultaneous axial movement. The slideable bearings are connected in pairs for simultaneous axial movement by a bar to which the means for axially moving the drums is connected. 

Terry Fabric Knitting Machine. E. W. Clarke (Hamilton, Canada). B.P.567,620 of 3/6/1943:23/2/1945 (Conv. 7/8/1942). A knitted hosiery article comprises a ribbed portion and an integral terry fabric portion. The heel, sole and toe portions may be composed of terry fabric and leg and instep portions of rib fabric. This type of hosiery is produced on a knitting machine that is provided with a needle cylinder, sinkers between consecutive needles, means for feeding body thread and terry thread to the needles, a dial located above the needle cylinder inside the needle circle and rotatable therewith, a series of bits carried by the dial and movable independently between an inner retracted position and an outer position in which consecutive bits project out between consecutive needles and between the body thread and the terry thread fed by the feeding means, and means for manipulating consecutive needles to receive the threads and draw loops of the body thread over the sinkers, and longer loops of the terry thread over the bits. 

Circular Knitting Machine Picker. Bentley Engineering Co. Ltd. and F. E. Deans. B.P.567,652 of 3/5/1943:26/2/1945. In a circular knitting machine in which some needles have long butts and some short butts, the picker for moving needles from one position to another in the trick or groove is formed with a lateral extension on one or each side of that part of the picker which is intended to operate on the short butts, the dimension of each such lateral extension being such as to cover the widest gap in the long butts which will occur owing to the lay-out of the needles in the needle bed. 

Tapered Package Winding Apparatus. Courtaulds Ltd. and C. H. Hampson. B.P.567,673 of 20/8/1943:26/2/1945. Apparatus for winding thread packages tapered at each end comprises a rotating roller, a reciprocating thread guide, a collar capable of swinging about the roller axis, a rod attached to the collar passing through a slot in a lever which is pivoted to a traverse rail and is thereby oscillated about a fulcrum so that the collar reciprocates the arm along the axis, the roller being carried in a cradle which moves away from the thread guide as the package builds up on the roller and thereby moves the rod.
in the slot in the lever towards the fulcrum thereof and so shortens the traverse of the thread guide. The fulcrum of the lever may be adjustable in a direction parallel to its length; this renders possible a variation in the angle of taper of the ends of the package. The shape of the package may also be varied by applying a reciprocating motion to the fulcrum in a direction parallel with that of the traverse rail.

4—CHEMICAL AND FINISHING PROCESSES

(D)—MILLING

Prevention of Curled Selvedges in Milling.  D. R. H. Williams.  Wool Rec., 1945, 67, 411-415. Curling of selvedges in milling was prevented by accurate beaming of the warp (using e.g. solid metal flanges and steel beams), and by weaving the list slightly slacker than the ground. For Shirting Angola Drab T.56/4, plain weave, it was impossible to put a different weave on the list; a slackler list was produced by having attached to the temple a device, invented by Holdsworth of Brighouse, which holds out the weft automatically until the beat-up has taken place, thus preventing the weft from being drawn tight by the pull of the shuttle. A cored edge may lead to permanent stretching of the blowing wrapper. For Barathea Blue Grey T.105 with a hopsack list, and for Whipcord, P.A.-G. and H. with 11-shaft weave, modifications were made in the healding arrangements. For U.S.A. Elastique, Cavalry Twill, special precautions were taken in beaming-off the warp, weaving, scouring, and tentering and blowing to reduce unevenness to a minimum.

(E)—DRYING AND CONDITIONING

Cloth Drying Machines.  Silk J. Rayon World, 1945, 21, No. 248, 34-37. A broad review, with illustrations, of recent types of clip and pin stenters, multi-layer stenters, drying machines for woollens and worsteds, and tubular driers for hosiery.

Textile Materials: Radiant Heat Drying.  R. H. Wilhelm.  Textile Research, 1944, 14, 400-401. An abstract is given of a progress report on studies of the radiant drying of woven wool felt and absorbent cotton. The course of drying was found to be closely similar in radiant and air-convection drying. In each case, two major periods are clearly distinguishable on a rate/regain diagram. In the first period, free water capable of being centrifuged from the material, is dried at a relatively rapid rate, and in the latter, water held in the fibres is removed by a slower, diffusion mechanism. The rate of radiant drying is greater than that of convection air drying in each period. A theoretical equation has been developed for a heat balance and for the rate of radiant-heat drying of textiles in the free-water period. A stream of air at room temperature passed over material being dried by radiant heat does not materially decrease the rate of drying, but does lower the temperature of the work to a significant extent. Sample temperature measurements during radiant drying and penetration studies with an optical bench and thermopile give strong evidence that radiant energy may penetrate a considerable distance into thick textile materials. The direct result is a rise in temperature of the centre of the material above the surface temperature. A heat balance equation for this effect has been developed. It relates the temperature at any given distance from the surface with the surface temperature, the radiant flux density, the radiation absorption coefficient for the material, and its thermal conductivity.

(G)—BLEACHING


(I)—DYEING

5-Hydroxycoumarin Azo Dyes: Formation.  S. Rangaswami and K. Ranganadha Rao.  Proc. Indian Acad. Sci., 1944, 19A, 14-16 (through Chem. Abstr., 1945, 39, 193b). 5-Hydroxy-7-methylcoumarin, 5-hydroxy-4:7-dimethylcoumarin, and 7-hydroxy-5-methylcoumarin were coupled with diazotised p-nitraniline at 0°C. Calculated quantities of the diazonium salt solutions were added to give one molecule and slightly more than two molecules. The mixtures were left in a refrigerator for two days and the dye was then filtered, crystallised from acetic acid and analysed for nitrogen. In all three cases only the monoazo dyes were formed when one molecule of the
diazonium salt was employed, and a mixture of the mono- and disazo dyes when slightly more than two molecules of the salt were used. With 5-hydroxy-7-methylcoumarin and 5-hydroxy-4:7-dimethylcoumarin, although both the 6- and 8-positions are free, disazo dyes were not formed alone even when excess diazonium salt was available. This confirms the authors' opinion that disazo-dye formation is not controlled only by the disposition of double bonds in the original compound, but is subject to various other factors, such as solubility related to the monoazo dye and its reactivity.


The sorting of rags for the production of union goods is briefly discussed and methods of dyeing dark shades on unstripped grounds are described. Suitable dyes are listed. An account is given of experiments illustrating the different results obtained under different conditions in the dyeing of wool-cotton unions with Chlorazol Fast Red K and Chrysophenine G, and the conditions necessary for the production of the same shade on the cotton and the wool are indicated. The dyeing of cellulose acetate rayon-wool unions, the dyeing of loose wool-cotton waste blends with sulphur dyes, and the application of diazotisable direct dyes to union goods are discussed.

Dyes Applied by Saponification: Chemistry. J. Wakelin. *Silk and Rayon*, 1945, 29, 202, 205. A concise account is given of the chemistry of the Ionamine, Rapidogen, and other dyes that are applied in the form of readily saponifiable derivatives.


Dyes: Brightness. T. Vickerstaff. *Proc. Phys. Soc.*, 1945, 57, 15-31. It is pointed out that the term "brightness" as used by the dyer covers a combination of purity and lightness, where lightness refers to the amount of light reflected from the surface and is equivalent to the physicist's brightness. Reasons for the existence of limits to the purity and lightness attainable are outlined and an account is given of work done in an attempt to develop a method of determining the approach of a real dye to the ideal limits, i.e. the efficiency of a dye. From the results obtained it is considered that the chroma deficiency of a dye at the optimum value level of the appropriate hue provides a satisfactory measurement of the efficiency of the dye and the possibilities of visual improvement in brightness which remain. Details of the procedure and results for various dyes are given. These results seem to show that colours which have only one absorption band edge in the visible spectrum are more efficient than those with two, as might be expected. Reds and yellows appear to be highly efficient, blue-greens and bluish reds less so, and purples and greens very inefficient.

Textile Fibres: Structure and Dyeing. E. Kornreich. *Textile Manufacturer*, 1945, 71, 33-34. An outline is given of views on the relations between fibre and dye structure as the basis of a science of dyeing. The emphasis is placed on the power of dyes to form aggregates and the tendency of these aggregates to crystallise and thus reach an inactive state. For example, the experience in dyeing with direct dyes to dark shades that though an apparent end is reached in one bath the dyed fibre will continue to take up dye in a fresh bath is explained by saying that in the stale bath the dye has formed crystalline aggregates. Further, some dyes readily form these crystalline aggregates and the presence of a powerful solvent is necessary to bring out the tinctorial power.

(K)—FINISHING.

Plastics: Manufacture and Uses. *Silk and Rayon*, 1944, 18, 1330, 1334-1336. A continuation of a popular account of the textile applications of plastics, as claimed in patent specifications. Part 7 deals with the urea-formaldehyde resins and their use in the crease-resisting finish, the imitation "oiled-silk" finish, delustring, and increasing the flexibility of acetate rayon and nylon.

1944, A246) claims excellent shrinkage control, but is time-consuming and costly. The melamine resin Lanaset (trade mark of the American Cyanamid Co.) eliminates practically all felting shrinkage and alleviates sponging shrinkage. The process is covered by U.S.P. 2,329,622 (these Abs., 1944, A110). The mill equipment required is described and shown diagrammatically. Curing temperatures of 290°-310° F. do not affect the tensile strength of the wool; yellowing and harshening occur, but these can be counteracted by a mild peroxide bleach and by the use of softeners. There is good correlation between laboratory and mill shrinkage control results; unsatisfactory mill results are in many cases due to excessive oil content; other factors which may cause differences in dyeing rates and in shrinkage control are tentatively indicated. The resin lasts the life of the fabric, and a good shrinkage control is maintained for at least 10 launderings. The application of melamine resins to raw wool, tops and slubbing has not yet been commercially successful. Data are given on the relative shrinkage of untreated and melamine resin treated yarns washed by a modification of the technique of Le Compte and Creely (these Abs., 1940, A556; 1941, A510; 1943, A192). As well as controlling shrinkage and felting, Lanaset stabilizes yarns in fabrics, and prevents the bleeding of many dyes. W.

(L)—PROOFING

Water-repellent Wax Emulsion Finishes: Application. R. A. Pingree, Textile World, 1944, 94, No. 12, 86-88. The author describes current practice in the application of non-durable finishes employing emulsions of wax in solutions of the acetates or formates of Al, Zr or the rare earths. C.

PATENTS

Pigments: Fixing on Textile Materials. H. C. Olpin, S. A. Gibson and W. C. McKnight. B.P. 567,493 of 22/2/1943; 16/2/1945. A process for fixing pigments on textile fabrics, films, foils and like materials comprises applying a paste containing the pigment and a water-soluble condensation product of formaldehyde with an amino-triazine, after the application to the material of an acid of sufficiently low volatility to remain in the material and capable of catalysing the conversion of the condensation product into an insoluble condensation product under the influence of heat, and then heating to bring about the conversion. The acid may be a 10 per cent. aqueous solution of tartaric acid. The treatment may be applied to regenerated cellulose, cellulose ester and ether, and fibre-forming polymer materials. By the application of titanium oxide or barium sulphate in this way to cellulose ester or ether materials, a pleasant delustred effect is produced which is resistant to soap scouring operations. Coloured effects can be produced by the use of coloured pigments or by the incorporation of suitable dyes in the composition containing the condensing agent and pigment. C.

Pile Fabric Producing Machine. Brown, Ogden & Co. Ltd. and T. A. Brown. B.P. 567,527 of 15/5/1943: 19/2/1945. A machine for producing a pile fabric comprises means for projecting loose textile fibres on to the edges of plates spaced apart so that the fibres extend around the edges of the plates due to the force with which they are projected thereon, across from plate to plate and up into the spaces between the plates, means for traversing the fibres along the plates and means for securing the fibres to a backing. The fibres may be secured to the backing by threads laid in the gaps formed in the fibrous mass by the spaced plates. The fibres may be secured to the backing by sewing the two together at the gaps formed in the fibrous mass. The fibres in sliver form are projected by a roller covered with card clothing on to thickened edges of the spaced plates, and the fibrous mass is traversed along the plates by spikes or teeth (upon an endless conveyor) which project in the mass between the division plates. The fibrous mass with threads laid in the gaps therein is advanced in separate or discrete quantities intermittently after it leaves the division plates so as to leave a gap between the advanced part and the main body of material leaving the plates, and a sewing machine crosses the machine in the gap and binds the threads to the backing material. C.

Wool: Chlorinating. Henkel & Cie., G.m.b.H. D.R.P. 715,484 (through Textilber., 1943, 24, 150. Wool goods are treated in a solution of chlorine in organic, chlorine-resistant solvents. Solvents are preferably used which, after the wool has been treated, do not require too high temperatures for their
removal, e.g. carbon tetrachloride. As a general rule, very dilute solutions are used. Too high concentrations can damage the fibre. The length of treatment and the temperature can fluctuate within fairly wide limits, room temperature being preferred. After chlorination the wool is dried and treated with a weak solution of an antichlor. A particularly uniform action of the chlorine is obtained, even with very thick fabrics. The goods are unshrinkable, and their elasticity, strength and dyeing capacity considerably increased. W.

**Textile Materials: Reducing Felting Tendency.** A. W. Baldwin, T. Barr, J. B. Speakman and Imperial Chemical Industries Ltd. B.P. 567,501 of 16/2/1945. Materials composed wholly or partly of wool are treated at room temperature, and at any stage of manufacture, with a solution of anhydrocarboxyglycine in an organic solvent. After removal of the solvent by drying, the material may be baked at 90-140°C. The treatment is fast to dry-cleaning, and the felting properties of the material are substantially reduced. W.

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**5—ANALYSIS, TESTING, GRADING AND DEFECTS**

(A)—**Fibres**

**Cellulose:** **Density.** K. Lauer and U. Westermann. *Kolloid Z.*, 1944, 107, 89-93 (through *Chem. Abstr.*, 1945, 39, 183a). The density of cellulose is influenced by the molecular forces which operate between its hydroxyl groups and certain groups of the displacement media in which the measurements are made. This influence is small when water is used, because only small changes occur when the intramolecular attraction between the hydroxyl groups of the dry cellulose shifts to the molecular attraction between the latter and the hydroxyl groups of the water. It is claimed that the density of cellulose in water (which the authors find to be 1.6) equals its theoretical (i.e. crystal) density and is thus unaffected by the presence in the fibre of non-crystalline cellulose. Consequently, the measurements in water show no difference for native and cellulose hydrate fibres. In contrast, the influence of the molecular forces between cellulose and the displacement medium is appreciable if the latter is an organic liquid (e.g. higher alcohols, chloroform, acetone, benzene or toluene). In these cases the fact that the density of cellulose in any displacement medium is not identical with that of cellulose alone, but with that of the system cellulose-displacement medium becomes more pronounced. The density values in the organic liquids are all lower than those for water. This difference is said to be a result, not of a volume contraction in the cellulose-water system (hitherto held responsible for the higher values in water), but of lyophilic sorption of the organic liquid by cellulose. The same hypothesis is used to explain the fact that the densities measured in organic liquids are lower than those obtained in helium. The idea that this difference is the result of inability of the relatively large molecules of the organic liquids to fill the interstices of the fibre completely is therefore discarded. C.

**Cellulose Fibres: Organic Vapour Sorption.** K. Lauer. *Kolloid Z.*, 1944, 107, 86-88 (through *Chem. Abstr.*, 1945, 39, 183a). Adsorption isotherms of purified cotton for all organic liquids investigated deviate from the S-shaped isotherm characteristics for water. Nevertheless, the adsorption isotherms for the lower (polar) alcohols (methyl and ethyl alcohol) reflect, as do those for water, the overlapping of adsorption and swelling phenomena, though in a different order. In contrast, propanol, isopropanol, butanol, benzene, toluene, paraffin hydrocarbons, carbon tetrachloride and chloroform produce pure adsorption isotherms without involving swelling phenomena. Acetic acid produces swelling only, whereas acetone shows indifferent behaviour at low and adsorption at higher vapour pressures. Similar results are obtained with viscose rayons. Swelling-by-weight and swelling-by-volume data are compared and confirm the results shown by the isotherms. Heat of adsorption is positive in all cases, but the difference which native cellulose and cellulose hydrate fibres show in water disappears in most organic liquids. C.

**Cellulose Fibres: Strength and Structure.** K. Lauer. *Kolloid Z.*, 1944, 107, 93-103 (through *Chem. Abstr.*, 1945, 39, 183a). This paper, which is mostly speculative, deals particularly with the dry and wet strength of native cellulose and cellulose hydrate fibres as measured in water and organic liquids. An explanation for the different behaviours of the various types of fibres toward different immersion liquids is attempted on the basis of two assumptions. (1)
native cellulose fibre is conceived as being built up of spiral ribbons composed of lamellae, representing the crystalline portion of the fibre, with the amorphous portions between the spiral ribbons; the lamellae are considered as composed of fibrils which run parallel to the fibre axis. In contrast, cellulose hydrate fibres are pictured as lacking the spiral ribbon arrangement, the crystalline and amorphous portions being arranged at random. (2) Hermans' $\beta$-glucopyranose model is considered, in which the hydroxyl groups are located on one side of a plane and are believed to be projected parallel to the fibre axis through the anhydro-glucose ring, whereas the hydrogen atoms are located on the other side of the plane. The behaviour of various fibres on freezing at $-150^\circ$ is considered. Cotton fibres show no loss in tensile strength, whereas staple fibre loses from 10 to 40 decreases. C.


Cotton Lint: Length, Fineness and Strength. N. I. Hancock. *J. Amer. Soc. Agron.*, 1944, 36, 530-536 (through *Exp. Sta. Rec.*, 1944, 91, 666). Measurements of the length, fineness and strength of cotton lint have been made on the fibrograph and arealometer and Pressley fibre strength tester. These lint properties are definitely genetic characters of the cotton plant, and varieties show significant differences in their expression. Environmental conditions of the area where a variety is grown have an important influence upon the expression of the three lint properties. The three lint properties are genetically independent, but, under variable environments, fineness follows length in a positive manner and strength follows length in a negative manner. C.


Alginate Rayons: Properties. N. H. Chamberlain, A. Johnson and J. B. Speakman. *J. Soc. Dyers & Col.*, 1945, 61, 13-20. All alginate rayons are highly hygroscopic and there is considerable hysteresis between the adsorption and desorption isotherms of Ca, Al, Cr and Be alginates at $25^\circ$ C. The water absorption capacity at 65 per cent. R.H. and 22.2° C. of the Ca and Ba alginates increases with increasing metal content, after a slight initial drop, and so does the absolute strength of the yarns. The denier also increases with increasing metal content, and when the breaking load is expressed as g. per denier, the maximum tenacity is given by Ca and Ba contents of 0.10 and 0.06 g.-atom per 100 g. alginic acid, respectively. The high metal contents result in high densities (e.g. 1.780 for a Ca-Cr alginate) but have the advantage of making the materials non-inflammable so that they should be specially suitable for the manufacture of curtains and furnishing fabrics. Unlike Ca alginate rayon, which is soluble in a solution of soap (0.2 per cent.) and soda ash (0.2 per cent.), the Cr and Be rayons are only slightly weakened by treatment with the solution for 30 min. at $25^\circ$ C. or $40^\circ$ C. The extensibility of the Cr and Be alginate rayons is much too low to permit their successful use in weaving and knitting. Calcium alginate rayon possesses satisfactory elastic properties for such purposes and can be stored for long periods at ordinary humidities without deterioration. Calcium alginate rayon fabrics can be made alkali-resistant by treatment with chromium or beryllium acetate in finishing. C.

Glass Fibres: Fineness Measurement. P. A. Koch and G. Satlow. *Glastech. Ber.*, 1943, 21, 36-42 (through *Chem. Zentr.*, 1943, ii, 358-359 and *Chem. Abstr.*, 1945, 39, 165). The usual procedures of the German textile standards (DIN, DVM 3801) cannot be applied to measuring glass fibres. A series of 2000 fineness measurements each were made on glass filaments produced by the Gerresheimer jet-drawing (I) and jet-blowing processes (II), and the Schuller rod-drawing process (III). Duplicate measurements were avoided by measuring only 25 fibres of each preparation. A total of 20 preparations were used with 102 single fibres each for I and 80 single fibres each for II and III. The probable error $f$ of the mean value of the measurements was determined. The correlation of results showed that 100 single measurements were required for III to give $f$ less than 1 per cent. and 250 measurements for II. (Bemberg cuprammonium rayon gave better results.) Considerable differences existed between high and low values of irregularity. Graphical determinations showed that 300 single measurements
must be made to determine the range of irregularities, whilst 150 can be considered adequate for routine control.

**Glass Fibre: Testing.** Byezborodov and Ramlau. *Zavodskaya Laboratoriya,* 1941, 10, 182 (through *Industrial Chemist,* 1945, 21, 28-30). Drawn glass fibre is obtained by pulling out a fibre from a molten mass of glass and rolling it on a drum. It has a fairly uniform thickness and is used for yarn and cloth. Blown or staple fibre is obtained by blowing a jet of molten glass with compressed air or steam. Single fibres of this type vary greatly in thickness along their length and different fibres vary between 3 and 144 µ in diameter. The action of water was assessed by determining the quantity of alkali extracted from a known surface area in a given time by boiling water. Measurements were also made of the amount extracted on standing in distilled water at room temperature for periods up to 31 days. For glass fibres of the same chemical composition the resistance to attack depends upon the diameter and the surface area. The quantity of alkali extracted per unit area of a thin fibre is less than that obtained from a thicker fibre. In breaking strength tests considerable differences were observed between fibres of the same diameter selected from the same sample. A mean value of 90.7 kg. per sq. mm. was found for one sample. Mean tensile strengths of fibres of different diameters varied with the diameters. For characterising a sample the results of tests of 25-50 individual fibres in each of the thickness ranges present in the sample must be averaged. Figures for three different samples are given.

**Wool: Sulphur Content and Degree of Damage.** Klepzig's *Text. Z.*, 1941, No. 42, 172 (through *Textilber.*, 1943, 24, 194). The total sulphur of wool is no criterion of the changes caused during processing, since the cystine content can decrease and the total sulphur remain unchanged. Comparison of the total sulphur and the cystine sulphur of a wool can be used as a measure of damage, since in an undamaged wool practically all the total sulphur can be accounted for as cystine sulphur.

**Wool: Influence of Environment on Spinning Quality.** J. C. Cotsell and E. A. Elliott. *Agric. Gazette of New South Wales,* 1944, 55, 446-450. Observations were made on 2 groups of sheep to investigate the influence of change of environment on the spinning quality of wool (as influenced by fineness). One group (Peppin type, producing medium to strong wool) was transferred from the west of New South Wales to the tablelands, and the other group (Saxony type, producing fine to superfine wool) was transferred from the tablelands to the west. At the end of 4 and 5 year periods there was no general change in the wool spinning quality of either of the groups. This finding is contrary to the opinions concerning wool quality generally held by sheepmen. Recent evidence suggests that, under normal circumstances, the genetical make-up fixes the upper and lower limits of wool fineness and strength, the nutritional plane operating only within the range of these fixed limits. There were considerable variations as the result of seasonal, not climatic, changes, but the wools were capable of returning to their original spinning qualities.

**New Zealand Wool Appraisement Scheme.** J. E. Duncan. *New Zealand J. Agric.*, 1944, 69, 453-465. After a brief review of the scheme for the requisition of New Zealand wool brought into force at the end of 1916 ("Commandeer"), of the activities of B.A.W.R.A., and of normal disposal methods, the working of the present appraisal scheme is described, with details of valuation, price agreement, preparation of the clip for appraisal, and wool classing. The Wool Buyers' Association has drawn up a type and price schedule ("Bareme") covering 977 types of greasy wool, the over-all average price to the farmer being 12.25c. per lb. There is also a Bareme for nearly 500 types of slipe wool. A single page of the Bareme is reproduced, and the definitions given for the various types of fleece wool.

(B)—Yarns

**Cotton Knitting Yarn: Knittability.** G. M. Cooper. *Textile World,* 1944, 94, No. 12, 94-95. This paper was abstracted from another source in the preceding *Summary.* It is now ascribed to G. M. Cooper, of the Dixie Mercerising Co.

**Rubber Filament Threads: Testing.** W. A. Johhns. *Textile World,* 1944, 94, No. 11, 139, 141, 200, 201. A simple device is described for measuring the
extension of rubber thread under load and the recovery on removing the load. Some comparisons between natural rubber and Neoprene in 44S threads are reported in tables. Both had the diameter \( \frac{3}{4} \) in., the natural rubber thread ran to 1,590 yards per lb. and 3-inch loops broke under loads of 1-50-2-25 lb. after extending to 23-3-29-0 inches, whereas the Neoprene thread ran to 1,333 yards per lb. and gave breaking load and extension figures of 1-25-2-00 lb. and 17-21-9 inches. After 10 cycles of loading and unloading under a half-lb. load, the 3-in. loop of natural rubber would stretch to 21-6 ins. and recover to 3-50 ins; the Neoprene loop would stretch to 14-75 ins. and recover to 3-90 ins. Under a half-lb. load the 3-in. loop of natural rubber extended to 25-0 ins. in 15 hours but recovered to 3-75 ins. in 5 hours; corresponding figures for Neoprene were 18-8 and 4-65 ins. Other figures relate to tests on corset cloths and conditions of tension in weaving are suggested for securing with Neoprene threads a cloth comparable with that obtained with natural rubber. For example, it would be well to use a lower beaming tension for Neoprene warps and to release the warp tension over the week-end.

Moscrop Single Thread Tester: Speed of Loading. G. W. Pfeiffenberger. Textile Research, 1944, 14, 421-427. The influence of the speed of loading on the results obtained with a Moscrop single thread tester has been studied on an instrument adapted for pendulum loading and loading speeds of 1, 12, and 24 ft. per min. Tests were made on 22S and 60S yarns spun from two different samples of cotton. Photographic reproductions of sections of the charts, and tables showing the breaking load corrected to nominal counts, the coefficient of variation for each speed, comparative lea test data, and the ratio of 22S yarn strength to 60S yarn strength, both spun from the same cottons, are presented and discussed. The results show the impracticability of testing at a speed as high as 24 ft. per min. At high loading speeds the factors of inertia and momentum are involved and the breaks tend to group themselves into a bi-modal frequency. The ratios of the strengths of 22S and 60S yarns obtained with low speed of loading are very close to those obtained by the lea method. With the middle speed greater differences are observed and with high speed the ratios are completely out of line. Data on strength variation show a medium variation for low speed, lowest variation for medium speed, and extremely high variation for the high speed. The low speed of 1 ft. per min. appears to be the most suitable for accurate work.

Quality Control in Practice. 'Questor.' Wool Rec., 1945, 67, 361-363. Textiles and engineering are compared with regard to the application of quality control methods. In engineering, a much greater amount of testing is done, a higher proportion of material is tested, and the testing is non-destructive. In textiles, more emphasis is laid on the factor of quality than of control. Engineering procedure would need modifying for textile use. Tolerances imposed by the weaver or the customer within which the spinner might allow his yarns to vary without anxiety would provide an alternative method of setting limits. This angle of approach would accord with the theory of the quality control system, and would be more acceptable in practice than limits based merely on a nominal standard.

Yarns: Variability. 'Questor.' Wool Rec., 1945, 67, 64-67. Yarn variability is an indicator of yarn quality and of machine performance and defects, and is the main factor in deciding the accuracy of testing and sampling procedures. A technique is needed for the objective and permanent assessment of variability, which the spinner can use as a supplement to the usual tests for count, strength, etc.

Mill Testing: Statistical Methods. 'Questor.' Wool Rec., 1945, 67, 238-240, 280-282. Every result in yarn testing should consist of an average figure and a second figure expressing standard deviation. The test of significance ('t' test), the control chart method and the analysis of variance are described as related to the investigation of problems in yarn manufacture. Examples given concern the difference in strength of 2 spools of worsted yarn ('t' test), and the designing of a correct sampling procedure for routine purposes, e.g. for testing the regain of cones or similar packages, by means of the analysis of variance.

(C)—Fabrics. Hosiery Shrinkage Tester. S. W. Frazier. Textile World, 1944, 94, No. 12, 136. An instrument is shown on which a sock can be clamped across the ankle
A form in it to hold out the toe, and then measured under a load of 5 lb. hanging over a pulley from the toe.

Vacuum-type Porosity Testing Instrument. B. F. Goodrich Co. *Textile World*, 1944, 94, No. 11, 148. A brief announcement is made of a patented instrument for testing resistance to air flow. The material forms one wall of a vacuum chamber which is exhausted by means of a constant-speed fan. The pressure established in the chamber is recorded on an arc which may be graduated in suitable units.

American Soldiers' Clothing: Selection. H. E. Reed. *Textile World*, 1944, 94, No. 11, 113-117. A brief account is given of the work of the "Climatology and Environmental Protection Section, Research and Development Branch, Military Planning Division" of the Office of the American Quartermaster-General, which is concerned with the design and selection of clothing best suited to the bodily needs of the soldier in different regions. One section of the work is concerned with the production of climate maps of different countries and seasons. These are coloured in a uniform system to show temperature, dryness and wetness, so that the climate of any particular region could be matched by reference to the map for the United States and clothing selected accordingly. It is suggested that such maps would assist travellers in the post-war era of rapid communications. Another section is concerned with determining the protection afforded by uniforms and expressing it in units. The unit adopted is the "clo," which is a measure of heat loss by the body through the clothes. As developed by Gagge, Burton and Bazette the measurement required the technique and apparatus of a physiological laboratory but the Climatology and Environmental Protection Section has found that one clo is equivalent to the effective insulation afforded by a 1/2-inch layer of air, so that it is sufficient to measure the thickness of the clothing material plus the included air. Allowance has to be made for the fact that the body is not a flat plate but a series of parts approximating to cylinders. The efficiency of the insulation decreases with the radius of the cylinder, so that the clo values have to be weighted according to the magnitude of the various cylinders—torso, head, feet, hands, fingers and so forth. The values determined by measuring the circumference of the various layers of clothing and the thickness of the materials, duly weighted, are tabulated on charts for the different uniforms. From the data it is possible to calculate the body temperature that should be maintained indefinitely when the clothing has a particular clo value, and also to predict how long the wearer could withstand the cold if the clothing happens to be insufficient.

Defective Duck Cloths: Causes and Remedies. T. Nelson. *Textile World*, 1944, 94, No. 11, 131-133. Illustrations are given of twelve types of defect in duck cloths, and their causes and cure are discussed.


Accelerated Weathering Units: Operation. R. W. Matlack. *A.S.T.M. Bull.*, 1944, No. 131, 34-36. A report is given of the results of a questionnaire sent to about 180 individuals using accelerated weathering units for the testing of protective coatings. The questions concerned the control of temperature and humidity at the specimen, control of the temperature, volume, pressure and composition of the spray water, control of the arc, continuous running and the effect of shut-down periods, drying or conditioning panels before starting tests, and operating for a period with light alone. The replies show that there is a great lack of uniformity in the operation of accelerated weathering units. A sub-committee has, therefore, been established to develop standardized operating conditions.

Salt Spray Test Cabinet; Humidity in —. (1) A. C. Hanson. (2) V. M. Darsey. *A.S.T.M. Bull.*, 1944, No. 131, 38-39, 39. (1) The author criticises Darsey's method of calculating relative humidity in the salt spray cabinet, discusses a statement concerning the fall and collection of salt fog particles, and gives a list of factors influencing the corrosion of panels in the salt spray cabinet and variables upon which these factors depend. (2) A reply to Hanson's criticism.

tested included lawn, dimity, dotted swiss, gingham, shantung and poplin. The lawn, dimity, and swiss with a woven dot weighed less than 2 oz. per square yard, and swiss with a composition dot somewhat more. Weft values, which were generally lower than warp values by both the grab and strip methods, were below 20 lb. for the 22 samples of lawn, dimity and swiss. Loss of weight on desizing was not more than 5.3 per cent. in this group. The light-weight lawn, dimity and swiss, in general shrank more in the weft (4.0-11.5 per cent.) than in the warp (1.3-5.4 per cent.) direction. The 21 ginghams, varying from tissue ginghams to coarse play-cloth fabric, ranged in weight from 1.63 to 4.67 and averaged 3.23 oz. Warp count was somewhat higher than weft. Warp breaking load (grab method) was more than 20 lb. in most samples, loss in desizing ranged from 0.9 to 21 per cent., and shrinkage in the warp (greater than in the weft direction in most ginghams) varied from about 3 to 12 per cent. Poplins and shantungs (heavier than the majority of the ginghams tested) had approximately twice as many warp as weft yarns per inch, resulting in the characteristic ribbed effect. These fabrics with minimum warp and weft breaking load (grab method) of 47.6 and 20.4 lb., respectively, were stronger as a group than lawn, dimity, swiss or gingham, and should prove serviceable when high breaking load is required in use. Loss in weight on desizing the poplins and shantungs ranged from 1.3 to 10.4 per cent., and all but three of the fabrics shrank at least 3 per cent. in the warp or weft or both directions. It is recommended that the quality of the types of fabrics tested should be defined in terms of minimum weight, count, breaking load and maximum amount of finishing material. The colour-fastness and maximum shrinkage should also be stated. By defining these qualities it will be possible to peg quality to price.

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**Unbleached Muslins: Analysis.** G. B. Frankenberg and M. B. Hays. *J. Home Econ.*, 1942, 34, 737-741 (through Exp. Sta. Rec., 1945, 92, 153-154). A report is given of a study of 33 representative qualities of unbleached muslins obtained from large manufacturers. The fabrics varied in weight from 2.25 to 5.32 oz., with the majority weighing between 3.0 and 4.5 oz. In general, there was a relationship between weight and count, the latter varying from 40x40 to 68x72. The amount of sizing varied from 6.0 to 11.6 per cent., with an average of 8.8 per cent. Thickness ranged from 0.0135 to 0.0204 in., with an average of 0.0158 in. The maximum residual shrinkage varied from 5 to 12 per cent. (average 8 per cent.) warp-way, and from 4.9 to 9 per cent. (average 7 per cent.) weft-way. These amounts are high enough to affect the fit of a garment or make several inches difference in the size of a sheet, so that unbleached muslin should be laundered before making it into any article where fit is important. A comparison between strip and grab methods of determining breaking load was made with samples paired so that the same set of yarns was tested by both methods. A close correlation was observed between results of the two tests, with the average grab breaking load of all 33 fabrics approximately 6 lb. more than the strip breaking load. Calculating strip values from grab values and vice versa by the formula of Mereness gave results which tended to be too high for grab values and too low for the strip values, in comparison with experimental values.

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**Full-fashioned Cotton Hose: Serviceability.** M. B. Hays and M. C. Boyer. *J. Home Econ.*, 1944, 36, 35-37 (through Exp. Sta. Rec., 1945, 92, 155). Ten doz. pairs of nurses' white cotton hosiery of each of three lots were put into service in a Washington hospital. These hose, knit from 120s/2 S\times P variety American-Egyptian cotton, differed only in the toe reinforcement yarn. The average time of discard for the three lots of hose was 19.4 days. If the experiment were repeated, the probability is 90 per cent. that this average would not be in error more than 5 per cent. (1 day). The hose made with the toe reinforcement of two ends of 80s/2 and one end of 120s/2 had the greatest resistance to abrasion by laboratory test and required the least mending in service. The hose with two ends of 90s/2 and one end of 120s/2 reinforcement was next, followed by the regular two-end reinforcement which had the least resistance to abrasion and needed the most mending.

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**Hosiery: Labelling.** M. Smith. *J. Home Econ.*, 1944, 36, 89-92 (through Exp. Sta. Rec., 1945, 92, 155). This paper outlines in chronological order the developments leading to the present hosiery labelling regulation. As the regulation now stands, one stocking of each pair must bear a label, transfer, insert,
5—Analysis, Testing, Grading and Defects

or ticket giving the maximum price and the gauge or needle count for that type of stocking. No mention is made of grade labelling, but the hose must meet minimum specifications (for plain-knit full-fashioned and circular-knit hose) set up in the American W.P.B. Limitation Order No. 274, and can carry the trade-mark, brand name, or the American O.P.A. registration number of the manufacturer or wholesaler. Since standards of inspection are included in the regulation, all hose are graded uniformly. Some of the qualities in hose assured by these minimum specifications, such as those for length, welt, heel, toe, colour and denier, are presented.

C.

Labelling Textile Products: South African Legislation. Bradford Chamber of Commerce J., 1945, 25, 218. A Standards Bureau Bill is to be introduced into the South African Parliament which, if passed, will enable South Africa to come into line with the U.S.A. and with Australia on the question of wool labelling. The proposed Act would give producers and consumers of wool goods the same protection as that afforded by the U.S. Wool Labelling Act. W.

Labelling Textile Products: Australian Legislation. Board of Trade J., 1945, 151, 91-2. The text is given of the Act of the State of South Australia entitled ‘Textile Products Description Act, 1944.’ Similar legislation will be enacted by the other Australian States and copies of the relevant Bills of the States of Queensland and Victoria have been received by the Board of Trade. (See also these Abs., 1945, A122). W.

(D)—Other Materials

Cellulose Acetate and Nitrate Sheets: Effects of Outdoor Exposure. T. S. Lawton, Jr., and H. K. Nason. Modern Plastics, 1945, 22, No. 5, 145-150, 176-178. The general effects of outdoor exposure on cellulose ester plastics are summarised and tables and graphs are given showing the effects of exposure at Miami (Florida) and Springfield (Massachusetts) on the ultimate tensile strength, modulus of elasticity, yield stress, tensile strength and elongation at break, impact strength, light transmission, haze, and colour and denier of cellulose acetate and nitrate sheets. The effects of (1) 48 hours under an S-1 sun-lamp at a distance of 6 in., (2) 14 days in a circulating-air oven at 50° C., and (3) two months’ outdoor exposure at Springfield on stress/strain relationships are also shown. Data are presented showing the effect of the amount of abrasive on the gloss of the sheets in "abrasion" tests, and the effect of immersion time on the total water absorption and the loss of soluble materials by cellulose acetate and nitrate sheets. The results show that cellulose acetate is moderately resistant to outdoor ageing whilst cellulose nitrate tends to degrade rather rapidly. Cellulose acetate is more sensitive to moisture than cellulose nitrate, whereas the effect of temperature is about the same for both. Tensile strength, elongation and yield stress for both materials decrease with increasing outdoor exposure time. The modulus of elasticity increases with increasing exposure time as long as the material remains sufficiently coherent to be tested. Impact strength decreases with increasing exposure, whereas hazy, light transmission and shrinkage increase. The increase in light transmission is thought to be due to a bleaching action. Viscosity measurements show that, for both cellulose acetate and cellulose nitrate sheet plastic, most of the degradation is on the surface. As the exposure time increases, the degradation penetrates deeper into the sheet. Cellulose nitrate shows a much greater decrease in molecular weight than does cellulose acetate for the same exposure time. Plasticizer appears to be lost from the surface of the sheets on exposure.

C.

Pulps: Viscosity Determinations. S. Coppick. Paper Trade J., 1945, 120, TAPPI, 7-10. Viscosities of pulp obtained by delignifying wood to various extents were determined by the cuprammonium, cupriethylenediamine and nitrate methods and the corresponding apparent degree of polymerisation values were calculated. The results indicate that nitrate viscosities are much more reliable than the other two methods for cellulosics containing residual lignin. Non-cellulosic encrustants interfere with the solution of the polysaccharide in the cuprammonium and cupriethylenediamine solvents to such an extent as to produce an erroneous picture of the degradation which occurs during the purification of wood cellulose. With purified cellulosics, the apparent degree of polymerisation derived for the nitrates bears a linear relation to the degree of polymerisation determined by cuprammonium viscosities. By the application of this relationship the various methods can be reduced to a common basis and
good agreement between the cuprammonium and nitrate methods can be obtained for pulps in the later stages of cooking. The nitrate method has the advantage of being applicable to both cooked and uncooked material.

**Paper Base Plastics: Abrasion Resistance.** E. R. Hoffman. *Paper Trade J.*, 1945, 120, TAPPI, 31-34. A device for testing abrasion resistance comprises a base carrying a turn-table for supporting the specimen and two abrading heads each consisting of a free turning abrading wheel and means for applying loads of 125-1000 g. The turn-table is electrically driven at 70 r.p.m. and is cooled by a fan. The abrading wheels are \( \frac{1}{4} \) in. apart, are equally distant radially from the centre of the turn-table, and have a common line of rotation about \( \frac{1}{3} \) in. from the centre. The wear track on the specimen is a circular path covering approximately 10 sq. cm. of surface. The abrasion resistance of the material is defined as the loss in weight resulting from a specified number of revolutions of the material when using a given abrading wheel under a given load. Results are given for plastic coated and laminated papers and various other materials. The results of investigations of the influence of moisture, thickness of laminate, and type of resin and paper are discussed. The data show that the abrasion resistance of thermo-setting laminates is better than that of wood and pressed boards and comparable to that of soft metals. Paper base laminates made with commercial phenolic resins vary in abrasion resistance, but it appears that the abrasion resistance of the resins can be improved by the use of additional agents to such an extent that the wear-rate of the laminate is independent of the paper base. In general rag and bleached sulphite paper base laminates have equal abrasion resistance and are better than unbleached sulphite paper base laminates. The abrasion resistance of paper base laminates is unaffected by moisture up to about 75 per cent. R.H., decreases with increase in the number of impregnated sheets per panel up to a certain point, and does not vary with variation in resin content between 35 and 48 per cent.

**Thermosetting Plastics: Flame Resistance.** J. A. Gale, R. W. Stewart and J. B. Allers. *A.S.T.M. Bull.*, 1944, No. 131, 23-27. In a method for determining the flame resistance of plastics, a Nichrome wire coil is used as the heating element, with the specimen supported in a vertical position within the coil. Materials are rated in terms of ignition time, or time required to ignite the specimen after the coil is energised, and burning time, or time required for self-extinguishing of the flame after the coil current is shut off. The amount of distortion caused by burning is noted and, where possible, the strength of the specimen after test is determined. Details of the apparatus and procedure are given, together with the results of tests on 16 moulded and 10 laminated types of thermo-setting plastic compositions, and photographs of the apparatus and of specimens after testing. Considerable differences between samples of different types and between samples of the same type supplied by different manufacturers were observed. With respect to ignition and burning times, the melamine resin plastics gave better results than most of the phenolic resin materials. Generally, the mineral-filled materials (including asbestos and glass base materials) were least affected by exposure to the test conditions. They retained some semblance of mechanical strength after burning and resisted the effect of flame to a greater extent than the cellulose-filled materials. All the cellulosic specimens either carbonized completely or continued to smoulder after being tested. Mechanical strength was nil in both cases. Mineral-filled melamine materials appeared to be suitable for applications requiring flame resistance.

**7—LAUNDERING AND DRY CLEANING**

**Patent**

**Amidophosphoric Acid Salts: Application in Wash Waters.** Zschimmer & Schwarz Chemische Fabrik Dölauf. G.P.728,926 (through Chem. Zentr., 1943, i, 1836, and *Water Pollution Res. Summ. Current Lit.*, 1944, 17, 12-13). Sodium mono- and di-amidophosphates are claimed as agents for the treatment of water for washing textiles. If 3 gm. of the diamidophosphate are added to 1 l. of water with 18° of hardness (German), 3 gm. of soap per l. may be added without deposition of Ca soaps.
Melamine Resins: Use in Production of Laminated Materials. Modern Plastics, 1945, 22, No. 5, 105-107, 182, 184. Decorative laminated panels and other products are obtained by the use of pigmented or printed paper or fabric surface sheets impregnated with melamine resins. The fabric or paper is passed through a bath of resin in the form of a varnish and then through drying ovens which evaporate the solvent in the varnish and partially polymerize the resin. Lamination is carried out in an ordinary hat-type press under a pressure of not more than 250 lb. per sq. in. When suitable dyes are used, the impregnation and lamination can be carried out without producing any distortion of the coloured pattern. The surfaces show high resistance to abrasion and alkalies, low moisture absorption, and general inertness in regard to odour and taste. Laminated panels of this type are suitable for use in the production of trays, game boards, radio panels, table tops and other articles of furniture. Applications of the process to the production of weather-proof signs, automobile dashboards, etc., are also suggested.

Plastics: Application in Protection of Finishing Plant. C. N. Rabold. Textile World, 1944, 94, No. 12, 105-106. Brief references are given to the use of modern plastics as varnishes and sheets for protecting finishing plant from corrosion and for moulding into pipes, hoods and ducts. An illustration shows Lucite (methyl methacrylate) sheets being applied as an acid-resistant lining to a tank.

Staypak Heat-stabilized Compressed Wood: Production and Properties. R. M. Seborg, M. A. Millett and A. J. Stamm. Mechanical Engineering, 1945, 67, 25-31. Solid flat-sawn non-resinous wood and veneer spread with glue and assembled in parallel-laminated or cross-banded form can be compressed to a dense product that does not tend to spring back under moist conditions if it is pressed under conditions that cause some flow of the lignin. The product is called "Staypak." A report is given of tests on yellow-poplar veneer designed to determine the best combinations of moisture content, temperature, and time of pressing to obtain panels with optimum stability, and the most suitable conditions for the manufacture of Staypak are described. The suitability of various types and species of wood is discussed and a table is given showing the properties of Staypak made from veneers of four species conditioned at three relative humidities. Staypak swells appreciably in water but returns to practically the original compressed thickness on drying, whereas densified wood tends to lose its compression to a marked degree under conditions that cause swelling. The strength properties of Staypak are considerably higher than those of the wood from which it is made and the tensile strength, modulus of rupture and modulus of elasticity in bending are significantly greater than for Compreg of the same specific gravity. The chief advantage of Staypak over adequately stabilized Compreg is its superior impact strength. Potential uses of Staypak are indicated.


Spray Nozzles: Design. S. M. Doble. Engineering, 1945, 159, 21-23, 61-63, 103-104. An account is given of theoretical considerations and experimental work undertaken with the aim of designing nozzles to give sprays of defined characteristics (e.g. particle size). The practical object in view was the activation of coke by spraying it with a soda solution. Various relationships are established between the pressure, particle size, orifice diameter, spray cone apex angle, cross-sectional area of the channels, and spin of the liquid in the vortex chamber, and three nomograms are provided for solving numerical problems.

Weaving Shed: Restarting. I. Laird. Textile Manufacturer, 1945, 71, 4-6. Practical advice is given on the renewal of the flooring, heating and humidification system, painting, lighting, lavatories and cloakrooms, and first-aid and rest rooms in preparation for restarting a closed weaving shed.
Chemical Removal of Scale by Acid Solutions. D. Brownlie. *Steam Engineer*, 1945, 14, No. 163, 195-7. An important investigation on this subject has recently been carried out in America and this article is a summary of the published results. Before chemical treatment is carried out a sample of scale, suitably chosen, should be subjected to X-ray analysis so that its constitution can be determined. The composition of the cleaning liquor, e.g. inhibitors to be used, is based on the results of this analysis. Chemical treatment offers several advantages over manual or mechanical descaling, namely, elimination of dismantling, and reduction in time, equipment and labour required. The treatment is now widely used in America on all types of boiler and examples are quoted.


Oil-Engine Crankshafts. E. Ingham. *Power & Works Engineer*, 1945, 40, 56-7. The life of an oil engine crankshaft depends on the quality of the material from which it is made, its design and treatment during manufacture and its maintenance during use. Misalignment, overloading, shocks and vibration, overheating of the shaft journals and local heating of the shaft by a welding flame can all contribute to an early breakdown. Each of these points is briefly discussed.

Engineering Insurance. F. G. W. Tree. *Power & Works Engineer*, 1945, 40, 87-8. Insurance against breakdown or for 'inspection only' is discussed and is shown to have advantages worth the money expended on premiums. Typical premium figures are quoted.

Cooling and Lubricating Drills. *Mech. World*, 1945, 117, 328-30. A condensed translation from Technische Rundschau (Berne, 1944, No. 21 and 22) describes a method of using air-driven oil vapour for this purpose. Drills have holes bored through their length so that the oil vapour can be forced through to the cutting edges. Improvement in output, drill life and surface finish are said to be obtained.


Plastics. A. E. Williams. *Mech. World*, 1945, 117, 371-5. Notable progress in the use of plastics has been made during the last few years and a number of these are described. Composite construction frequently offers appreciable advantages. The subjects are considered under the headings: laminated sheet (urea-formaldehyde), belting, heating by high frequency methods, chemical plant synthetic rubbers, rubber in engineering and bonding rubber to metal.


(B)—FIRE PREVENTION

Electrical Plant: Earthing. *Silk and Rayon*, 1945, 19, 217-221. The regulations of the Institution of Electrical Engineers for the protection of electrical plant in circumstances where it is difficult to obtain a low-resistance connection to earth are satisfied by fitting voltage-operated leakage trips. The electrical features and maintenance are explained with the help of wiring diagrams and earth resistance tests are described.

(C)—STEAM RAISING AND POWER SUPPLY

Steam: Generation; Production and Suppression of Foam. H. M. Cassel. *J. Applied Physics*, 1944, 15, 792-798. Vaporization of pure liquids is reviewed as a problem of heat transfer and the rate of vapour bubble creation. Based on an idea of Gibbs, the influence on the activation energy of nucleus formation exerted by the contact angle at the vapour/liquid/solid phase boundaries as well as by the shape and size of submerged solids is quantitatively expressed by the reduction in the volume requirement of the nucleus. Possible effects of
solute in superheated liquids on steam bubble creation and growth are discussed. The stabilization of foam in boiling electrolyte solutions is explained by the thermoelectric potential differences originating from the temperature gradient around growing bubbles. The effect of foam-inhibiting agents (e.g., castor oil) is interpreted as a change in the rate of bubble creation caused by surface conditioning of heating elements and suspended particles.

Steam: Undercooling and Rate of Condensation. R. Ruedy. *Canadian J. Res.*, 1944, A 22, 77-94. The first and most difficult stage in the condensation of water vapour is the increase in the size of the drops until their radius satisfies the Kelvin-Helmholtz equation for the degree of undercooling or supersaturation reached at the temperature of the vapour; the second stage is the increase in size by continued addition of molecules until the vapour pressure $p(v)$ of the drop containing $v$ molecules approaches the pressure $p_\infty$ exerted at the same temperature by a pool of water. A gradual enlargement to visible drops follows. Consideration of the number of collisions of the molecules with the drops forming at the vapour pressure $p_v$ of steam, and the loss of molecules by virtue of the higher vapour pressure of small drops leads to the conclusion that at condensation temperatures between $0^\circ$ and $50^\circ$ C. the centres of condensation in the absence of dust or ions contain fewer than 100 molecules. When the degree of supersaturation corresponds to larger drops, condensation is bound to fail. The conclusion drawn from the theory is confirmed by the values obtained in the tests with flowing steam and with cloud chambers. At higher temperatures larger drops act as nuclei. The growth in the second stage is also extremely rapid, at least until the radius equals in size the wave length of visible radiation. Water drops of this size, that is, drops that produce coloured diffraction rings behave as large drops. The heat of condensation may furnish part of the work to be performed against the surface tension.

Flames: Measurement of Emissivity. R. H. Baulk. *British Coal Utilisation Res. Assoc. Bull.*, 1945, 9, 32-39. Radiation from flames takes place from the gas molecules and from solid particles. Radiation from gases occurs mainly in the infra-red and is principally due to the presence of water vapour and carbon dioxide. The radiation from the solid particles, which are principally carbon, covers both the visible and the infra-red wave lengths. The nature of the non-luminous radiation, the production of the luminous radiation, the importance of luminosity, and the importance of flame-emissivity measurements are discussed. Various methods of measuring emissivity, which are divided into (a) radiometer methods using a wave-length range extending beyond the limits of the visible spectrum, and (b) optical methods using wave lengths within the visible range, are briefly described.

High Pressure Land Boilers. R. Carstairs, P. Hamer and B. M. Thornton. *Mech. World*, 1945, 117, 388-94, 420-2, 445-8, 476-9. Operating experiences with such boilers are described. Header distortion, superheater construction and air heater losses in particular are discussed. B. & W. and La Mont boilers are among those considered. Feed pumps, feed water regulators, safety valves, gauge glasses, Hi-Lo water alarms, continuous blowdown valves and steam traps are the boiler auxiliaries considered. The third section of the paper deals with boiler operation and includes water treatment and testing, carry over, scale formation, corrosion and idle boilers. Finally, fouling of turbines, fouling of furnace, superheater, economiser, etc., and the removal of deposits are discussed.


Reducing Boiler Outages. W. M. Gore. *Power & Works Engineer*, 1945, 40, No. 466, 85-6. Notes on sootblowers and steam and water lancing of water tube boilers are given to show how attention to these matters can reduce time lost in boiler outages.

Avoidable Losses in Lancashire Boiler Plants—I. I. B. Frisby. *Steam Engineer*, 1945, 14, 198-9, 204. In the drive for the efficient operation of all boiler installations the careful maintenance of brickwork is exceedingly important.
The simplest method of detecting brickwork faults is by measurement of temperatures and temperature gradients at various parts of the system and a multipoint indicating pyrometer is the best instrument for the purpose. Cold air infiltration must be prevented and the following items require regular examination: external brickwork, manhole and furnace doors, dampers, economiser chain holes, front cross wall and blow-down recess.

**Saving Money in the Boiler House.** S. N. Duguid, *Steam Engineer*, 1945, 14, 200-1. The desirability of training stokers is stressed and suggestions for carrying it out are given.

**Shaft Speed Indicator.** M. J. Wilkie. *J. Sci. Instruments*, 1945, 22, 36-37. Apparatus for measuring the speed of a belt-driven high-speed bearing machine is described and shown in diagrams. An image of a lamp filament is focused on to a stainless steel mirror fixed to the end of the high-speed shaft, and is reflected on to a photocell. Half of the mirror is blacked, so that as the shaft rotates a current of approximately square wave form is generated in the photocell. By means of a suitable circuit and frequency meter, a direct reading is obtained on a linear scale. The accuracy is of the order of ± 0.1 per cent. and the indicator is particularly useful for the range 3,000-100,000 r.p.m.

**Coloured Guide Card Lubrication System.** Alemite Division, Stewart-Warner Corporation. *Textile World*, 1944, 94, No. 12, 99-101. An illustrated account is given of a "Coloroute" system to govern lubrication. Different colours are assigned to the various lubricants and employed to identify the oil cans and other containers and the lubricating points on the machines. A system of markings indicates the frequency with which the lubrication is to be done; circles for days (a figure 2 in the circle would indicate "every two days"), squares for weeks and hexagons for months. Guide cards are used to tabulate the particulars and one is attached to each machine with the rows and columns appropriately filled in after finding the best lubricants and frequencies for the various points.

**Lubricants: Durability.** E. N. Dacus, F. F. Coleman and L. C. Roess. *J. Appl. Physics*, 1944, 15, 813-824. A description is given of apparatus for measuring the relative ability of rubbed-down monolayers of polar lubricants to maintain low friction under test conditions which do not permit replacement of the lubricant. This quality of a lubricant is called its "durability." The clean polished rim of a slowly rotating steel wheel rubs on the monolayer deposited on a polished flat steel specimen and the slip between the wheel and specimen is observed. The preparation of the surfaces and films is described. It was not found possible to prepare reproducible test surface-monolayer combinations, hence it was necessary to compare each lubricant with a standard deposited on a separate area of the same surface. Significant differences were found in the relative durabilities of a number of polar compounds. For the monocarboxylic acids tested, the values increase with the number of carbon atoms per molecule. An investigation of the stability of rubbed-down monolayers on polished stainless steel shows that ageing in a desiccator causes a continuous decrease in durability, and also a decrease in molecular orientation as shown by electron diffraction. Similar reduction of durability and orientation results when the film is flushed with a fine stream of benzene. On chromium the orientation is destroyed by the solvent, but the durability is not changed.

**Thermionic Rectifiers.** "Engineer-in-Charge." *Mech. World*, 1945, 117, 293-5. The operating principles of thermionic rectifiers are discussed and illustrated by circuit diagrams. Half-, full-wave rectification and single- and multiphase supplies are considered.

**Air-Flow Curves.** R. F. Brown. *Mech. World*, 1945, 117, 320-1. It is often desirable or necessary to calculate the flow of compressed air from a leak or from a high to a low pressure. A graph is given which enables such problems to be solved up to pressure drops of 100 p.s.i.

**Colloidal Graphite.** A. H. Stuart. *Mech. World*, 1945, 117, 353. An oil film is required to reduce the friction between two moving surfaces, but conditions of running may be such as to reduce the thickness to one or two molecules or even to break the film and establish metal to metal contact. Graphite incorporated in the oil forms a film which, under these circumstances, has very
desirable properties which counteract the likelihood of failure owing to seizing up.


K.V. Rope-Drive. Power & Works Engineer, 1945, 40, 92. An illustrated description of a rope-drive for short centres which has been developed by Messrs. Wm. Kenyon & Sons, Ltd.


Knitting Factory: Lighting. Sweetwater Hosiery Mill. Textile World, 1944, 94, No. 12, 96-97. An illustrated account is given of the installation of fluorescent tubular lighting in a knitting factory. After one year's operation the system is providing 65 foot-candles at the knitting plane, 85 f.-c. at the seamers, and 45 f.-c. at the inspection bench.

Fluorescent Lighting Systems: Applications. Textile Manufacturer, 1945, 71, 25. Recent developments in fluorescent lighting (Osram; Siemens Electric Lamps and Supplies Ltd.; Metropolitan-Vickers Electric Co.) are briefly reviewed. The "cold" daylight types of lamp are now supplemented by "warm white," which may be preferred for rest rooms.

Gas Filter Media: Properties. L. C. Verman, K. A. Nair, M. L. Khanna and S. K. D. Gupta. J. Sci. Ind. Res. (India), 1944, 3, 251-258. In a search for filter media suitable for use in portable producer-gas plants tests were made on samples of satin drill, drill, longcloth, twill, pressed wool felt and Chester cloth. Photo-micrographs are given, and the results of visual observations, measurements of the difference in pressure on the two sides at various rates of air flow, and measurements of pore size based on microscopic measurements of the size of particles carried through by air at a velocity of 25 ft. per min. are tabulated and discussed. The conclusion is reached that the satin drills, especially the weft satins, are the most suitable for producer-gas filtration. Specifications for these materials are given. Next in order are the drills. Chester cloth is comparable to the drills but too expensive for this purpose. The pressed wool felts are inferior to the drills, and longcloth and twill are unsuitable.


Zeo-Karb Cation Exchanger: Action at High p\(\text{H}\). R. Nelson and H. F. Walton. J. Phys. Chem., 1944, 48, 406-410. Curves are given showing the uptake of Ca and K ions from solutions of their salts as a function of p\(\text{H}\). In both cases the exchange increases almost linearly with p\(\text{H}\), suggesting that the increasing Ca exchange is not due to the absorption of CaOH\(^+\). The continued increase in exchange up to p\(\text{H}\) 12.5 indicates that Zeo-Karb contains extremely weak acidic groups with dissociation constants of the order of 10\(^{-13}\). These are probably phenolic hydroxyls, the acidity of which is depressed by the presence of sulphonate or carboxylate radicals in the same molecule. The uptake of Ni, Cu and Zn is much greater in ammoniacal than in acid solution. Copper appears to be absorbed principally as Cu(NH\(_3\))\(_2\)\(^++\), nickel as Ni(NH\(_3\))\(_4\)\(^++\), and zinc as a complex or complexes of intermediate composition.

Dielectric Heating and Drying. L. Hartshorn. Textile Manufacturer, 1945, 71, 37-38. A non-technical account is given of the principles of dielectric heating and drying by high-frequency heating.

Woollen Mill: Fuel Economy. D. R. H. Williams. Textile Manufacturer, 1945, 71, 39-41. A personal story of fuel economies achieved during recent months. The following points are emphasised: (1) The value of reducing the
load to small units with individual or group electric drives. (2) The difficulty of getting machine makers to state the h.p. required for any particular machine. (3) The value of providing extra power for starting a machine, the actual power for running being in many instances much less. (4) Fuel saving by fitting appropriate valves to pumps, steam lines, return valves and the like. (5) Fuel economy by the even distribution of heat in a room for cloth inspection and mending, down-draught being curied. (6) Thermostatic control of heating systems. (7) Fuel saving by painting and varnishing steam pipes.

(H) — Water Purification

Lime-Soda Water Treatment Developments. R. P. Donnelly. *Power & Works Engineer*, 1945, 40, No. 466, 79-82, 88. In the settlement stage in the ordinary lime-soda process no marked progress was made until comparatively recently although considerable improvement had been made in the design of proportioning gear and other parts of the plant. The recent advances all depend on the acceleration of precipitation by growing the settling hardness on nuclei, in order to form larger particles. With this process the reaction is brought to a definite chemical end point and the resulting liquid is stable so that there is no after precipitation in pipes, lines, pumps, filters, etc. The "Spiractor" process uses sand as nucleus for precipitation and the necessary plant is here described in some detail, including its use in conjunction with base exchange plant. The "Accelator," Spaulding precipitator and hot process plant depend on the use of previously deposited sludge. These processes are described and compared.

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(I) — Waste Disposal

Laundry Waste Water: Treatment by Flotation. R. Eliassen and H. B. Schulhoff. *Waterworks and Sewerage*, 1943, 90, 419 (through *Water Pollution Res. Summ. Current Lit.*, 1944, 17, 26). Experiments are reported on the formation of the floc obtained by the addition of coagulants to laundry waste waters as a floating mass instead of a deposit. For example, by adding 500 p.p.m. of ferric chloride to the waste at pH 4-6, aerating for 5 minutes and then storing in a vacuum tank for 15 minutes, the grease in the water was reduced by 97 per cent, and the "biological oxygen demand" by 83 per cent. The capacity required is only about 15 per cent. of that of the usual settling tanks.

9—PURE SCIENCE

Leather and Disinfectants: Fungicidal Effect. C. O. Foulton, N. E. Gibbons and R. L. Moore. *Canadian J. Res.*, 1944, F 22, 163-168. Vegetable-tanned leather had a fungicidal effect on one strain of *Trichophyton gypseum* and two strains of *T. interdigitale* (associated with "athlete's foot") but not on several strains of common mould contaminants. Chrome-tanned leather, vegetable-tanned leather from an old shoe, and vegetable-tanned leather leached overnight in running water did not possess fungistatic or fungicidal properties. Three of the compounds usually found in vegetable-tanning liquors, tannic acid, gallic acid and pyrogallic acid, were inhibitory. Of a number of disinfectants tested under conditions similar to those occurring during the fat-liqouring operation, phenylmercuric acetate was the most effective, destroying the above organisms in a concentration of 1:100,000. Under the same conditions a 1:1,000 dilution of commercial formalin was required.

"Glycostat" Glycol Vapour Concentration Controlling Device. T. T. Puck, H. Wise and O. H. Robertson. *J. Exptl. Med.*, 1944, 86, 377-381 (through *Chem. Abstr.*, 1945, 39, 47). Glycol vapour in the air is condensed on a cooled surface so as to interfere with the transmission of a ray of light. A photo-electric cell, responding to the fluctuations, causes a glycol vaporizer to be turned on or off, depending on whether the air contains too little or too much of this material. The concentration is regulated within a few thousandths of a mg. per l. The instrument (termed a glycostat) can be used also to measure the glycol content of air directly, even in air containing high concentrations of dust or other foreign materials which interfere with a chemical analysis. The glycostat can be used for either propylene or triethylene glycol.
Alkylcelluloses: Methoxyl and Ethoxyl Group Micro-determination. A. A. Houghton. *Analyst*, 1945, 70, 19-21. A micro method is described for quantitatively collecting as liquid all the alkyl iodide evolved when a compound such as methylethylcellulose is boiled with hydriodic acid. Attempts to determine the ratio of methyl to ethyl iodide in mixtures obtained in this way by micro critical temperature measurements were unsuccessful owing to decomposition. Density determinations gave accurate results within 1 per cent. but required 30 mg. of sample. Boiling-point determinations required only 3 mg. of sample and gave results to within about 5 per cent., the error being due to false boiling points caused by dissolved gas. Results obtained with mixtures of known quantities of methyl and ethyl cellulose are presented.

Corn and Wheat Starch: Determination. F. R. Earle and R. T. Milner. *Cereal Chemistry*, 1944, 21, 567-575. Seven samples of starch comprising two from corn, two from wheat, and one each from waxy corn, tapioca and potato, were analysed for non-starch constituents. The results are tabulated together with the results of moisture content determinations, specific rotations, and starch contents by difference. The specific rotation of all these starches was found to be 203° in calcium chloride dispersion, when corrected for the non-starchy material. Starch determinations were made by polarimeter, acid hydrolysis, and diastase methods. The results of the polarimeter and diastase methods agreed satisfactorily with the starch by difference values, whilst the results obtained by acid hydrolysis were consistently lower. The application of the polarimetric method to the determination of starch in corn and wheat was studied and modified procedures were devised which gave results agreeing closely with those obtained by the diastase method. Details of the improved procedures are given.

Wheat and Flour Proteins: Determination. W. J. Eva and J. A. Anderson. *Cereal Chemistry*, 1944, 21, 560-566. The photometric method developed by Zeleny for determining protein content in wheat and flour has been examined to decide whether it gives results that are more closely related to loaf volume than are conventional Kjeldahl data. The Zeleny correlations, both within one variety or between 25 varieties, were not as high as the corresponding Kjeldahl correlations. The correlations between Zeleny values and Kjeldahl protein were -0.92 and -0.93 for wheat and flour in the inter-varietal series, and -0.98 and -0.99 for wheat and flour in the one-variety series. The Zeleny method can apparently be used for predicting Kjeldahl protein in sound samples of one wheat variety grown in different places, or in samples of different varieties grown at one place. It is improbable that a satisfactory general equation for all samples can be developed. The evidence strongly suggests that the Zeleny procedure is measuring some relatively constant proportion of the total protein and that this protein fraction is concentrated largely in the endosperm. The method is very simple, but at present the analytical error is higher than that of the Kjeldahl test.

Tannin: Quantitative Precipitation with Azo Dyes. R. C. Davies, M. Nierenstein and C. W. Webster. *Analyst*, 1945, 70, 17-18. Chrysoidine, Bismarck brown, Congo red, Trypan red, Afridol blue and Fast Yellow form precipitates with tannin which are insoluble in water and suitable for quantitative work. The following method is recommended. To a molecular suspension in water of Fast Yellow (Eger; Colour Index No. 16) add an aqueous solution of 2 mols. of potassium hydroxide, and run the solution slowly from a burette into an aqueous solution of the tannin until no more precipitate is formed. After 48 hours collect the precipitate in a Gooch crucible, and wash it first with 250 ml. of 5 per cent. hydrochloric acid and then with 500 ml. of water. Dry at 160° C. to constant weight. The difference between the weight of the tanned dye and the weight of dye used gives both the tannin and the depsiphore contents. Results are compared with tannin determinations by other methods. Phenols and catechins do not give precipitates that resist washing with water.


Wheat Starch “Amylodextrin” Fraction: Composition. M. M. Mac-Masters and G. E. Hilbert. *Cereal Chemistry*, 1944, 21, 548-555. Microscopic and analytical studies have shown that the so-called “amylodextrin,” small-granule or tailings fraction separated by centrifuging crude wheat starch after the removal of the bran and gluten comprises starch (87-94 per cent.), protein (1-2 per cent.), pentosans (4 per cent.), fatty material (about 0.7 per cent.) and ash (about 0.3 per cent.). In addition there is a small amount of cellulosic material, probably about 3 per cent., present in cell wall fragments. The starchy material is composed of ungelatinized small granules and damaged, large granules which gelatinize partially or wholly in cold water, the former predominating. An outstanding characteristic of the small-granule fraction is its semi-fluid nature, which cannot be attributed to density alone. The large difference in volumes (per unit weight of dry substance) of the starch and “amylodextrin” layers after centrifuging indicates a difference in the packing of the particles. These characteristics may be due to the much larger ionic charge per unit volume that small granules possess, the effect of a charge on a particle becoming more pronounced as the size of the particle decreases and its surface area per unit volume increases. The high ash content of the small-granule fraction suggests that a considerable part of the inorganic matter may be adsorbed by the particles, thus increasing their polarity. Particle size is not, however, the sole factor influencing consistency. It would appear desirable to avoid the designation of the small-granule fraction by the name “amylodextrin,” since amyloidextrin is a recognised enzymic degradation product of starch, which, unlike the small-granule fraction, is soluble in water.

Silk Fibroin: Denaturation. D. Coleman and F. O. Howitt. *Nature*, 1945, 155, 78-79. The results of studies of silk fibroin lead to the following tentative conclusions. The molecules of fibroin consist of long chains (length about 1300 Å; weight 33,000) orientated parallel to the fibre axis. In its natural state the chains are in the almost fully-extended configuration, corresponding to Astbury’s β-keratin. The greater part of the chain shows a regular periodicity of amino-acid distribution but there appear to be two regions, relatively small and symmetrically placed in the chain, that are rich in tyrosine, and include all of the four proline residues. Adjacent chain molecules are linked by hydrogen bonds between opposing :CO and :NH groups of the peptide linkings. On dissolution of fibroin in cupri-ethylenediamine, these bonds are broken and each of the Cu-en groups combines with two proximate :NH groups along almost the whole length of the chain so that the whole molecular complex has a ratio of Cu to fibroin-N of nearly 1:2. This complex formation occurs very rapidly and is followed by a slower reaction in which the chain folds back on itself at the two proline-containing centres to give a 3-limbed configuration (either as a lamina or a prism of axial ratio approximately 20:1). The extent of the folding is dependent on time and concentration of the cupri-ethylenediamine. This folding is probably due to swivelling of the molecular parts at a prolyl-tyrosylprolyl grouping in the two tyrosine-rich regions of the chain. Neutralisation of the cupri-ethylenediamine complex liberates the fibroin either in the completely renatured form (for which the name “fibrinogen” is suggested) or as a mixture of renatured and denatured forms (both of molecular weight approximately 33,000) according to the conditions of dissolution. In the former case, dialysis affords a water-clear solution that gives no immediate precipitate on acidification and from which protein separates as a gel in the course of two or three days; in the latter, the solution is more opaque and stable for periods up to 14 days, and acidification to pH 3 causes immediate precipitation of the denatured portion. It follows that the process of denaturation of fibroin is essentially an unfolding of molecular chains, which, in appropriate circumstances, is followed by their subsequent aggregation. In the folded chain the β-keratin configuration of the chain itself appears to be retained.

DDT Insecticide: Development and Applications. G. A. Campbell and T. F. West. *J. Oil & Colour Chemists’ Assoc.*, 1944, 27, 241-262. The investigations of moth-proofing agents of the stomach-poison type that led to the selection of Mitin FF, and the extension of the work to studies of contact poisons for other insects that led to the development of DDT (aa-dichloro-
Diphenyl-βββ-trichloroethane) are reviewed. The mode of action of DDT on insects is briefly discussed and uses for the control of lice and mosquitoes are described. An account is given of trials of DDT against house flies. Promising results in the killing of flies have been obtained with oil-bound water paints, coumarone resin films, fabrics, and wax floor polishes containing DDT.

Diazotised Aniline: Decomposition at Different pH Values. H. H. Hodgson and E. Marsden. *J. Soc. Dyers & Col.*, 1945, 61, 20-21. Previous studies of the decomposition of aqueous solutions of diazotised amines in the presence of calcium carbonate afforded data in favour of a coupling mechanism between diazohydroxide and phenol. These data are now supplemented and supported by further experimental evidence obtained from a study of the decomposition of diazotised aniline at the six approximate pH values, viz. 10.5, 8.8, 6.7, 5.3, 5.2 and 4.2, obtained by the presence of an excess of a metallic hydroxide instead of calcium carbonate. Tables are given showing the weight of uncoupled phenol, weight of azo compounds, composition of mixture of azo compounds, and ratios of coupled phenol to total phenol and weight of coupled product to total phenol. The rates of decomposition relative to the rates of coupling decrease as the pH value increases. This fact and the well-known fact that rate of coupling increases with increase of pH up to a limiting value, are illustrated by decreases in the amounts of mono-coupled products with corresponding increases in the amounts of di-coupled products as the pH value increases. The amount of tri-coupled product increases with increase in pH up to 8.8 and then falls again. This may indicate a tendency of the coupling diazohydroxide to be in equilibrium with the non-coupling diazotate at pH 10.5.

Contact Angle Measuring Apparatus. J. W. L. Beament. *Trans. Faraday Soc.*, 1945, 41, 45-47. An apparatus is described which is being used to investigate variations with temperature in the hydrophilic properties of lipid extracts of insect cuticle and changes in the surface of the cuticle after molting, by measurement of the angle of contact of water droplets. For tests on lipid extracts the film is laid down from a chloroform solution as a uniform layer on a glass cover-slip and supported in the surface of a beaker of water by cork slips. Water passes through a fine glass jet into the centre of a droplet on the film and water is removed from the droplet by a second jet which just touches the top of it, and is attached to a filter pump. In this way the surface of the drop is always being removed and the water kept clean. The positions of the jets can be adjusted to produce any constant size of droplet or an advancing or receding boundary. Direct readings of the contact angle are obtained by means of an optical system comprising a low-power compound microscope having a rotatable hair-line, a transmitting and reflecting prism, a protractor and a mirror. Details of construction are shown in a diagram.

Raindrops: Relation of Size to Intensity. J. O. Laws and D. O. Parsons. *Amer. Geophys. Union Trans.*, 1944, 24, 432-460 (through *Exp. Sta. Res.*, 1944, 91, 640). Attempts have been made to measure erodibility and infiltration capacity by sprinkling small areas of land with artificial rain. The results are affected by the drop size and velocity of the artificial rains, and the applicability of such results to conditions of natural rainfall has been thrown in doubt. Drop-size measurements are presented (in the original) which should be useful in evaluating simulated rain tests and in interpreting phenomena of erosion generally. The literature of the subject is briefly reviewed.

Calcium Soap-Oil Systems: Wetting Power. W. Gallay and I. E. Puddington. *Canadian J. Res.*, 1944, B 22, 155-160. Contact angles were measured of various mineral oils and water on relatively polar and non-polar calcium stearate surfaces prepared by special means. Previous moistening of the soap surface with small quantities of water decreased the subsequent contact angle against oil. Contact angles of oils were lower on non-polar than on polar surfaces. After moistening the surfaces with water, contact angles were of the same order in all cases. The sedimentation volume of calcium stearate in mineral oil, with and without various added materials, was measured. Additions of water, glycerol and fatty acid resulted in rapid settling, agglomeration and larger sedimentation volume. Ethyl alcohol had a smaller agglomerating effect and other less polar materials had no effect.
Calcium Stearate: State of Dispersion in Mineral Oils. W. Gallay and I. E. Puddington. Canadian J. Res., 1944, B 22, 161-172. Calcium stearate undergoes a partial melting to a mesomorphic state at about 100° C., as shown by discontinuities in the density/temperature relation and in differential cooling measurements, and by the onset of plasticity. No surface activity is exhibited by the soap in mineral oil, even in the mesomorphic state. Calcium stearate dispersions in a non-polar mineral oil are essentially lyophobic up to 180° C., whereas soap is dispersed to a sol in more polar oils at a temperature slightly above the partial melting point. The viscosity of these dispersions, measured over a range of temperatures in a variable-pressure efflux viscometer shows unusual characteristics. A maximum viscosity at intermediate temperatures is observed, accompanied by a high degree of dilatancy. The presence of water lowers the viscosity and destroys dilatancy by agglomeration of the dispersed soap.

Calcium Soaps: Recrystallisation in Mineral Oils. W. Gallay and I. E. Puddington. Canadian J. Res., 1944, B 22, 173-181. When a suspension of calcium stearate in a non-polar mineral oil is heated to produce a well-dispersed sol and then cooled the soap recrystallises to a form that is incapable of holding oil. The dispersion is essentially lyophobic at lower temperatures and is unstable. In polar oils, suspensions are produced that are stable and lyophilic in character, with little or no rigidity. The effect of the presence of water in the system is very marked. Where a non-polar oil is used, the suspension shows a high degree of stability and a high yield value in flow. As a result of agglomeration, a structure is developed, and the system shows a strong stream double refraction. Lower alcohols have a similar effect. Fatty acid brings about agglomeration also, but increasing quantities produce a solvent effect. Calcium oleate behaves similarly to calcium stearate, but recrystallised calcium linoleate dispersions show lower stability and viscosity than those of the oleate or stearate.

Colloid Particles: Lyophobic Association. O. Neunhoeffer. Kolloid Z., 1944, 107, 104-107 (through Chem. Abstr., 1945, 39, 117). The association of molecules dissolved in water is affected, not only by the forces emanating from the molecules themselves, but also by the resistance to penetration of water molecules between the contact surfaces formed by chance meeting of molecules, particularly those of non-polar-polar nature, such as fatty acids. The cohesion in this case is due to the compression of the water, and is designated as "lyophobic association." The cohesion of colloid particles in soap solutions depends upon lyophobic association. This assumption is used to explain the cleansing action of soaps. The hypothesis of lyophobic association in certain surface elements (hydrocarbon surfaces) in the structure of native cellulose makes it possible to clarify certain phenomena in the behaviour of cellulose (such as the high ammonia content of the cuprammonium cellulose spinning solution and similar problems in cellulose nitrate and cellulose acetate manufacture) not easily explained hitherto.

Gluten: Dispersion by Salt Solutions. N. H. Grace. Canadian J. Res., 1944, C22, 280-281. Approximately neutral Na salt solutions of known plant growth stimulants disperse fresh, natural gluten. Marked dispersing effects have been noted with salts of naphthylacetic, naphthylbutyric, naphthylhexoic, indolyl-acetic, indolybutyric, and phenylacetic acids. Salts of anthranilic and sulphanilic acids also had some effect. When nitrogen determinations were made on dispersions and the dispersed nitrogen was expressed as a percentage of the total nitrogen of fresh gluten, the values obtained with dispersions in solutions of salts of the following acids were 97 per cent. for naphthylacetic, 86 per cent. for phenylacetic, 85 per cent. for anthranilic, and 67 per cent. for sulphanilic; 1 per cent. sodium hydroxide and 10 per cent. sodium salicylate effected dispersions of 94 and 96 per cent. of total nitrogen, respectively.

Solvent Extraction: Diffusion Theory. J. O. Osburn and D. L. Katz. Trans. Amer. Inst. Chem. Engrs., 1944, 40, 511-532 (through Chem. Abstr., 1945, 39, 37). The application of diffusion theory to solvent extraction from a porous solid has been expanded to include the structure of the solid. It is shown that different structures may produce wide variations in the type of theoretical extraction curve. Extraction data for different materials can be compared only when details of structure of the solid are compared. Extraction curves for the
extraction of soybean flakes are similar to theoretical curves for extraction with two different diffusion coefficients. A method is shown for finding the two coefficients from the extraction curve. C.

**Soybean Flakes: Solvent Extraction.** C. O. King, D. L. Katz and J. C. Brier. *Trans. Amer. Inst. Chem. Engrs.*, 1944, 40, 533-556 (through *Chem. Abstr.*, 1945, 39, 3'). Experimental data were obtained on the solvent extraction of soybean flakes of various screen sizes and average thicknesses of 0.0080, 0.0109, 0.0171 and 0.0207 in. in solvent mixtures containing approximately 0, 5, 10 and 15 per cent. raw soybean oil in trichloroethylene. Supplemental data were obtained for the extraction of oil-saturated porous clay plates with trichloroethylene and for the extraction of different soybean flakes with a carbon tetrachloride-ethylene dichloride mixture. The application of the theory of molecular diffusion to the extraction of the oil from a uniform porous inorganic solid was confirmed. The simple diffusion theory for uniform porous solids does not correlate the extraction data for the soybean flakes. The structure of the soybean flakes was considered to be the cause of the divergence from theory. General extraction rate curves and equilibrium data have been utilised for the prediction of extraction time under commercial conditions. C.

"Megapermselective" Collodion Membranes: Preparation and Properties. C. W. Carr and K. Sollner. *J. Gen. Physiol.*, 1944, 28, 119-130. Porous collodion membranes were cast on the outside of rotating tubes and then actuated ("oxidised") with 1M. caustic soda. By allowing the oxidised porous membranes to dry in air on the tubes membranes of desirable properties are obtained. These membranes are smooth, have a well defined shape, and allow considerable handling without breaking. This type of membrane when tested for ionic selectivity by the measurement of characteristic concentration potential, consistently gives potentials of 54 to 55 mV., the maximum thermodynamically possible value (at 25° C.) being 55.1 mV. This high degree of ionic selectivity is not lost on prolonged contact with water, and is only very slowly affected by electrolyte solutions. The absolute permeability of such membranes can be varied over a wide range by changing the time of activation. Under optimum conditions membranes can be obtained with a resistance in 0.1N. potassium chloride solution of only 0.5 ohm per 50 sq. cm. membrane area. The absolute rate of cation exchange through these membranes between solutions of different univalent electrolytes is very high, in one case 0.9 m. eq. cations per 4 hours, the anion leak being 0.02 m. eq. The absolute permeability of these membranes is thus two to four orders of magnitude greater than the permeability of the dried collodion membranes and the oxidised (activated) dried collodion membranes used heretofore. Because of the characteristic properties of these membranes, the term "megapermselective" (or "permselective") collodion membranes is proposed for them. C.

**Semi-permeable Membranes: Deposition of Metals in the Pore Spaces.** W. A. Moor. *Science*, 1944, 100, 494-495. Following attempts to silver sheets of cellulose, the author tried the effect of separating the reactants by the membrane and thus obtaining a deposit in the interior. A silver mirror that could be rolled up was obtained with a triethanolamine solution. A lavender-brown deposit of copper was made by having copper sulphate on one side and a suspension of finely divided iron on the other. Silver halides were deposited in the dark, dried, exposed behind a negative and developed; very distinct images were formed within the membrane and the silver particles were much more regular in size, shape and arrangement than in ordinary photographic emulsions. Similar deposits in other membranes, including viscose sausage skin, were also found to be ordered in definite arrangements, depending on the material. Salts reacting to give insoluble products also gave orderly arrangements. The technique might be used in studies of the pore structure of membranes. C.

**Long-chain Polymer Solutions: Viscosity; Effect of Solvent Type.** Elizabeth M. Frith. *Trans. Faraday Soc.*, 1945, 41, 17-27. A semi-quantitative discussion is given of the viscosity relationships of polymers in various solvents. Quasi-thermodynamic reasoning, based on modern statistical theories, shows how the slope of the ordinary viscosity/concentration \((\eta_p/c) - c\) curve is related to the interaction energy between solvent and polymer, and it is shown how small differences in interaction energy appreciably alter the slope. The differences are traced back to slight kinking of the long molecular chains in agreement
with the qualitative views of Mark. Retention of a solvent effect on the limiting intrinsic viscosity, $[\eta]$, at zero concentration is demonstrated but not proved; it is inferred that more extensive coiling of the chains is necessary than the slight kinking which affects the slope.

**Structural Suspensions: Viscosity and Rigidity.** P. S. Roller and C. K. Stoddard. *J. Phys. Chem.*, 1944, 48, 410-425. The authors have studied the relation between the viscosity and rigidity of structural suspensions, which consist in the resting state of a rigid network of particles enclosing the liquid medium, using in part original data on bentonite suspensions. The occurrence of structural suspensions is widespread, and rigidity may be present in suspensions containing less than 0.1 per cent. solids. During structural viscous flow, the structure is broken and the suspension consists of a concentrically disposed composite of liquid suspension and undecomposed residue. The transition of a structural suspension from its rigid state during rest to its broken state during viscous flow is analysed. It is indicated that equilibrium values for the structural viscosity may be closely realised. At a sufficiently high mean rate of shear, the structure is completely decomposed and the viscosity, hitherto decreasing with increase in rate of shear, becomes constant. At constant viscosity, the structural suspension is equivalent to a simple suspension having discrete particles. The application of the Einstein equation to structural suspensions in the range of constant viscosity is discussed and several examples are given, including suspensions of asymmetric particles. At zero rate of shear, the shear stress for a structural suspension is shown experimentally and theoretically to be zero. Although a breaking strength exists, it may be determined only with angular displacement as variable. It cannot be measured with mean rate of shear as variable, and any result obtained in this way is necessarily fictitious. It is proved that at zero rate of shear a singular condition does exist for a structural suspension which is that the viscosity is infinite. The Ostwald-de Waele power equation for structural suspensions satisfies the necessary boundary conditions of zero shear stress and infinite viscosity, and its application is considered.

**Viscometers: Vertical Mounting.** Townsend & Mercer Ltd. *Chemistrv and Industry*, 1945, 39. Details are given of a method of mounting a "V" tube viscometer in a flat Tufnol disc in such a way that the capillary tube itself is at right angles to the under surface of the disc in both planes.

**Germicidal Energy Measuring Devices.** A. H. Taylor. *Gen. Elec. Rev.*, 1944, 47, No. 10, 53-55. Germicidal sources radiate most of their ultra-violet energy in the $\lambda$ 2537 line. The separation of this region from the $\lambda$ 3000 and longer can be accomplished by exposing the photocell or other measuring device first through quartz and then through a thin pyrex filter. The pyrex transmits the energy in the $\lambda$ 3000 region and longer but not the $\lambda$ 2537 energy, whereas the quartz is transparent to both. A zinc-silicate phosphor receiver shows satisfactory selectivity of response. An attachment for use with a General Electric Light Meter for the measurement of germicidal energy employs a thin film of fluorescent material between quartz and glass. Radiant energy of $\lambda$ 2537 may also be measured by means of an arrangement of compensated light meter cells with zinc-silicate phosphor in combination with microammeter or galvanometer, or a system comprising a cadmium-magnesium alloy phototube and amplifier. The sensitivities of these devices are compared. Apparatus used in the measurement of the transmission of $\lambda$ 2537 energy by water and an absolute reflectometer for the measurement of the total reflectance of various materials at $\lambda$ 2537 are briefly described.

**Phase Difference Microscopy.** E. H. Linfoot. *Nature*, 1945, 155, 76. Advantages of the application of Zernike’s phase contrast method to microscopy are outlined. New possibilities in the preparation of phase-contrast configurations, e.g. disks and strips, have lately been opened up by the development of the modern technique of controlled evaporation in vacuo. By this process, a transparent layer can be deposited on a thin glass plate of such a thickness as to increase by one quarter of a wave length the retardation of yellow light passing through the plate. By drawing a fairly sharp stylus across this layer it is possible to remove the soft coating from a narrow strip of the glass without damaging the glass surface. The result is a “phase-advancing strip” which can be used for phase-contrast testing in the same way as the phase-retarding disks.
and strips prepared by Burch. A relatively easy way of producing such coatings is to leave the glass plate in a lens-blooming chamber during five or six consecutive runs. This builds up a layer of approximately the desired thickness.

**Photo-electric Reflectometer.** E. Glückauf. *J. Sci. Instruments,* 1945, 22, 34-36. A circuit designed for measuring the amount of light reflected from a surface in relation to the intensity of the light source makes use of the approximately logarithmic voltage-current characteristic of gas-filled photocells. The reflected and the direct light fall on separate photocells, and a microammeter indicates directly the ratio of the two light intensities, independent of the absolute value. The circuit is independent of large variations in the absolute value of the light intensity used, and the ratio of the illuminations can be varied over a range from 0.25 to 4. This range can be widened by the use of shutters excluding part of the more intense light.

**Acoustic Strain Gauge.** R. S. Jerrett. *J. Sci. Instruments,* 1945, 22, 29-34. The author describes an acoustic strain gauge and its application to the measurement of surface strains produced both by static and dynamic loading. In this device the frequency of vibration of a stretched wire clamped to the structure under observation is matched against the frequency of a second steel wire. The apparatus consists in effect, of two similar gauges. In one, the test gauge, a thin steel wire is mounted between two knife-edges, one of which is free to move longitudinally. The wire is maintained vibrating at its natural frequency by an electrical method and any relative movement between the knife-edges is accompanied by a change in the pitch of the note. In the other gauge, the reference gauge, the tension of the wire may be varied by a micrometer screw-head and the gauge is used as a standard of reference. Adjustment of the screw-head will cause the frequency of the reference wire to approach that of the wire in the test gauge when beats will be produced. When strains produced by static loads are being measured a reading is obtained by reducing the beat frequency to zero, whilst for constantly changing strains a record is taken of the change in beat frequency. Under normal conditions strains of the order of $1 \times 10^{-6}$ can be recorded. The test gauge may be used in remote positions and controlled from a distance.

**Alloys: Damping Capacity; Dependence on Stress.** A. Gemant. *Mechanical Engineering,* 1945, 67, 33-38. It is pointed out that damping data on alloys can be reviewed by plotting the experimentally obtainable logarithmic decrement as a function of stress, and examining the various curves obtained. An alternative procedure is suggested which consists in converting the decrement into a quantity called the transient flow resistance and then plotting this quantity against the stress. The basis for a conversion of the logarithmic decrement to transient flow resistance is explained and it is shown that there is a correlation between creep and damping. Creep data on steel alloys, copper alloys, and lead and lead alloys, and damping data on alloy and carbon steels and copper, nickel and light alloys are analysed. It is shown that alloys having damping characteristics of pronounced stress dependence do exist, and that such a characteristic is particularly promoted by additions of silicon and nickel.


**Hexaploid Cottons: Cytology.** N. K. Iyengar. *Indian J. Agric. Sci.,* 1944, 14, 142-151. Chromosome conjugation has been studied in four hexaploids involving cultivated Asiatic and American cottons, two hexaploids involving wild and cultivated American cottons, and two hexaploids involving wild African and cultivated American cottons. Conjugation has also been studied in the triploids from which the hexaploids were derived. Though the triploids showed marked variations in conjugation, the hexaploids showed only slight differences. The progeny behaviour of the several hexaploids studied showed that gametes with 39 chromosomes seem to function most in the parent hexaploids and some of the gametes have the same constitution as the triploid progenitors. Crosses of hexaploids with suitable diploids gave fertile tetraploids.
with 52 chromosomes. During meiosis, the chromosomes paired mostly as bivalents. These facts indirectly show that the cultivated American cottons with 52 chromosomes are allopolyploids having two sets of Asiatic and two sets of wild American chromosomes.

**Cellulose-decomposing Bacteria: Activity.** C. E. Skinner and E. M. Mellem. *Ecology*, 1944, 25, 360-365 (through *Exp. Sta. Rec.*, 1945, 92, 20). On adding finely divided filter paper to acid soils, 60 per cent. saturated with water, with or without nitrates, no evidence was found of the activity of cellulose-decomposing bacteria, although mould growth increased greatly. In soils with an initial pH above 5.0, both moulds and cellulose-decomposing bacteria showed a significant increase. The conclusion of Dubos that both aerobic bacteria and moulds take part in the decomposition of cellulose in non-saturated soils, unless they are distinctly acid, is shown to be correct.

**Lysine: Determination in Protein Hydrolysates.** M. S. Dunn, M. N. Camien, S. Shankman, W. Frankl and L. B. Rockland. *J. Biol. Chem.*, 1944, 156, 715-724. A microbiological method is described for the determination of L(+)-lysine in protein hydrolysates with *Lactobacillus mesenteroides* P-60. Results obtained with casein and silk fibrin hydrolysates and mixtures of amino acids are presented and compared with results of lysine determinations by other methods. The data indicate that casein and silk fibrin contain 8-3 and 9-6 per cent., respectively, of lysine.

**Cellulosic Materials: Quantitative Saccharification.** J. F. Saeinan, Janet L. Bubl and E. E. Harris. *Ind. Eng. Chem., Anal. Edn.*, 1945, 17, 35-37. A rapid analytical technique for the hydrolysis of cellulosic materials to reducing sugar in nearly quantitative yields involves treatment of the material with 72 per cent. sulphuric acid for 45 min. at 30°C. followed, after dilution of the acid, by a secondary hydrolysis for 1 hour in a 15-pound autoclave or for 4½ hours at the boiling point. Data are presented to show how the yield of reducing sugar varies with the conditions used. A table shows the "potential reducing sugar" content of 15 species of wood and the variation occurring within a species.

**Dextran: Electron-microscopic Study.** B. Ingelman and K. Siegbahn. *Arkiv Kemi, Minn., Geol.*, 1944, 18, B, No. 1, 6 pp. (through Brit. Chem. Physiol. Abstr., 1944, A I, 271). A dilute dextran solution dried on "Zapon" lac foil shows a branched thread-like structure with magnification 65,000 diameters. The threads have a minimum thickness of 30-100 A., with swellings at intervals of approximately 800 A. The observed thickness is of the order expected for the polysaccharide chains.

**Tall Oil: Composition and Uses.** R. H. McKee. *Paper Trade J.*, 1945, 120, TAPPI, 35-36. Recent developments in the refining of tall oil are briefly discussed and the demand for a higher degree of refining, and particularly for fractional separation of the fatty acids from the resin acids, is mentioned. Requirements of the soap, varnish, paint, textile, synthetic resin and other industries are reviewed. The fatty acids of tall oil comprise 75 per cent. linoleic, 6 per cent. linolenic and 19 per cent. oleic acid. Steele's abietic acid forms 60-90 per cent. of the resin acids, and the non-acid portion contains 2:2-dihydrostigmasterol and lignoceryl alcohol.

**10—ECONOMICS**

**Cotton: World Supply and Consumption, 1920-1944.** Rayon Organon, 1944, 15, 172-175. Tables give the carry-over and consumption in the United States and "other countries" and the world production for "all cotton" and for American cotton, from 1920-1944. The trends are discussed. The latest figures for a complete year (1943) are: Total world supply of all cotton 49,710,000 bales; total world consumption 23,778,000 bales; world supply of American cotton 22,529,000 bales; consumption 11,078,000 bales.

**Cotton Piece Goods: Production in the United States, 1943.** Rayon Organon, 1944, 15, 74-76. A detailed, tabular analysis is given of the yardage of various piece goods (more than 12 inches wide but excluding tyre fabric) produced in the United States, quarter by quarter for 1943. The totals, in thousands of yards are: Duck 578,655, narrow sheetings 2,888,443, printers 3,288,968, napped cloths 447,177, coloured-yarn cloths 699,406, fine combed and carded fabrics 1,322,012,
towels, etc., 416,695, wide sheetings and drills 584,600, specialities (pile fabrics, furnishings, etc.) 388,260; grand total, 10,614,216 thousand yards. In addition, 184,678 thousand lb. of cotton tyre fabric was produced. C.

Dye Industry: Relation to National Security. J. Ewing. J. Soc. Dyers & Col., 1945, 61, 3-8. The development of the British dye industry since 1914 is reviewed and its importance for national security is pointed out. The methods employed by Germany to dominate the economic life of Europe are described. The ramifications of the I.G. Farbenindustrie A.-G. in the United States are discussed and examples are quoted showing how cartel activities between the two wars contributed to a re-armed and aggressive Germany and to the weakening of States which were likely to oppose Germany’s national policy. The example of the Sterling Products Co. (U.S.A.) is given to show how the I.G., after the first world war, circumvented precautions designed to prevent them from regaining their world-dominating position, and it is pointed out that the I.G. commercial activities were quite secondary to their primary function as the instrument of German Government policy. Restriction of the capacity of Germany’s chemical and dye manufacture to her own domestic requirements for a long period after the war is recommended. The needs of the British textile industry, the capability of the British dye industry to meet those needs, and problems of price are discussed. C.

Hosiery: Production in the United States, 1943. National Association of Hosiery Manufacturers. Rayon Organon, 1944, 15, 62-63. A table analyses the production of hosiery for 1942 and 1943. In many classes the figures are entirely different, chiefly because of the almost complete absence of silk and nylon in 1943. The total for 1943 was 149,281,974 dozen pairs. C.

Pneumatic Tyres: Production in the United States. Rayon Organon, 1944, 15, 57-61. The American programme for meeting the rubber and fabric requirements in tyres is summarised with the help of: (1) A map showing the location of plant for producing rubbers of the butadiene, styrene, copolymer, butyl and Neoprene types, (2) diagrams of tyre cross-sections giving the weights of the rubber, fabric and other components, and (3) histograms to show the projected quarterly consumption of rubbers and of rayon and cotton cords from March, 1944. It is said that the need for using the artificial Buna S rubber in the large tyres required for inter-city buses and lorries demands the employment of rayon cord because of the heat effect. C.

Textile Fibres: Consumption in the United States, 1923-1943. Rayon Organon, 1944, 15, 131-133. The monthly consumption figures of cotton, wool, rayon filament, rayon staple and silk are plotted on a large chart from 1923 (mid-1936 for rayon staple) to mid-1944 (1941 for silk). C.


Textile Wholesale Prices, 1944. Bd. Trade J., 1945, 151, 25-27. Tables are given showing the movement of wholesale prices from December, 1943, to December, 1944, in various groups of commodities, and the changes in the individual groups are discussed. The figures show an advance of 17.2 per cent. in the cotton index which was essentially the result of an increase of 43d. per lb. on 17th April in the issue price of raw cotton to spinners, the percentage rise being 58 per cent. for American and 43 per cent. for Egyptian. This was reflected in dearer yarn prices, which had also shown a small rise in January as a result of changes made on 22nd December, 1943; these two factors combined to give increases on the year for those yarns used in the index ranging from 21 to 31 per cent., American yarns rising more than Egyptian. A system of rebates was introduced to prevent the prices of utility cloths from rising as a result of increases in wages and material costs, but an increase of 22 per cent. was recorded for industrial canvas. There were few changes of note in the index for the wool group, which rose by barely 1 per cent. during 1944. An increase of 2.2 per cent. in the “other textiles” group was largely the result of a rise of 18d. per cent. in the price of sisal. Raw jute rose by 41 per cent., but the price of aero warp linen yarn fell by over 4 per cent. on the year. C.

United States Rayon Producers. Rayon Organon, 1944, 15, 90, 91, 93. A list is given of the producers of rayon in the United States, with the location of
their administrative and sales offices and plant and the trade names of their chief products. A map is also provided to show the location of the factories. C.

**Cotton Trade: Competition.** Sir E. Raymond Streat. *Textile Mercury & Argus*, 1945, 112, 281-285. A report of an address on the way competition affects the cotton trade in respect to (1) rivalry between cotton-growing countries, (2) alternative use of cotton and (a) other natural fibres, (b) rayon, or (c) non-textile materials, (3) international rivalry, and (4) rivalry between firms within a national industry. C.

**Mill Counting House Equipment.** H. M. Broadley. *Textile Manufacturer*, 1945, 71, 35-36. Illustrations are given of (1) a pay-roll, (2) a tear-off advice slip, (3) a history card showing earnings, efficiency rating, pay-as-you-earn items and holiday pay, and (4) a wage envelope giving gross wages and deductions, which, with an addressing machine and suitable filing apparatus are designed to "mechanise" wage accounting. C.

**Textile Machinery: Depreciation Accountancy.** S. H. Withey. *Textile Weekly*, 1943, 32, 706-8, 746-7; *Silk and Rayon*, 1943, 17, 792-4, 860-2; 1944, 18, 45-7, 203-6, 325-6, 419, 664-6, 879-880. The writer explains a system of book-keeping for costing the machinery depreciation and maintenance in a mill. C.

## 11—INDUSTRIAL WELFARE, INDUSTRIAL PSYCHOLOGY AND EDUCATION

**Silk Operatives: Training.** Macclesfield Textile Classes Advisory Panel. *Silk and Rayon*, 1945, 19, 326, 335. An account is given of steps taken by employers and workers in the Macclesfield district to re-establish textile classes at the Technical School and School of Art. An advisory panel has been set up and their recommendations are recorded. C.

**American Economic Textile Research Project.** A. M. McLsaac. *Textile Research*, 1944, 14, 405-408. An account is given of the organization of the economic research project of the U.S. Textile Research Institute. The project involves a preliminary survey of the present position and problems of the textile industry, studies of special problems, and the preparation of a final summarizing and integrating report. The subjects listed for detailed study include the demand for textiles, foreign textile industries and markets, topics bearing on the cost conditions affecting textile production, and problems of industrial organization, marketing and distribution. C.

**American Fundamental Textile Research Programme.** H. Eyring. *Textile Research*, 1944, 14, 396-399. In this account of the fundamental research programme of the U.S. Textile Foundation and Textile Research Institute the author indicates the complexity of the problems to be studied and discusses briefly the work being carried out on the deformation of fibres and the relaxation of stress at constant strain of natural cellulosic fibres, and plans for the study of the effect of chemical treatment on natural and artificial fibres, the mechanism of dyeing, the constitution of dyes, polymer length distribution in artificial fibres, and the methods and mechanisms of water-, fire- and rot-proofing. C.


**Industrial Research: Organisation in Sweden.** E. Velander. *Engineering*, 1945, 159, 141-143. An account is given of the organisation of industrial research in Sweden with the Royal Institute for Engineering Research (the Ingeniors Vetenskap Akademien=I.V.A.) as nerve centre and the Technical Research Organisation (=F.B.O.) as informal consultative committee. Establishments are mentioned, including a Textile Research Institute at Goteborg, which will be equipped with the apparatus developed by Svedberg and Tiselius for the study of large molecules. Diagrams explain the internal organisation of the I.V.A., a research centre attached to the I.V.A., the I.V.A.'s own research institutes and work groups, and the F.B.O. C.
Textile Industry: Prospects. G. J. Esselen. Textile Research, 1944, 14, 410-413. The effect of the war on the textile industry, probable future competition from paper and plastic products, and opportunities for new developments in fabrics for laminating purposes, in the production of finished webs without the use of elaborate weaving machinery, and in new surface coatings are discussed. It is pointed out that it is to the application of chemistry that the textile industry can probably look for the greatest improvement in the next 10 or 20 years, and reference is made to the chlorination of wool, the treatment of rayon pile fabrics with formaldehyde to prevent crushing, the use of plastics in the production of bonded-fibre webs and in the production of waterproof and crease-resistant materials, and various chemical treatments for making fabrics resistant to fire, water, insects, mildew, etc. The advantages that can be derived from the application of statistical analysis are indicated. It is suggested that industry is on the threshold of many new developments which, if properly received and utilized, should result in the renaissance of the textile industry. The importance of research is emphasized, and the support of co-operative research, the establishment of research and development divisions in individual mills or groups of mills, and the use of consulting organizations are urged.

Textile Operatives: "Work Simplification" Studies. C. W. Bendigo. Textile World, 1944, 94, No. 12, 77-80. An account is given of "work simplification" investigations introduced by A. H. Mogensen in a number of textile factories in the United States. A basic idea is to induce the workers themselves to inquire critically into the "why," "what," "where," "when" and "who" aspects of their jobs and then to ask "how" best can the job be performed. Examples are given of a "flow process chart" used for tabulating notes made in a cloth folding inquiry, and also of a "standards motion chart" used in a study of cone winding. The "therblig" symbols (derived from reversing the name Gilbreth) are employed. Emphasis is also placed on the "make ready" and "put away" phases of the job as well as on the "do" phase, since it is in these neglected phases that labour saving is often possible. Great use is made of motion pictures. It is claimed that money and pride are the important things for which people work and that in many factories the most powerful incentive to making suggestions for improvement is the pride of seeing an idea translated to the cinema screen.

Cotton Mill Labour-saving Devices. O. Glaessner. Textile Weekly, 1945, 35, 582-6, 686-8. A report of a lecture and discussion under the headings (a) reducing the human effort required to perform duties in the spinning mill, (b) replacement of human effort by steam or electrical power, and (c) analysing the application of steam power in the form of mechanical or electrical motive energy.


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<table>
<thead>
<tr>
<th>Advertisement</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoa Chemical Co.</td>
<td>Cover iv</td>
</tr>
<tr>
<td>Arundel, Coulthard &amp; Co., Ltd.</td>
<td>Cover iv</td>
</tr>
<tr>
<td>Bodden, Wm., &amp; Son, Ltd.</td>
<td>Cover iii</td>
</tr>
<tr>
<td>British Thomson-Houston Co., Ltd.</td>
<td>i</td>
</tr>
<tr>
<td>Courtaulds Ltd.</td>
<td>i</td>
</tr>
<tr>
<td>Drayton Regulator &amp; Instrument Co., Ltd.</td>
<td>ii</td>
</tr>
<tr>
<td>Eadie Bros. &amp; Co., Ltd.</td>
<td>iii</td>
</tr>
<tr>
<td>International Wool Secretariat</td>
<td>i</td>
</tr>
<tr>
<td>Laporte, B., Ltd.</td>
<td>Cover iv</td>
</tr>
<tr>
<td>Mather &amp; Platt Ltd.</td>
<td>Cover iv</td>
</tr>
<tr>
<td>Metropolitan Vickers Co., Ltd.</td>
<td>Cover iv</td>
</tr>
<tr>
<td>National Provincial Bank</td>
<td>ii</td>
</tr>
<tr>
<td>O'Brien, J. Oudin, &amp; Son</td>
<td>iv</td>
</tr>
<tr>
<td>Platt Brothers &amp; Co. Ltd.</td>
<td>Cover iii</td>
</tr>
<tr>
<td>Power Installations Ltd.</td>
<td>i</td>
</tr>
<tr>
<td>Small &amp; Parkes, Ltd.</td>
<td>iii</td>
</tr>
<tr>
<td>Textile Institute</td>
<td>Cover iii</td>
</tr>
<tr>
<td>Tragasil Products, Ltd.</td>
<td>iii</td>
</tr>
<tr>
<td>Tweedales &amp; Smalley (1920) Ltd.</td>
<td>iv</td>
</tr>
<tr>
<td>Universal Winding Co., Ltd.</td>
<td>iii</td>
</tr>
<tr>
<td>Wildt &amp; Co., Ltd.</td>
<td>ii</td>
</tr>
<tr>
<td>Wilson Bros. Bobbin Co., Ltd.</td>
<td>Cover iv</td>
</tr>
</tbody>
</table>