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PROCEEDINGS

Lancashire Section

THE ELECTRON MICROSCOPE

By D. G. Drummond

(*Paper delivered to the Lancashire Section, 20th February,* 1945)

Light has a wave nature and the fineness of detail which can be seen by its aid is limited by its finite wavelength—just as a harbour breakwater will throw a "shadow," in the form of still water, when the length of the approaching waves is small compared with its own size, whereas the finer detail represented by a mast fixed in the path of the rollers will leave the wave pattern unaffected.

In an optical instrument the detail observable is, further, dependent on the aperture of the lens and, for a microscope, the resolving limit is given by:

$$d = 0{\cdot}61 \frac{\lambda}{\text{N.A.}}$$

where λ is the wavelength used,

N.A. is the numerical aperture of the objective,

and d is the smallest distance of separation at which two points will be distinguished as separate.

Thus, since the mean wavelength of light may be taken as 5000 Å and the highest value of N.A. available is the order of 1·4, we have

$$d = 0{\cdot}61 \times \frac{5000}{1{\cdot}4}\text{Å} \doteqdot 2000\text{ Å} \quad \text{or } 0{\cdot}2\mu^*$$

The magnification which is to be used in such circumstances is that which is just sufficient to enlarge this value of d to a size at which it is distinguishable by the human eye and since the resolving limit of the eye is from one to two minutes of arc, or say 0·1 mm. at the least distance of distinct vision, the magnification usable with the best optical microscope is given by:

$$\frac{0{\cdot}01}{2000 \times 10^{-8}} \text{ diameters, } i.e. \text{ 500 diameters.}$$

This is called the "greatest useful magnification" since the whole of the detail resolved by the objective is made visible to the eye under these conditions. Larger magnifications are quite possible and may add to the comfort of vision, but add nothing to the ultimate detail discernible.

To see finer detail the value of d must be decreased either by increasing N.A. or by reducing λ and the magnification may then be increased accordingly. At 1·4 however, the numerical aperture of the optical lens has nearly reached its theoretical maximum and the only real avenue of advance is by way of reducing the wavelength used.

* 1Å (Ångstrom Unit) = 10^{-8} cm. 1μ (Micron) = 10^{-4} cm. = 10^4 Å = 0·001 mm.

About 1904 the ultraviolet microscope was developed,[3] but the usable ultraviolet ends at a wavelength of about 2500 Å, so that this device only doubles the useful magnification. Moreover, since the technique is much more difficult than with the optical microscope, this instrument has been very little used.

A considerable advance might have been possible by using X-rays, whose wavelengths are of the order of 1 Å, had not this radiation suffered from the two disabilities that we have no lens by which it can be focused and that its penetrating power is so great that material in the thicknesses suitable for microscopy would show no contrast.

In 1924, however, de Broglie[4a] postulated that a particle such as an electron when in motion has a wave character of which the wavelength is given by:

$$\lambda = \frac{\text{Planck's constant}}{\text{Momentum}} = \frac{h}{mv}{}^{*}$$

The correctness of this theory was proved in 1927 by the electron diffraction experiments of Davison and Germer[4b], and G. P. Thomson[4c&d].

For an electron accelerated through a potential of P (electrostatic units), the following relation holds

$$eP = e\frac{V}{300} = \tfrac{1}{2}mv^2$$

where V is the potential expressed in volts and e, m and v are the charge, mass and velocity, respectively, of the electron.

Thence
$$\lambda = \frac{h}{\sqrt{\frac{2emV}{300}}} = \sqrt{\frac{150}{V}\cdot\frac{h^2}{em}}$$
$$\doteqdot \sqrt{\frac{150}{V}} \times 10^{-8} \text{ cms.}$$

If V is 50 kilovolts, then $\lambda = 0{\cdot}055$Å. This wavelength is very suitable for high resolution microscopy and fortunately a beam of electrons can be focused by the use of radially symmetrical electrostatic or magnetic fields and, moreover, the penetrating power of the beam is low enough to give adequate contrast in the image.

If the Rayleigh formula is applied to this case and a value of 1·0 is assumed for N.A. then

$$d = 0{\cdot}61 \times \frac{0{\cdot}055}{1{\cdot}0}\text{Å} = 0{\cdot}033\text{Å}$$

This corresponds to a greatest useful magnification of 30 million diameters at which an atom of 1 Å diameter would appear 3 mms. across. This, of course, has not been attained because, in fact, the numerical apertures of present-day electron lenses are very much less than 1·0.

The focusing action of the radially symmetrical magnetic field of a solenoid whose length is short in relation to the path length of the beam of electrons was first realised by Busch in 1926[5], but it was not until 1931 that Knoll and Ruska[6a] first attempted to make an electron microscope based on such a lens. By 1934 they had succeeded in building a two-stage microscope which for the first time definitely surpassed the optical microscope in resolving power[6b].

At about the same time, work on similar lines was going on in various parts of the world and, while there is not space here to enumerate all these, it may be stated that the first electron microscope in Britain was designed by Prof. L. C. Martin, of the Imperial College, with the collaboration of R. V. Whelpton and D. H. Parnum, and was built in 1937 by Messrs. Metropolitan-Vickers[6c]. The developments of the magnetic lens during this period had resulted by 1940 in a form in which the solenoidal windings are completely

* Relativity corrections are here neglected.

enclosed in an iron shroud with a gap in the central tubular portion. The field is developed across this gap and is concentrated by the pole pieces to a very small volume on the central axis which results in a much more powerful lens than the early types. It still suffers, however, from considerable spherical aberration and this limits the aperture which can be used. When the aperture of a lens is reduced the disc of confusion due to spherical aberration is reduced but, on the other hand, the diffraction disc increases so that optimum definition will be obtained when the aperture is such that these two discs are equal in size. In the modern magnetic lens this occurs at an aperture of about 1/400 (as compared with 1·4 for the optical microscope) which gives for 50,000 volt electrons,

$$d = 0\cdot61 \times 0\cdot055 \times 400 \text{ Å}$$
$$= 13 \text{ Å}$$

corresponding to greatest useful magnifications of about 80,000 diameters.

Full attainment of this result has not been claimed in practice because residual electrical instability of the lenses and, possibly, contaminating films in the apertures and pole pieces detract from the performance. Claims to resolve 25Å have been made[17], but a more usual figure would be about 50Å. This last can be regarded as the practical working standard and corresponds to a greatest useful magnification of 20,000 diameters. At this a water beetle half an inch long would attain the size of an aircraft carrier whilst at the 500 diameters of the optical microscope it would only be as big as a lifeboat. Another comparison which may be helpful is that a cotton fibre (which is 10 to 20 microns in diameter) magnified 20,000 times would be the size of a telegraph pole a third of a mile long, whereas at 500 diameters it might be represented by a thin pocket diary pencil 14 yards in length.

This magnification in the present-day electron microscope is attained by a two-stage lens system which is essentially parallel to the lay-out of an optical microscope. The illuminant is represented by an electron gun aligned on the axis of a magnetic condenser lens functioning as a sub-stage condenser. The specimen is placed in the field of a magnetic objective lens which gives a first-stage magnified image of about 100 diameters (which can be viewed on a fluorescent screen), part of which is further enlarged by the magnetic projector lens, corresponding to a projection eyepiece, and viewed on a fluorescent screen in the final stage. Alternatively, the electron beam may be allowed to fall directly on a photographic plate if a permanent record is required.

Focusing and change of magnification are effected not by racking up and down, but by adjusting the currents in the lenses which are thus altered in focal length and are in this respect analogous to the eye with its power of accommodation, rather than to a glass lens. The currents in the lenses, however, once set must not fluctuate or the image will be blurred and resolution lost, and to this end supply circuits stabilised to one part in 15,000 or better have been devised. Similar stabilization is applied to the accelerating potential on the electron gun. Fluctuation of gun potential of course results in fluctuating electron velocity and wavelength which results in an effect analogous to chromatic aberration in the uncorrected magnetic lenses. Recent indications, however, suggest that in practice stabilization of the gun potential is much less important than that of the lens currents.

In the last few years the electron microscope has passed out of the purely experimental stage and commercial models are appearing. Plate I shows the Radio Corporation of America's Type B instrument, designed about 1940, and of which there are now several examples in this country. It is compactly designed and all the control and stabilizing circuits are housed in the cabinet behind the optical column. The only separate components in this model are the rotary vacuum pumps, it being necessary, of course, to establish a vacuum in the column to permit the passage of the electron beam.

The necessity for evacuation imposes a limitation on the instrument since the specimens must be exposed to the vacuum and may undergo changes as a result. In particular, they will be highly desiccated. It is doubtful whether living organisms, for instance, can survive such treatment, and though they can be examined, one must be on the watch for artefacts arising from this cause.*

The specimen in addition to withstanding a high vacuum must undergo a heavy electron bombardment and is sometimes damaged as a result. This happens when the specimen is so thick that appreciable inelastic scattering and electron capture occurs within it, in which case part of the kinetic energy of the beam appears as heat, and results in distortion, swelling, fusion or charring. Absorption of electrons in this way also means that electrostatic charges develop, and the resultant forces can cause movement, vibration or even disruption of the object.

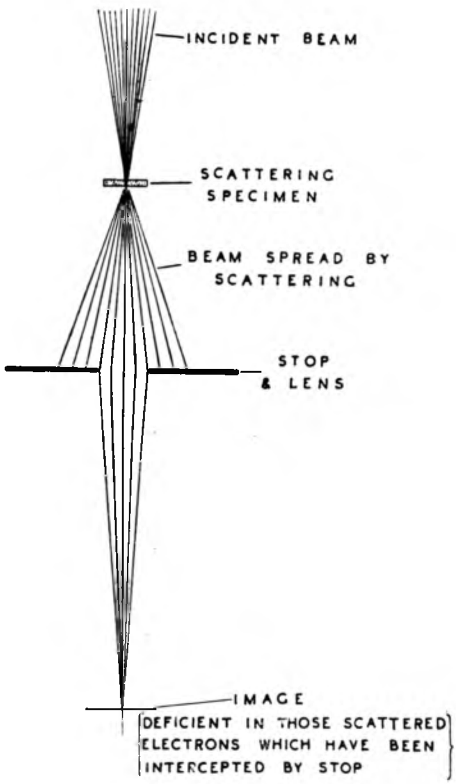

Fig. 1. Formation of image

If, however, the specimen is sufficiently thin (not more than a few tenths of a micron for a 50 K.V. beam) the probability of electron capture is low and it will successfully survive the impact of the beam. This observation naturally raises the question as to why so thin a specimen of such low absorption should produce an image at all, and this is explained by reference to Figure 1. The electrons in passing through a thin layer of matter undergo some degree of elastic scattering by which they are deflected through small angles with inappreciable transfer of energy. The angle of the conical beam diverging from any point of the specimen therefore exceeds that of the incident beam to an extent depending on the scattering power at the point in question. But the numerical aperture of an electron lens is very low, so that a proportion of the scattered cone will fail to pass the lens and the intensity at

* Attempts have been made recently to enclose specimens in an extremely thin cell in which higher pressure or even moist conditions can be maintained (7) but until more experience has been gained we cannot truly assess the value of these experiments.

the image will be thereby reduced. Thus, variations of density in the image reflect variations of scattering power from point to point of the object, and since the scattering power may depend on four factors, the thickness, the mass density, the nature of the atoms present, and (in a crystal) their arrangement,* it is these factors which determine the formation of an image.

It will be seen that increased lens aperture will result in reduced contrast in the image, and this may well be a limiting factor in attempts to improve the performance in electron microscopy.

The requirement of thinness in the specimen is no less necessary in the mount for supporting the specimen, and for this purpose a very thin film of some suitable plastic such as nitrocellulose, ethylcellulose or "Formvar" (polyvinyl formal) is used. If a drop of a 3 per cent. solution in amyl acetate of a suitable nitrocellulose is placed on the surface of water in a dish about 8 inches in diameter it will spread to give a nitrocellulose film of thickness about 0·01 micron and this, being very tenuous, is itself attached for support to a small $\frac{1}{8}$-inch disc of metal grid with 200 meshes to the inch. Each square aperture in this grid is of 60 to 70μ side and the field examined in the instrument is a small portion of one of these apertures.

The preparation of the specimens for presentation to the instrument is one of the difficulties of electron microscopy and almost every material investigated must be treated as a new problem for which a new technique of preparation must be devised. Various general methods are beginning to emerge, but it remains true to say that at the present stage of development the best method of handling a specimen is a major preoccupation of the electron microscopist.

The most easily tackled field is the investigation of the size and shape of small particles and in this field some of the simplest preparations are those of the smokes of burning metals such as magnesium, zinc or lead. The nitrocellulose-coated grid may be simply held in the smoke, or, if better control of the density of deposit is required, the smoke may be caught in an inverted test tube which is subsequently placed over a prepared grid and the smoke allowed to settle.

Sublimation is another method by which a specimen can be prepared *in situ* in a form suitable for examination. Indigo will sublime chemically unchanged forming needle-like crystals and Plate II (i) shows an extremely small needle-shaped particle which has been prepared by direct sublimation on to a prepared grid. This shows cross striations which are roughly 500Å apart, a distance much larger than any molecular distance in indigo, and it is difficult to see why a presumably crystalline material should show such a structure. A similar effect is observed in sublimed anthraquinone and some of the formations in Plate II (ii) are very reminiscent of twinning crystals.

A process similar to sublimation is the evaporation of metals *in vacuo* and metal films produced in this way on a nitrocellulose substrate have been examined[8]. Many such films are discontinuous, which explains their anomalous electrical resistance, and so far as the electron microscope is concerned can be regarded as an array of small particles.

There are many industrial problems involving small particles, however, in which we are not free to prepare the particles in a form convenient for examination. The technique required is rather one which will display particles already preformed. Such is the case with pigments, polishing abrasives, fillers (for rubber and plastics), clays (for ceramics, paper filling, absorbents

* The intensity of the scattered cone from a crystalline material will not fall off uniformly from the axis to the periphery but will segregate into various regions to form an electron diffraction pattern which could be seen by placing a screen at the plane of the lens stop (Fig. 1). Whatever the intensity distribution at this level, however, all those electrons which pass through the stop will come to a common focus and form a true image of the object examined.

or agriculture), fine metal particles (for powder metallurgy), atmospheric pollution problems, and so on. Here we are usually concerned with methods of dispersing the material so that individual sizes and shapes can be seen. Pigments, in ordinary paints, are dispersed usually by rubbing out in a drying oil, such as linseed oil, as a medium, but this procedure is undesirable for electron microscope purposes since traces of the oxidised oil would almost certainly be left in the final preparation. A pigment may, however, be rubbed out in the nitrocellulose-amyl acetate dope and a film cast from this with the dispersed particles embedded in it. Plate II (iii) shows a sample of yellow ochre prepared in this way. Another method is to rub it out in a non-drying oil such as castor oil, dilute with benzene and, after depositing a drop on the nitrocellulose film, to wash away residual castor oil in several changes of benzene. This treatment does not remove the pigment particles once they have settled on and adhered to the film. A still better method is to mill the powder into crêpe rubber and then, after dissolving in xylene and depositing a drop on the grid, to wash away the rubber in changes of xylene. Plate II (iv) shows a good dispersion of a carbon black obtained in this way. For comparison, three undispersed carbon blacks are shown in Plate II (v) where it will be seen that, even without special treatment to disperse the material, some information as to particle size can be obtained.

In atmospheric pollution, the problem is not one of dispersion but rather of the collection of air-borne dusts which are too fine to settle out under gravity. Attempts are being made to modify the thermal precipitator[9a] and electrostatic precipitator[9b] so that they can be used in conjunction with the electron microscope in this field, and some tentative work with these instruments has been begun on the dust-laden air of the cotton card room. In Plate III (i) one type of particle derived from this source is shown but until more work has been done it cannot be definitely claimed that this is a typical feature of the dust.

As has already been mentioned, biological material presents difficulties on account of the desiccation of the specimen. Nevertheless, micro-organisms are frequently photographed in an apparently undamaged state[1 and 2], Plate III (ii) shows one such organism which has been observed several times, always in association with cellulose, though it has not yet been identified. This particular specimen was collected (in an electrostatic precipitator) from the air over a cotton carding machine and put straight into the vacuum with no further treatment. It shows internal structure, which may be to some extent artefact, and numerous flagellæ proceeding from the " tail " end, which are almost certainly genuine.

Viruses, consisting as they do of small particles of a size usually far below the resolving limit of the optical microscope form a type of subject of much interest and particularly suited to electron microscope examination. Several have now been investigated, including those of tobacco mosaic, influenza, equine encephalomyelitis, and others[1 and 2].

Organic tissues present a difficulty in that not only must they withstand a vacuum, they must also be prepared in sufficiently thin sections for electron microscope work. As we have already seen, this means, for a 50 K.V. beam, cutting to something of the order of 0·1 micron, which is not possible with the technique used in optical microscopy. Various sectioning methods for this purpose are now being devised[10], but another possibility is to increase the energy of the electron beam until its penetrating power is sufficient to allow of the use of ordinary cut sections[11]. The Radio Corporation of America have been experimenting, to this end, with a 300 K.V. instrument, but it must be remembered that the increased penetrating power involves a great loss of contrast in the image, and is unsuitable for use with specimens intended originally for a 50 K.V. instrument.

Textile fibres are, in general, too thick for examination directly at 50 K.V., and until special section-cutting devices are available we have to break them up into their constituent structural units for investigation. A cotton fibre, for instance, has a structure of spirally-arranged fibrils and whilst the whole fibre, of diameter 10 to 20 microns, would be burned up on exposure to the electron beam, the individual fibrils or small bundles of them can be safely examined. In an attempt to break such fibrils out of the fibre, simple grinding in a mortar has been tried, but this merely produces dense lumps showing no structure. The fibrils can be separated, however, by passing an aqueous suspension of the very short staple shearings from a cotton velvet through a colloid mill. A similar effect is obtained by pulping a charge of cotton in a paper beater and Plate III (iii) shows the result of such treatment. The finest fibrils seen here are of approximately 100Å diameter so that, assuming they are cylindrical and made up of parrallel chain molecules of cellulose, the cross section must contain 100 to 150 molecular chains. There is, of course, no indication about what part of the fibre these fibrils have come from and further information on this point must await the development of new micro manipulative techniques. In Plate III (iv) is a fibrous particle which has not been identified, but which turned up as an impurity in a cotton pulp. These pictures suggest that different fibres may appear sufficiently characteristic for identification even in these extremely small broken fragments.

We have so far discussed only the transmission type electron microscope which is not very well suited to the examination of solid surfaces. The emission type instrument[1a&b (Sections II & VII)] may be used for the examination of electron-emissive surfaces such as hot metals, with or without oxide coatings, the electrons emitted being themselves focused into a greatly enlarged image of the emitting surface. Valuable work has been done in this field, but it is of limited scope and more general methods for the examination of surfaces are needed. One such method is provided by the Scanning Electron Microscope[1a&b (Section VII)], in which the magnetic lenses are used to produce not an enlarged image of the object, but a reduced image of the source. This forms an extremely fine electron probe which is scanned over the object and the reflected electrons are collected and applied through an amplifier to a cathode ray tube where the enlarged picture appears on the screen.

The scanning instrument has not so far equalled the transmission instrument in resolving power and has not been developed commercially, so that in spite of difficulties the transmission instrument is, in fact, being used for the bulk of the work done on surfaces, the method used being to make a cast or replica of the surface as a thin film and to examine this replica[12]. Formvar is a tough plastic material which, being better able to withstand the stripping and handling involved than the nitrocellulose used for normal specimen-supporting films, has commonly been used for these replicas, though recently a technique in which the final replica is of evaporated silica has come into favour.

Whatever film is used must itself appear structureless and fortunately this is usually the case. The only material which has shown marked structure in a very thin film so far is polythene, of which Plate III (v) is an electron microgram. In this picture the variations of photographic blackening are most probably due to variations of thickness and not to changes of density in the polythene.

It is not always possible to strip a thin replica directly from the surface to be examined, and in such cases an intermediate process may be needed. A thick layer of gelatine, for instance, may be dried on the surface to be examined, and after stripping, coated with Formvar, which is subsequently separated by dissolving away the gelatine. In an attempt to apply this method to the examination of a rubber surface, however, it was found that no replica was formed, but that the gelatine, when stripped, carried part of the rubber surface away with it and Plate III (vi) shows such a stripping mounted on Formvar. The carbon black filler particles can be distinctly seen embedded in the cloudy looking rubber.

The small aperture of the magnetic lens has the effect of giving a great depth of focus and electron micrograms look very much sharper than optical micrograms not only because of the greater resolving power, but also because the whole depth of the object is focused at once instead of only a single shallow layer[13]. This is disconcerting to the optical microscopist who is accustomed to building up a three-dimensional concept of his specimen by a process of differential focusing on successive planes, but it nevertheless permits the taking of electron stereomicrograms of considerable depth[14]. The specimen is tilted first to one side and then the other of the beam axis, and the two resulting pictures are mounted as a stereo pair* from which a good idea can be obtained of the vertical dispositions of the features viewed. If a measuring instrument such as a contour finder is used the vertical distances in the stereograms can be measured and claims for a vertical resolution of 150Å have been made.

We have so far only considered electron microscopes based on the magnetic lens. A radially symmetrical electrostatic field can, however, also be used as an electron lens[15], and has been so used in a few instruments. There are several types of electrostatic lens, but the most generally useful consists of three parallel metal disc electrodes, equally spaced and with small collinear apertures. The outer pair are earthed while the middle one is at a high negative potential. The equipotential surfaces, which act as refracting surfaces to the electron beam, are curved and axially symmetrical so that the whole assembly acts as an electron lens. An electron in passing through such a lens is slowed down and then accelerated again, which means that it is very sensitive to stray magnetic fields at the centre and requires careful shielding; also it is sensitive to contaminating films on the edges of the metal apertures, which may appreciably alter the effective potentials, so that, though the lens is simpler theoretically than the magnetic lens the practical difficulties tend to be greater.

In the special case in which the potential on the lens is the same as that on the electron gun, the electrons will come to the same focus independently of the absolute value of the potential and in an instrument using this arrangement special electrical stabilization is not needed and the control circuits are greatly simplified. The General Electric Co. of America have recently produced a commercial instrument on these lines[16], but intended for only moderate magnifications, and it will be interesting to see how this competes in practice with the Radio Corporation of America's simplified instrument which covers much the same range, but uses magnetic focusing[17].

As we have seen, the practical resolving limit of the present-day electron microscope is of the order of 50Å which is, of course, insufficient to make visible an individual atom or the atomic structure of a molecule. To achieve this would require resolution of about 1Å, that is, an improvement by a factor of 40 or 50 times, which is approximately the same as the factor by which the electron microscope to-day surpasses the optical microscope. This would involve either increase of lens aperture or a reduction in wavelength (by increasing the electron velocity) either of which courses will result in reduced contrast in the image, and since the contrast of a single atom will in any case be low, the difficulties in making it visible will be considerable. Further, it is difficult to imagine how specimens of atomic or monomolecular size can be handled and mounted in such a way as to show up against the background of their support.

There does not seem to be any immediate prospect of developments leading to the making visible of an atom, but it would nevertheless be incautious to say that this result will never be achieved.

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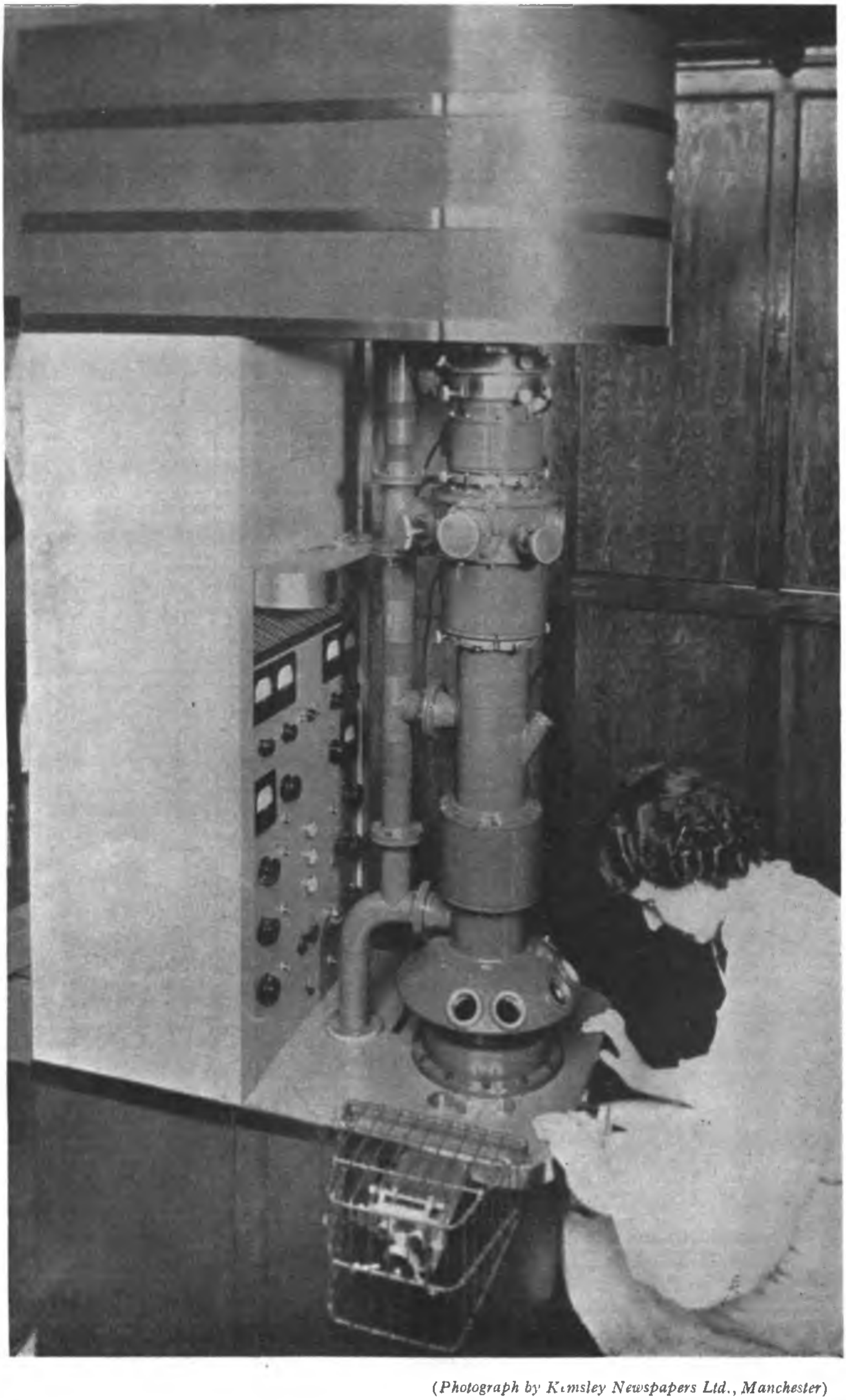
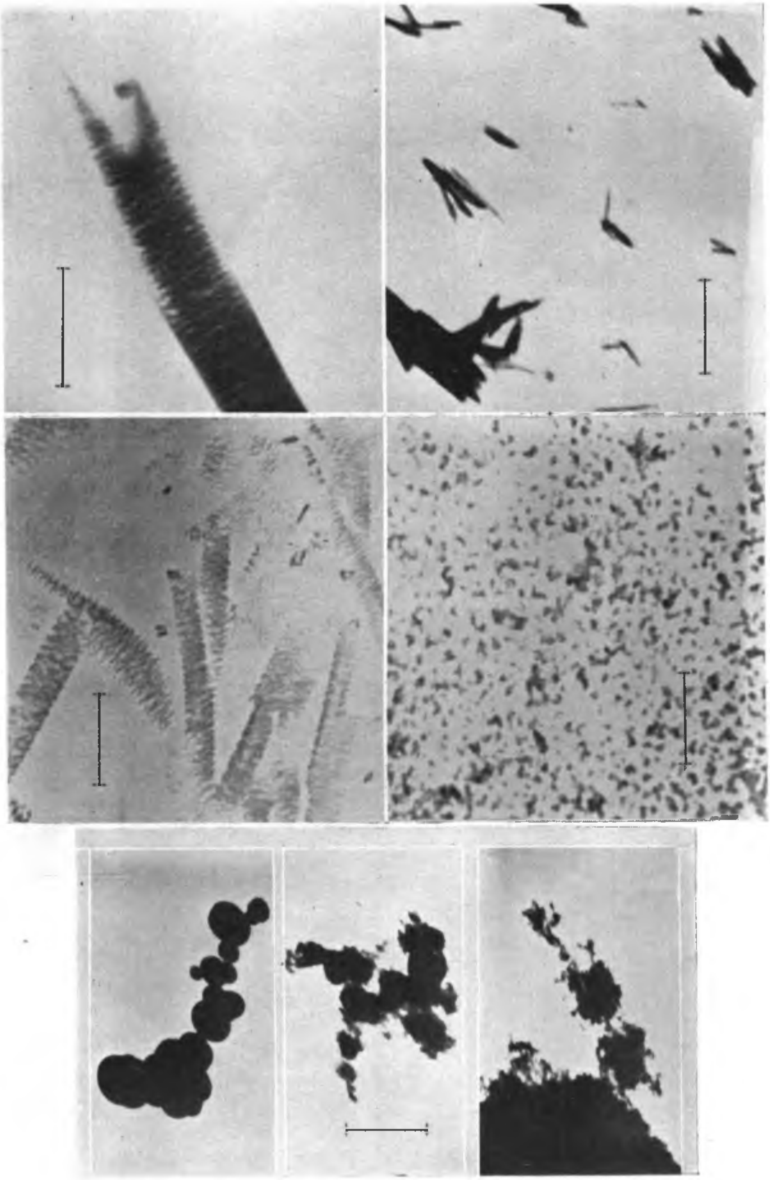
* The magnetic lens rotates the image about its axis because the electrons travel in spiral paths round the magnetic lines of force. In mounting a stereo pair, therefore, it is necessary to rotate the prints back until they are in the orientation of the original object in order to give the correct stereoscopic effect.



(*Photograph by Kemsley Newspapers Ltd., Manchester*)

Plate I
R.C.A. Type B Electron Microscope in use at The Shirley Institute



(i) (iii)

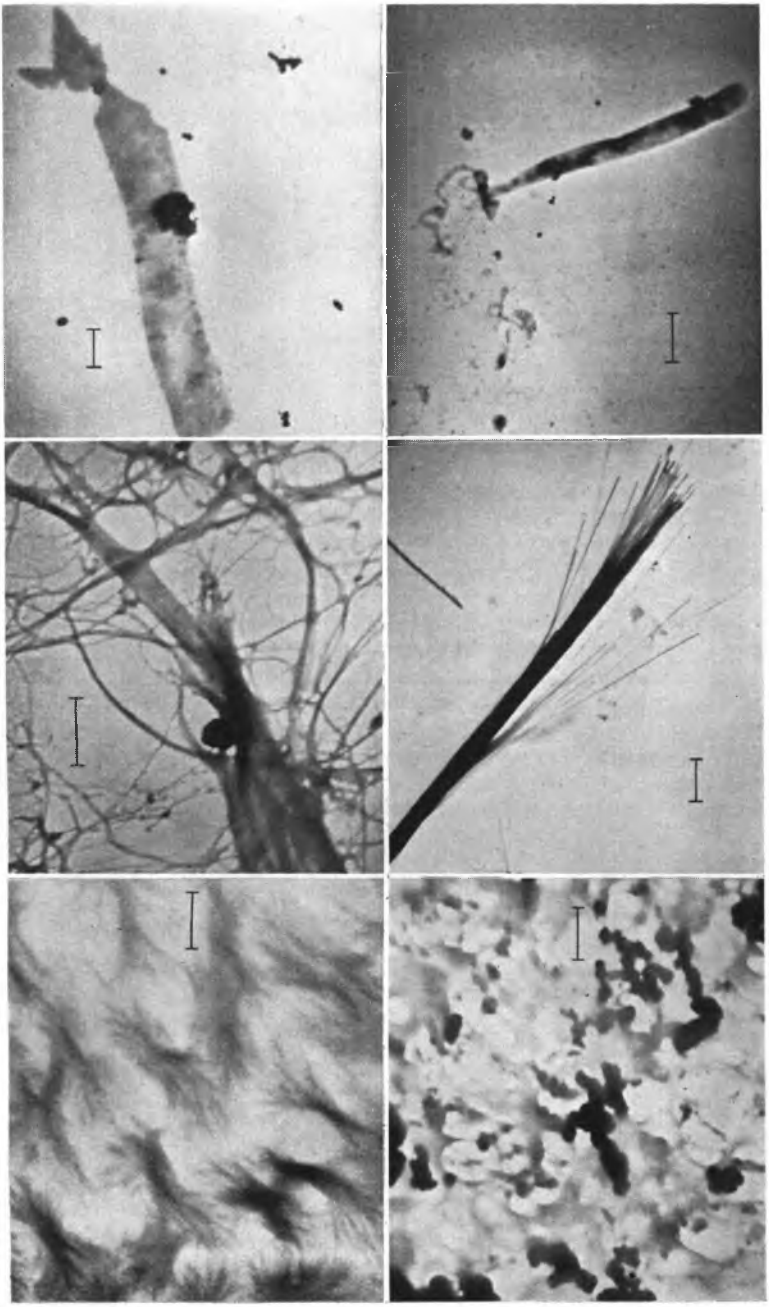
(ii) (iv)

(v)

(Electron micrograms taken at the Shirley Institute)

Plate II

(i) . Striated needle of Sublimed Indigo.
(ii). Sublimed Anthraquinone.
(iii). Particles of Yellow ochre pigment.
(iv). Carbon black dispersed by milling into crepe rubber.
(v). Three undispersed carbon blacks.
I————I indicates $1\,\mu$



(i) (ii)

(iii) (iv)

(v) (vi)

(Electron micrograms taken at the Shirley Institute)

Plate III

(i). Dust particles from air of card room.
(ii). Micro organism found in association with cellulose.
(iii). Cotton pulped in paper beater (showing fibrils).
(iv). Foreign fibre particle found in wet pulped cotton.
(v). Film of Polythene.
(vi). Stripping from a rubber surface showing embedded carbon black.
|———| indicates 1μ

BIBLIOGRAPHY

General References

[1a] C. Marton & S. Sass. *J. Applied Physics*, **14**, 522. (1943)
[1b] C. Marton & S. Sass. *J. Applied Physics*, **15**, 875. (1944)
[2a] G. A. Morton. *R.C.A. Review*, **6**, 131. (1941)
[2b] O. Klemperer. *Reports on Progress in Physics*, *VII*, 107. (1940)
[2c] E. F. Burton and W. H. Kohl. "The Electron Microscope" (Reinhold, New York; 1942).
[2d] M. von Ardenne. "Elektronen Ubermikroskopie" (Springer, Berlin, 1940).

Particular References

[3] A. Köhler. *Z. f. Mikroskopie*, **21**, 129, 273. (1904)
[4a] L. de Broglie. *Phil. Mag.*, **47**, 446. (1924)
[4b] C. Davisson and L. H. Germer. *Phys. Review*, **30**, 705. (1927)
[4c] G. P. Thomson and A. Reid. *Nature*, **119**, 890. (1927)
[4d] G. P. Thomson. *Proc. Roy. Soc.*, **117**A, 600. (1928)
[5] H. Busch. *Ann. der Physik*, **81**, 974. (1926)
[6a] M. Knoll and E. Ruska. *Z. f. Physik*, **78**, 318. (1932)
[6b] E. Ruska. *Z. f. Physik*, **87**, 580. (1934)
[6c] L. C. Martin, R. V. Whelpton and D. H. Parnum. *J. Sci. Instruments*, **14**, 14. (1937)
[7a] E. Ruska. *Kolloid Zeitschrift*, **100**, 212. (1942)
[7b] M. von Ardenne. *Z. physikal Chem.*, B52, 61. (1942)
[7c] I. M. Abrams and J. W. McBain. *J. Applied Physics*, **15**, 607. (1944)
[8] R. G. Picard and O. S. Duffendack. *J. Applied Physics*, **14**. 291. (1943)
[9a] H. L. Green and H. H. Watson. "Physical Methods for the estimation of the Dust Hazard in Industry." Medical Research Council. Special Report, No. 199. (1935)
[9b] G. Riedel. *Kolloid Zeitschrift*, **103**, 228. (1943)
[10a] A. G. Richards, T. F. Anderson and R. T. Hance. *Proc. Soc. Exp. Biol. & Med.*, **51**, 148. (1942)
[10b] F. Sjöstrand. *Nature*, **151**, 725. (1943)
[10c] H. C. O'Brien and G. M. McKinley. *Science*, **98**, 455. (1943)
[11a] V. K. Zworykin, J. Hillier and A. W. Vance. *J. Applied Physics*, **12**, 738. (1941)
[11b] M. von Ardenne. *Z. f. Physik*, **117**, 657. (1941)
[11c] H. O. Müller and E. Ruska. *Kolloid Zeitschrift*, **95**, 21. (1941)
[12a] V. J. Schaefer. *Phys. Review*, **62**, 495. (1942)
[12b] V. J. Schaefer and D. Harker. *J. Applied Physics*, **13**, 427. (1942)
[12c] H. Mahl. *Naturwissenschaften*, **30**, 207. (1942)
[12d] R. D. Heidenreich and V. G. Peck. *J. Applied Physics*, **14**, 23. (1943)
[13] R. B. Barnes and C. J. Burton. *Ind. Eng. Chem.*, **35**, 120. (1943)
[14a] H. O. Müller. *Kolloid Zeitschrift*, **99**, 6. (1942)
[14b] R. D. Heidenreich and L. A. Matheson. *J. Applied Physics*, **15**, 423. (1944)
[14c] L. Marton. *J. Applied Physics*, **15**, 726. (1944)
[15] C. J. Davisson and C. J. Calbick. *Phys. Review*, **38**, 585. (1931)
[16] C. H. Bachman and S. Ramo. *J. Applied Physics*, **14**, 155. (1943)
[17] V. K. Zworykin and J. Hillier. *J. Applied Physics*, **14**, 658. (1943)

Yorkshire Section

THE DISTRIBUTION OF WOOL ON WOOLLEN CARDS*

By J. G. Martindale

(Paper delivered to the Yorkshire Section, 18th January, 1945)

DISCUSSION

Mr. Marshall: It has been a great pleasure to me to listen to Dr. Martindale to-night, for several reasons. In the first place I am very pleased that the Research Association is tackling this problem—one that is very vital to woollen carding. In fact I think the emphasis that has been laid on slow workers and doffer speeds has held up progress for a generation, and I am pleased that Dr. Martindale has stressed these points. It is interesting to me because I have been stressing the value of high worker and doffer speeds, for over fourteen years, and I have been familiar with workers running much faster, and with very good results. I believe you get better results. I would add one word of warning: if you increase the worker speeds and the doffer speeds, do not make the mistake of expecting that the yarn will be twice as strong and smart in appearance. The difference is not so great. But there are improvements at the higher rate of production. There are a number of points that would benefit from discussion, but there is one thing that Dr. Martindale mentioned that I am not quite sure I agree with, and that is that increased speeds of the workers do give better mixing power. I agree with Dr. Martindale's statement of his case that the greater collecting power and taking the material round to the swift again gives an increase in that way, but there is one point that I feel may have been ignored—perhaps through lack of time. When the material on the swift is spread out in a very thin film, and is collected on the workers you get what is equivalent to a doubling action. Again, when you get it on to the doffer there is that doubling action. To my mind that is one part of the mixing action. Dr. Martindale has mentioned the first part: that is another. I think that when the speed of the workers is increased you reduce that part of the mixing power. If there is a slow worker there may be 40 in. of swift feeding 1 in. of worker. You are putting material from 40 in. to 1 in. That is going to mix it. If the speed of the worker is increased until only 10 in. is feeding 1 in., then some of that mixing is cut out. I have seen one case in practice in which the shade of a blend was altered by reducing the worker speed from 40 to 20. But do not forget that there cannot be perfect mixing unless there is perfect opening, and when you get better opening you get better mixing. That is one point that needs more discussion.

There are other points in which we shall perhaps all be interested. I believe that the idea of using more swifts with fewer workers per swift is sound. That conforms to standard English practice contrasted with Continental practice. Seven or eight years ago I took out a provisional patent—of placing a small fancy after four workers on top of the swift, and a second fancy after a further four workers, with the same idea, that the collecting power would be increased. But in all the work that I have done on doffer speeds I have approached it from another angle. I think one of the valuable things that Dr. Martindale has done is to show us a different aspect on this work. I probably followed the work done by Smith, published in his *Scribbling and Carding* in 1914/15, which is a very good work. He took the argument that working power depends upon the difference in speed between the swift and worker, and that argument was, of course, that the slower the worker went the greater the difference in speed and the greater the working power. That may be

* The substance of the lecture is given in this Journal on pp. T213-T228.

true up to a point, but it is not true when you overload the worker. An increase in worker speeds makes very little difference to the difference between the speeds. You have such a high speed swift and slow speed worker that you can increase the speed of the latter very considerably without reducing that difference between the two to any extent, and you may remember that Smith worked out percentages showing the working power in that way. That is the line on which I have tackled it. Dr. Martindale's work I should term as positive, where the other is really negative, and I feel very greatly indebted to him for putting this point of view forward. It is very valuable, and I hope to see a great deal more work done with both worker and doffer and fancy speeds, and also stripper speeds. All that should help to greater efficiency.

Dr. Martindale: In reply to Mr. Marshall, I think I should correct the misinterpretation that he made. I did not say that increasing the worker speeds improved the mixing: I said the opposite. In other words, I agree with him. I said that if you increase the speed of the workers, the mixing and the blending power of the workers was reduced, because the wool is brought round more quickly. (See Fig. 4.) I said that if you double the speed of the workers, then those fractions which were fed out from the swift came out at half the intervals, therefore the wool that comes out is distributed over a small length of the web. It is delivered in half the time, therefore the mixing is not quite so good.

There are one or two points that I have forgotten to mention. Mr. Marshall mentioned most of them. Another point about this—I find, in spite of all that I have told you, and however much I may like to advocate this point of view—that if you increase the speed of the workers on the carder you get a worse yarn, an irregular yarn. That is in accordance with what I have said, so that in any tests that we have done as regards yarn strength and appearance, we have always kept the workers on the carder part at a slow speed and tried to achieve any improvement on the scribbler and intermediate parts. Mr. Marshall might have something to say about that. The reason, of course, why the collecting power of the worker is increased when you increase its speed is simply that in the same time a greater number of clean worker points are presented to the swift, and therefore give the worker a better chance to pick up the material.

Mr. Butler: I would like to ask Dr. Martindale if he has made any records or found any results on the effect of the collecting power on fibre breakage. At the higher collecting power, is there more breakage or less?

Dr. Martindale: I am sorry, I have no information on that.

Mr. Collinson: I should say there is less. I think your two results relating to the strength of the yarn*—you get a stronger yarn with your higher speeds on the scribbler and intermediate than with the slow speeds throughout the machine—confirm this.

Dr. Martindale: The only information I have with regard to fibre length is in connection with the carding of Celafibre, and we definitely found there that increasing the speed of the workers increased the length of the fibres, and that gave better yarn strength. We have done more tests on wool lately and the increase in strength due to increasing the worker speeds has only been very small. For example, we have done some tests in a mill in which the speed of the workers throughout the machine was doubled: but then they were only doing about 3 r.p.m. to begin with.

Another thing—most Yorkshire carding sets have 6 or 7 parts, and in this particular instance the rate of production was small, something like 12 lb. an hour. I think if you have 7 parts, carding at 12 lb. an hour, it ought to be perfectly carded under any conditions. Assuming that it is perfectly carded in that way, doubling the speed of the workers cannot bring about any improvement. But I think probably where the effect would be found to be most marked would be when you had a machine with a smaller number of parts and

* W.I.R.A. publication No. 174.

a very high rate of production. I think Mr. Marshall mentioned that. You have a high rate of production, a lot of wool loading the machine, and to increase the speed of the workers then might be effective because it would get the wool away and bring more carding points to the swift in the same time. I think that is where the advantage of these things would be found.

Mr. Collinson: I quite agree.

Dr. Martindale: I mentioned that in some tests we found the doffer clearing from 50 per cent. to 75 per cent. of the material, with one particular wool. This means that if you have, say, 30 lb. an hour going through a card, and the doffer is only clearing say 60 per cent., there is 50 lb. passing over the workers and the top of the swift. I think that is a point that is interesting to note.

Mr. Townend: I think we must be careful in interpreting these experimental results. Supposing the swift and the worker have the same surface speed. Will the worker pick up any material then? I think there is going to be a maximum speed at which you will get this collecting power, and beyond that do you think it would decrease again?

Dr. Martindale: I should think that it would. We have done tests up to 40 revs. per minute, and I don't think that is getting near the optimum value. I don't think it is however very practicable to run workers at very much higher speeds that that.

Mr. Townend: I am only considering it from a fundamental point of view. Suppose you run 1,000 revs. per minute, what would happen? It would be interesting to find out.

Mr. Marshall: The point to my mind is this: there is an optimum speed for every rate of production and material. It is somewhere between 1 and 600 revs per minute. The tendency in the past has been to regard it as between 1 and 8 and 1 and 4. I have at the moment on our College plant 5 parts. The slowest workers are doing 20 revs. per minute: the others 38. The doffers apart from the scribbler, back doffer and tape doffer, are perhaps doing 16. The work is well carded, I think. We had a blend put through containing a lot of carbonised noil. When it came through it was very neppy. We had to alter the setting to get that out—the workers on the back part—if we increased the speed. The workers on our back part are running at 38, but they are reversed. I have in fact run them in both directions. I have seen evidence of a very irregular formation with workers when running them in the ordinary—the normal—direction at that high speed. But I took off a card of slubbing on Monday morning and it looked as nearly as you can tell from examination perfectly free from twits. Dr. Martindale tested some yarns for us a while ago. One that was done with high worker speed, 24 lb. production and those high worker speeds throughout, was perhaps slightly lower in strength than one done at 12, but it looked slightly more regular than the other. It doesn't appear that it necessarily causes the twitty appearance. By the way, I hadn't told Dr. Martindale how fast these workers were going when he told us that!

A Visitor: One point that Dr. Martindale missed was graded settings of the 3 workers. You said that the first worker had all the bite, more or less. I use the graded setting and give them all a chance, especially on the breast part. I find that by setting all the same gauge the first worker, especially on the breast, really gets all the hammer of the job, and with opening that setting and closing towards the back I find I get a more regular distribution of work amongst the workers.

Dr. Martindale: You will find that by opening out the first worker and grading them closer, you cannot, by using any settings which would be suitable, make them all do an equal share of the job. You can allow the first one to do slightly less, and the last to do rather more, but you cannot grade the setting in such a way as to make them all behave equally. From my results it is clear that you can make them behave more equally by grading the speeds rather than the settings.

Mr. Baxter: I am connected mostly with the worsted side. It appears from your remarks that you are dealing mostly with the woollen trade. I know from the types of material we produce, which eventually go to the woollen trade—broken tops, shoddies and noils, that these materials have been subjected to a type of pin action. I am wondering, do your arguments also apply to our type of carding? Would you say it would be just as effective? Would you use the same arguments in dealing with our class of material, which is the raw wool, in the English system subjected to the lickers, or if on the Continental type, the breast system, going to a swift? Would you say the same arguments regarding speed would be used?

Dr. Martindale: I have not done any tests on the worsted card, but I have tested fibres of similar lengths to the ones you mention on a woollen card, and the remarks that I have made are generally true. I don't see any reason why they should not be true on a worsted card.

Mr. Baxter: What I can't understand is this: we have about 40 cards, and if you go up the line of 40 cards and are trying to take tests on the same material, as near as possible with the same man's ideas of the same settings, you find a great variation in the slivering coming off, due probably to minute differences, but for which you can never say the reason is this or that. You can make adjustments which put it right, but from a quantitative analysis of some of the defects on a card I should say it was almost impossible to arrive at some conclusion as to how far what you had got was the result of the adjustments. I don't know how you do it at the Wool Research Association, but you must have very ideal conditions, and very ideal methods of testing, to be able to decide that your test has illustrated what would happen on a big plant.

Dr. Martindale: I don't know quite what you mean—when you said that you found defects you didn't say what kind of defects you were talking about. Many of these effects which arise due to altering the speeds of workers and settings, particularly the effect on yarn strength, are very small. The ones I have measured are. I might point out that this does not necessarily claim to be a very complete examination of what happens in woollen carding. It is just an approach to the subject from a rather different angle done to try to present some different ideas in thinking about these matters, and I think that there is quite a lot of experimental work that could be done on a larger scale. It is difficult when you are processing a small amount of material—50 lb. or so, to put 50 lb. through under one set of conditions, and another 50 through the following day with different speeds, to say that any differences are due to the speed changes. It is a question as to whether you have fettled your machines before you start, and if so whether you ought to fettle again before you put the second lot through. If you do you wonder whether results obtained on the first 50 lb. through an empty machine are really reliable. That is why I prefer to do further tests in a mill where you can study the action on, say, several thousands of pounds of material coming through for one week, and then go along the next week and alter some factors and see what the average performance is for the next week. I think that is the only way to get really valuable information.

Mr. Bonser: Regarding any tests you have made, can you give us some information on the materials used?

Dr. Martindale: We have done various types: scoured Australian matchings, 64s quality, about $1\frac{1}{2}$ in. long, coarser qualities, noils 56s and 64s; shorter fibres; Schlumberger noils; lambswool—New Zealand and Australian lambswool. The qualities have ranged from roughly 50s to 70s in worsted terms, and from a length of about $\frac{1}{2}$ in. to, say, 3 in. I can't describe now how these types of wool have been distributed amongst the various experiments, but I have not found anything with any of these wools to confute any of the arguments I have put forward.

Mr. Bonser: The carding power—is it affected as much by the settings as by the speed? In noils did you find that the neps were opened better?

Dr. Martindale: I don't think I can answer that. I don't think I particularly noticed anything of the kind when these tests were done.

Mr. Bonser: It seems to me that if you are to open neps particularly, a close setting is important. If you are opening a material which is in the first instance relatively open, there is not a great deal of carding required. If you are carding noil, or anything that is neppy or thready, there is going to be a slight difficulty there.

Dr. Martindale: That really to my mind deviates on to other questions which I would not like to discuss. My colleague, Mr. Wright, has ideas on the subject of carding out neps, and I know perfectly well that he cards out neps on our machine at Torridon at settings which you probably would think were not close enough. That is not my concern at the moment, it introduces other questions that I wouldn't care to go into and discuss to-night. As to threads —I did some experiments on threads, increasing the speed of the workers. I got some pulled worsted shalloon which is composed of very hard twisted threads that are difficult to remove. This was garnetted, and we did some very tedious measurements of the garnetted waste, measuring the number of pieces of thread in a given weight of it, and getting the proportion of hard twisted thread in the material which was red in colour. It was then blended with some white wool to the ratio of 10 per cent. of this material. Our object was to try to find out the effect of certain things such as speed and setting on the opening power. We took the sliver from the intermediate feed and picked out the red threads, and we were able to tell by weighing these how the average particle size of a thread had been reduced by going through the scribbler, and how the numbers had been reduced. I found that this is a very good test and gives surprisingly consistent results if you pay proper attention to the sampling. You can see how hard threads are split up and gradually diminished in size. I must admit that increasing the speed of the workers did not make any very great difference to the size of the threads after they had come through the machine, or to the number in a given weight of sliver emerging. The thing that made an appreciable difference to the particle size and the number in a given weight was the swift speed. That seemed to be the most effective means of getting rid of them.

Mr. Maud: I wondered what type of machine Dr. Martindale orders—if it is a general purpose machine. In his diagram he has given no size or dimensions. I should like to have his opinion of a machine to tackle anywhere from 50s to 70s quality, both size and dimensions, and also details, if you were going to order a machine to-day.

Dr. Martindale: I don't order machines. Quite frankly, that part of the business is rather outside my scope. I don't feel competent to deal with the subject in all its essential details, at least not without notice of the question.

Mr. Maud: When I get into communication with the machine makers I say, "Why can't you make a standard machine?" They say, "You can't get a standard. Nobody will adopt one. Some want this size, some another." I said, "It would be much simpler if you adopted a standard size and tried to make it satisfactory to the requirements of the trade, the same as the motor car." We have various makes of motor cars, but they are all of similar design.

Mr. Marshall: In the light of present knowledge I should say that if you were trying to lay out a machine to-day it should first of all be standardised in this sense: swift size should be standard 50 in., doffer sizes 36 in.; fancies, I think 8 in., would be big enough. The only things I would not have standard would be the number of workers and the size of the strippers. For long materials I would have 4 pairs; for medium materials and shorter, perhaps 5.

A larger stripper for the small stuff. If you had a machine like that with a garnet breast 40 in. in diameter with doffer, fancy, and 3 pairs of workers and strippers, then the number of parts would depend on the type of work you wanted to do. Every machine maker should make a part as a standard. Platts can do that. A swift and its complementary rollers can be built up according to the amount of working power you need. Our local machine maker, said they once standardised a machine, 54 in. swifts, 40 in. doffers, for one order, and they never had an order for one since. It is the users that are the trouble. The makers would be able to standardise, but one man says a 52 in. swift is no good; and with workers another can't do with 8 in. He wants 9 in. That is why there is no standardisation.

General Items

Institute Diplomas

Elections to Associateship have been completed as follows since the appearance of the previous list (August issue of the *Journal*):

ASSOCIATESHIP

DATTATRAYA MORESHWAR CHOGLE,
Assistant Inspecting Officer (Textiles), I.S.D. War Department, Ahmedabad, India.

FELLOWSHIP

THOMAS COUPE LORD:
The position held should read—Manager, J. S. Hargreaves & Co. Ltd., Spring Mills, Heywood, instead of that shown on page P.127.

Institute Membership

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

Ordinary.

Edward Hanbury Brooke, B.A., Healey House, Huddersfield (Managing Director, John Brooke & Sons Ltd., Armitage Bridge Mills, Huddersfield).

Alfred Dawber, 88, Croston Street, Daubhill, Bolton (Editor, *Textile Manufacturer,* 31, King Street West, Manchester).

M. C. Dutt, 52, Guruprosad-Chaudhuri Lane, Calcutta, India (Assistant Director of Textiles, Textile Directorate, Government of Bengal, 21, Chittayaranjan Avenue, Calcutta).

Rogers B. Finch, S.B., Captain Q.M.C., Eng. Div., Jeffersonville Q.M. Depôt, Jeffersonville, U.S.A. (Officer-in-Charge, Heavy Textile Research and Development).

David William Herbert Galbraith, A.I.I.A., 9, Reade House, Flixton Road, Flixton, Manchester (Assistant General Manager, Walmer Manufacturing Co. Ltd., Ancoats, Manchester).

Edward Wadsworth Hirst, "Selwyn," Beaumont Park, Huddersfield (Woollen Manufacturer, C. & J. Hirst & Sons Ltd., Longwood, Huddersfield).

William M. Holden, Park Mill (Royton) Ltd., Royton (Managing Director).

William Rawson Lang, B.A., M.Sc., A.Inst.P., Gordon Institute of Technology, Geelong, Victoria, Australia (Officer-in-Charge, Textile Research and Testing).

Simples Lopez, N.C. Mills, Gadag, Dharwar, India (Weaving Master, N.C. Spinning and Weaving Mills).

Stanley Morley Mather, Bonds Industries Ltd., Wentworthville, N.S.W., Australia (Assistant Mill Manager).

Désiré de Meulemeester, 107, Boulevard Albert, Gand, Belgium (Director of the Textile Laboratory of the University, Rue Veuve St. Pierre 57, Gand).

P. K. Mitra, L.T.M., Hilla House, Mahim, Bombay 16, India (Examiner of Stores, Indian Stores Dept.).

Bailli Nilssen, Ph.D., Konvallvn 34, Sogn have by, V. Aker, Norway (Lecturer in the University of Oslo, Chemical Institute of the University, Blindern by Oslo).

Cyril Shrigley, 222, Fields New Road, Chadderton, Nr. Oldham (Assistant Carder, Hagues Textiles Ltd., Orb Mill, Waterhead, Oldham).

William Hermon Slade, Bonds Industries Ltd., Camperdown, N.S.W., Australia (Manager Director).

William Turner Thornley, 45, Sherbourne Road, Heaton, Bolton (Textile Engineers' Salesman, Cook & Co. (Manchester) Ltd., 18, Exchange Street, Manchester).

Herbert Wrigley, 3, West Avenue, Daisy Lea Lane, Huddersfield (Woollen Manufacturer, C. & J. Hirst & Sons Ltd., Longwood, Huddersfield).

Junior.

Geoffrey Albert Nuttall, 5, Hampton Road, Great Lever, Bolton (Textile Student, Hollas Ltd., Mather St. Mills, Bolton).

Fernando Alvaro de Franca Pereira, 12, Lily Lane, Moston, Manchester 9 (Student).

Alec Philip Silson, "Fieldhead," Providence Lane, Oakworth, Nr. Keighley (Textile Trainee, Hattersley Sons & Co. Ltd., Mytholmes Mill, Haworth, Keighley).

James Edward Swales, 10, Seedall Avenue, Clitheroe, Lancs. (Assistant Costing and Designing Clerk, Charmfyl Rayons Mills Ltd., 11, Castle Street, Clitheroe).

Gilbert Ernest Watts, Back 78, Albert Road, Colne, Lancs. (Rubber Technologist, J. H. Fenner & Co. Ltd., Winewall Mill, Colne).

Obituary

The Institute regrets to announce the death of the following members:

SIR PERCY ASHLEY, Manchester.
D. N. R. McEWAN, Alloa.
H. HIBBERT, U.S.A.

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. 240—A.T.I., age 30 years, desires position as Technical Assistant with textile firm. Higher National and City and Guilds Full Technological Certificates in Cotton Spinning. Ten years' experience in modern spinning mill. Several years testing laboratory experience. Would consider any reasonable offer from progressive concern.

No. 246—41 years of age, desires position as manager or assistant manager in weaving mill. 27 years' experience of the industry, past six in charge of winding, warping, sizing, weaving and finishing in large mill in India. Shortly home on leave and desires to obtain position in British Isles. Would consider position of technical sales representative.

No. 247.—Young man, 22 years of age, desires position as Wool Yarn Dyer. Five years training as Assistant Foreman Wool Yarn Dyer. Certificates in Bleaching, Dyeing, Finishing and Chemistry.

No. 248—A.T.I. desires position as Manager or Assistant Manager, preferably in Furnishing Fabric Weaving Mill, Cotton or Rayon. Bradford Technical College Diploma in Cloth Manufacture. Over 10 years' Managerial experience in Rayon and Cotton Weaving.

No. 249—Member, 37 years, married, desires post at home or abroad as Cost Accountant. 15 years' Textile Costing experience, five of which were in Europe. Specialist in installation of Standard Cost methods. Cotton Spinning bronze medallist. Working knowledge of French, German and Portuguese.

No. 250—Young man, 22 years of age desires position as Assistant Manager or Assistant Superintendent in Knitting Factory. City & Guilds Full Technological Certificate in the Manufacture of Hosiery and Knitted Goods. Worshipful Company of Framework Knitters Gold Medal. Leicester College Diploma in Knitting.

Vacancy

TEXTILE TECHNOLOGIST wanted by worsted manufacturers to supervise the testing and control of materials from the raw material to the woven fabric. Applications to be addressed to Box No. 80.

INSTITUTE MEETINGS

IRISH SECTION

Saturday, 13th October, 1945—*Belfast*. 6.0 p.m. Lecture: "Dyeing of Acetate Rayon and its Mixtures with Viscose Rayon" by E. Waters, B.Sc. (Imperial Chemical Industries Ltd.), at the Lombard Cafe, Belfast, on the invitation of the Guild of Calico Printers.

LANCASHIRE SECTION

Wednesday, 3rd October, 1945—*Ramsbottom*. Visit to Messrs. Turnbull & Stockdale Ltd., Rosebank Print Works, Ramsbottom, Manchester.

Friday 12th October, 1945—*Manchester*. 1.0 p.m. Lunch-time meeting at the Institute's premises. "India's Cotton Industry" by B. B. Joshi, A.T.I., L.T.M.

Tuesday, 23rd October, 1945—*Manchester*. 6.30 p.m. Lecture: "Plastics for the Textile Industry" by C. D. Weston (Imperial Chemical Industries Ltd.) at the Institute's premises.

MIDLANDS SECTION

Wednesday, 24th October, 1945—*Nottingham*. 6.45 p.m. Lecture: "Oils Used in the Processing of Textile Fibres" by G. E. Cowlishaw (Messrs. Benjamin R. Vickers & Sons Ltd.), at the College of Arts and Crafts, Waverley Street, Nottingham.

YORKSHIRE SECTION

Thursday, 18th October, 1945—*Bradford*. 6.30 p.m. Lecture: "Standardisation in Textiles" by J. Lomax, F.R.I.C. (University College Testing Bureau, Nottingham) at the Midland Hotel, Bradford.

ALPHABETICAL INDEX TO ADVERTISEMENTS

THE JOURNAL OF THE

TEXTILE INSTITUTE

TRANSACTIONS

19—THE DISTRIBUTION AND MOVEMENT OF WOOL ON WOOLLEN CARDS*

By J. G. MARTINDALE

Introduction and Summary

In carding the interplay of wool between the various revolving parts, swift, workers, fancy, etc., is a continual source of interest to carding engineers. This is not surprising because it is here, where wool is being treated simultaneously by pairs of rollers, that the skill of the carder in arranging the working conditions to the best advantage finds scope for its full expression. Personal skill centres round the selection of the best type and condition of card clothing and the relative speeds and settings of the parts.

Fundamentally, one could describe the object of carding as an attempt to expand a stock of wool into such a completely tenuous condition that every fibre in the stock would be completely separated from its nearest neighbour. This would perform a complete opening and allow dirt to fall out, and also bring the fibres into such a condition that they could be mixed in a random way. The final step is then to condense this dispersed mass of fibres again in such a way that the correct number is brought together at the right time and place to form a uniform web. If this could be done effectively, without fibre breakage, it would result in perfect carding, so the essentials are complete opening, thorough mixing, and uniform or level condensing and it is from these standpoints that the behaviour of workers is considered in this paper.

In practice these operations are accomplished by what are, essentially, simple means. Wool in a fairly thick sheet, on a slowly moving surface, is transferred to a fast moving surface. This brings about the expansion, or opening, in two dimensions, and provides the conditions whereby a small amount of wool is distributed over a large surface area. The condensation of this very tenuous film into a web of mechanically manageable thickness is merely the reversal of this operation, the wool is transferred back to the slowly moving surface of a doffer.

This arrangement, although it is the basis of all carding, is crude and does not fully meet the requirements for perfect carding that have been enumerated. The transference of wool from feed rollers to swift is not performed smoothly and evenly fibre by fibre. Wool is not taken from the feed rollers in such a way as to give a uniform open dispersion of fibres on the swift ; it is snatched from them in tufts and so is not completely opened. This crude arrangement, similarly, has no powers of mixing the fibres even

* The substance of this paper was delivered by the author as a lecture to the Yorkshire Section of The Textile Institute on the 18th January, 1945.

A report of the discussion which followed the lecture appears on pages P143-P150.

if they were properly opened nor can it remove any irregularities of feed such as are caused, say, by uneven hopper weighings. The workers, and to some extent the doffer and the fancy, are the instruments by which the shortcomings of the crude arrangement are overcome on a woollen card, in addition to the more obvious mixing action of intermediate feeds. A worker on a swift divides the material which is passing their point of contact, and, as the stripper returns the worker's share to the swift some seconds later, the action is to provide a continuous series of doublings, doubling some of that which has gone before with wool arriving later. This results in mixing and levelling of the fibres both as regards quality and quantity.

Before one can say how effective this levelling action may be, one must at least know how the material is shared between worker and swift, i.e., what fraction of the material reaching their point of contact is picked up by the worker. This fraction has been called the "Collecting Power"* of the worker and is denoted by the letter "p"; it can also be defined as the probability of a fibre approaching a worker being picked up by the worker.

It is shown how the collecting power of a worker may be determined experimentally. A series of such tests has shown (1) the usual order of the values of p for the workers on the Torridon card, (2) how p varies from worker to worker on the card, (3) that it is different for different wools, (4) that the value of p is affected by the setting of the workers to swift, speed of workers, and degree of point of card clothing.

The way in which the wool fed to a card is redistributed by the action of the workers has been examined and it is shown that high values of collecting power are conducive to good mixing and levelling.

The evident relationship between some of the results and those practices generally regarded as good is discussed. It suggests that a high value of collecting power, as well as being a promoter of good levelling and mixing, might also be an index of good carding ability of a worker. This at once suggests that some of the other results might also be a useful guide to the value of other carding methods about which opinion is more divided.

The whole of the work described in this paper, therefore, centres round the following questions:

1. When wool approaches a worker on a swift, how much is taken up by the worker, or vice versa, how much passes forward on the swift?
2. How is the relative size of these two portions affected by carding conditions, e.g., speed and setting of workers?
3. When the power of a worker to pick up wool for itself (collecting power) has been found, what does this signify in terms of carding ability?

We will therefore take these three questions in turn, and for the first consider the diagram shown in Fig. 1.

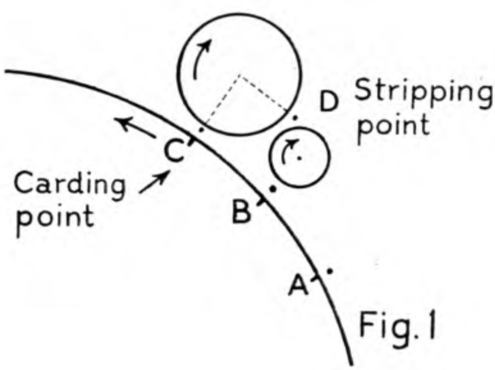


Fig. 1

* During the discussion a more popular term seemed to be Lifting Power.

The Calculation of Collecting Power "p" of a Worker

Suppose the swift is bringing wool along at the rate of 30 lb./hr., i.e., 30 lb./hr. is passing A. Also suppose (i) that the worker is doing 8 r.p.m., (ii) that observation shows that only $\frac{3}{4}$ of the worker surface (the area between C and D) is covered with wool and (iii) an experiment shows that this wool on the worker weighs $\frac{3}{4}$ oz.

Then 1. The swift carries or feeds to B 8 oz. per min.

2. The worker carries 1 oz. per rev., i.e., 8 oz. per min.

3. These two unite at B giving a carry forward to C of 16 oz. per min.

4. But as shown above in 2, the worker carries 8 oz. per min.

5. Therefore the worker removes 50 per cent. of the wool passing point C, hence we say the "Collecting Power" of the worker is 0·50 or 50 per cent.

The above example is illustrated by a particular set of figures; in general the collecting power "p" is given by the formula shown in Appendix 1.

The Experimental Determination of Collecting Power

It is a comparatively simple matter by means of this formula to determine the value of p for any worker on a card; x, n and f are easily found.* The amount on each worker can be found when the machine is stopped by removing worker chains and stripper belts, turning the worker by hand and stripping the wool from it by an oscillating motion of the stripper: the wool is then collected in the form of a long roll on the stripper from which it is easily peeled to be weighed. The only criticism of this method is that the wool on the worker has been picked up while the machine is slowing down to a standstill when conditions are not the actual working conditions. Some tests can be made, however, on our card with the machine at full speed as one of the workers can be lifted clear of the swift and held there until the machine stops. The wool on it (which was picked up at full speed) can then be removed for weighing. A comparison of these two methods shows that they give slightly different results but the difference is not sufficient to invalidate the experimental results which will now be given and which were obtained by the easier first method.

The Effect of the Conditions of a Worker on its Collecting Power

The following results were obtained on 9 in. workers on 50 in. swifts. They are only some of many experiments which have been made all leading to the same conclusions as are expressed here. In Tables II and III values of collecting power are given. For the sake of conciseness only average values are quoted, and each of these average values is the mean result from six experiments. The six individual values were very consistent and in close agreement with one another.

This is illustrated by the results of Table I showing six values of p for each of the four workers on the scribbler part of the card. Those were determined by six tests in succession, and the reason for the variation between the values seemed to be due most likely to slight irregularities in feed which caused the value of m (amount of wool on the worker when taking the test) to vary somewhat.

* x is taken as the rate of feed of wool to the card during the time of the test although strictly speaking the wool passing A is greater than this; it should include also the wool which escapes the doffer and comes round again. However, this approximation does not affect the validity of the conclusions reached.

Table I. Values of p for Workers

Test	SCRIBBLER			
	1st	2nd	3rd	4th
1	0·640	0·408	0·333	0·319
2	0·616	0·422	0·329	0·319
3	0·618	0·396	0·334	0·307
4	0·622	0·418	0·319	0·248
5	0·621	0·411	0·295	0·290
6	0·607	0·397	0·319	0·283
Mean	0·621	0·408	0·322	0·294

Experiment 1

In this experiment observations were made on the workers of the scribbler and intermediate parts of a three-part card clothed with continental card fillet. The wool used was a rather poor quality of scoured Australian pieces and the tests were made to find the effect of worker settings and speeds on collecting power, p. The 50 in. swifts made 69 r.p.m., and the rate of feed was 23 lb. per hr.

Table II. Mean values of p for Workers

Test No.	Scribbler Workers						Intermediate Workers					
	Setting Gauge	Speed r.p.m.	1st	2nd	3rd	4th	Setting Gauge	Speed r.p.m.	1st	2nd	3rd	4th
1	26	20	0·63	0·49	0·41	0·39	28	6	0·53	0·46	0·41	0·46
2	26	6	0·46	0·33	0·26	0·23	28	6	0·50	0·45	0·40	0·45
3	28	6	0·47	0·36	0·28	0·27	30	6	0·56	0·48	0·45	0·45
4	26	11	0·53	0·37	0·29	0·26	28	6	0·52	0·46	0·44	0·39

These results are plotted in Fig. 2.

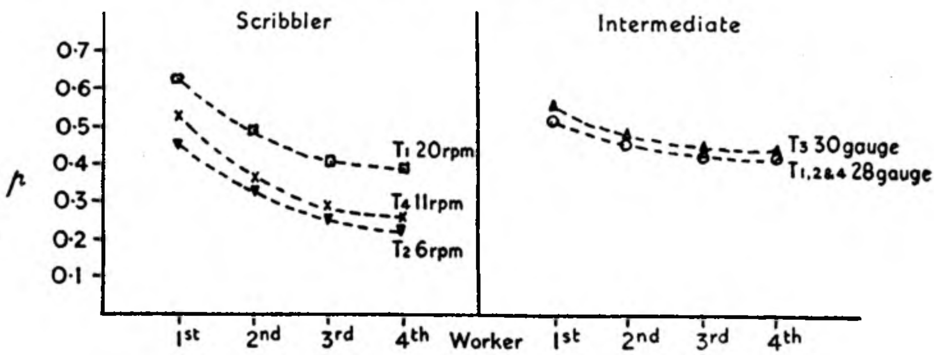


Fig. 2.

Note first of all the results for tests 1, 2 and 4 on the intermediate workers, these were all made under the same conditions and the reproducibility of the results will therefore be seen. The only lack of reproducibility is with the 4th worker and it was found after tests 1 and 2 that this was set closer than to 28 gauge, in fact it had a 30 gauge setting. (The settings had just been left as they were following a previous carding job). In test 4 this worker was set to a 28 gauge.

The following conclusions can be drawn :

1(a) The collecting powers of the eight workers differ from one another.

1(b) On both swifts the value of p decreases as we go round the swift from input to output side.

1(c) The power of the workers falls off less rapidly on the intermediate than on the scribbler swift.

1(d) The value of p is greater for the 1st intermediate worker than it is for the 4th scribbler worker.

1(e) Closer settings result in a small increase in all the values of p (compare test 2 with test 3). (It is interesting to note, however, that this effect is only small).

1(f) Worker speeds have quite an appreciable effect on the value of p (compare tests 1, 2 and 4 on the scribbler part). As the worker speed was increased from 6 to 11 and finally to 20 r.p.m. the values of p increased each time.

Experiment 2

In this experiment a very similar type of wool—Australian scoured pieces—was used. Measurements were now made on the collecting power of the workers on all three parts of the machine. During the course of the experiment one worker was re-ground and the effect of this was observed. The yarn spun from the slubbings carded under the various conditions was examined.

Table III. Mean values of p for Workers

Test No.	SCRIBBLER Setting 26 gauge					INTERMEDIATE Setting 28 gauge					CARDER Setting 30 gauge				
	Worker speed	1st	2nd	3rd	4th	Worker speed	1st	2nd	3rd	4th	Worker speed	1st*	2nd	3rd	4th
1	6	0·59	0·47	0·42	0·41	3·5	0·42	0·35	0·31	0·30	3	0·40	0·43	0·41	0·34
2	20	0·73	0·58	0·54	0·50	20	0·66	0·62	0·55	0·41	3	0·40	0·45	0·42	0·35
3	20	as in test 2				20	as in test 2				10	0·57	0·60	0·58	0·53
4	6	as in test 1				3·5	as in test 1				10	0·61	0·57	0·56	0·51

*This worker was re-ground between tests 3 and 4.

Table IV. Yarn strength

Test	Work done in breaking a 14 yd. hank of yarn* — in. × lb. —
1	68·8
2	70·9
3	63·7
4	53·4

* These tests taken as an index of yarn quality were made on 50 hanks on the Ballistic Tester.

The following conclusions can be drawn :

2(a) The results on the carder part show again that the mean results for collecting power under identical conditions are very reproducible (cf. tests 1 and 2 and tests 3 and 4).

2(b) It was found in experiment 1 that the values of p on the intermediate decreased less than on the scribbler when passing from the 1st to 4th workers. It is now seen that on the carder this decrease is smaller still. It may be that this observation is connected with the openness of the wool.

2(c) The fact that increasing the worker speed increases the value of p is now confirmed on all three parts of the card.

2(d) There is a slight suggestion that increasing the worker speeds on the scribbler and intermediate parts increases the value of p of the workers on the carder. If this is real it may indicate that the wool has been more opened by the higher worker speeds prior to carding.

2(e) On passing from one part to another, i.e., scribbler to intermediate or intermediate to carder, the value of p for the 4th worker on the earlier part is less than that for the 1st worker of the later part when the workers are going at similar speeds, e.g., test 2 for scribbler-intermediate, test 1 for intermediate-carder.

2(f) Between tests 3 and 4 the 1st carder worker was ground. Its collecting power was thereby increased.

2(g) Consider the strength of the hanks. Comparing these it will be seen that a high speed of carder workers gave a weak yarn and examination showed it to be very "twitty" compared with the yarn made with the slowly moving carder workers. On the other hand the yarns made with high speeds of scribbler and intermediate workers gave slightly stronger yarn than that made with slow worker speeds on these parts.

Experiment 3

In this experiment a small test was done to see how the values of p were influenced by the type of wool being carded. Two lots of wool were carded, first the scoured Australian pieces and secondly some Schlumberger noils chosen because of the shortness of the fibres.

The tests were done on the Scribbler and Intermediate parts only, the worker settings on the scribbler part being to a 26 gauge and on the intermediate to a 28 gauge. The speeds of the workers were scribbler 6 r.p.m., intermediate $3\frac{1}{2}$ r.p.m. The swift speed was 69 r.p.m.

Table V. Mean values of p

Test No.	Wool Used	Scribbler				Intermediate			
		1st	2nd	3rd	4th	1st	2nd	3rd	4th
1	Schlumberger noils—dry ...	0·42	0·34	0·30	0·26	0·33	0·31	0·30	0·23
2	Schlumberger noils with 10% oil	0·43	0·35	0·30	0·25	0·35	0·32	0·31	0·24
3	Australian pieces with 10% oil ...	0·61	0·47	0·41	0·38	0·44	0·38	0·35	0·22
4	50/50 Blend of 2 and 3	0·53	0·42	0·37	0·32	0·40	0·35	0·33	0·24

The conclusions to be drawn are:

3(a) The values of p for the shorter material are smaller than those for the longer material.

3(b) The addition of oil has little, if any, effect.

3(c) The values of p appear to show that the presence of two types of wool does not affect the way in which the workers deal with them individually, the noils in the blend, for example, are treated exactly as they would be if the Australian pieces were removed and replaced by an equal weight of noils (see Appendix 2 for this calculation).

Other evidence could have been quoted in support of the above conclusion; this article illustrates the kind of result obtained from this new type of test and therefore it is not considered necessary to multiply the evidence.

The Significance of the Value of Collecting Power of a Worker in terms of Carding Ability

First of all let us note some interesting comparisons between these observations on worker collecting power and some of the current ideas regarding woollen carding.

(1) The 1st worker on the scribbler is usually regarded as doing most work—it has the highest value of p.

(2) Closer setting is a usual way of obtaining more carding power. In these experiments setting closer has been found to give higher values of p.

(3) Grinding to retain point on the card wire is done to maintain carding power. Experiment shows that grinding increases p for a worker that is losing its point.

Such observations as these tend to suggest that there may be a close connection between the value of p and the amount of carding done by a worker. There is no direct experimental method of determining the degree of openness of carded wool coming off a doffer, if there were, we would be able to say whether this increase in worker collecting power did produce more open material. In the absence of such a test method we can, therefore, only note the above correspondence between practice and experiment and also the isolated observation that increasing the speed of the scribbler and intermediate workers in experiment 2 did give a slightly better yarn.

However, there are reasonable grounds for believing that the higher values of p will give better carding. These are based on the fact (see Fig. 1) that the more wool this worker lifts the more is given a second chance of reaching the carding point C and being worked again there. Also as some of this is picked up a second time more wool is gven a third chance of being worked again at this carding point, and so on. As an example, if a tuft of wool of weight M approaches the point C on the swift and if the collecting power of the worker is 0·5 this wool will be split up in its successive passages round the worker as is shown in Fig. 3(a). If the collecting power of the worker is increased to 0·7 it will be repeatedly divided at C as is shown in Fig. 3(b).

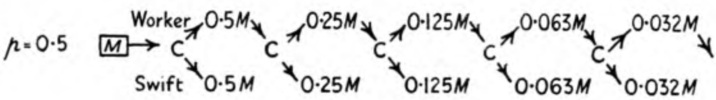


Fig.3a.

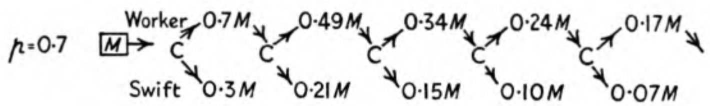


Fig.3b.

In this example it will be seen that when $p=0{\cdot}5$, 3·2 per cent. of the wool goes round the worker five times and therefore has at least six chances of being carded at C. When $p=0{\cdot}7$, however, 17 per cent. of the wool goes round the worker five times and passes point C six times. It seems reasonable to suppose that, as each time there is the opportunity of it being treated by the card wire at this point, the second lot will be carded better. The same is true, of course, for all the workers on a card so it is suggested that anything which will increase the collecting power of the workers will increase the carding ability of a machine.

The effect of closer setting and grinding on increasing the worker collecting power has already been commented upon and as this appears to be in conformity with established methods of getting carding power this seems to bear out the above theory.

One of the most outstanding features of the experimental work, however, has been the great increase in collecting power which arises from a speed increase of the workers. The increases which have been found are much greater than anything that can be obtained by setting closer within safe limits. The inference which is drawn from this is that better carding will be obtained by speeding up the workers. This is a matter on which opinion is divided, there have been advocates of fast running workers amongst carders and these experiments suggest that they are right. Most carders run their workers at a comparatively slow speed ; it is probable that the reason for this has been that on the majority of English cards the workers are chain driven from the doffer and there is no gearing to allow them to be speeded up independently of the doffer. There have, therefore, been difficulties in the way of increasing worker speeds. With cards being made at the present time it is arranged that the workers are gear driven from the swift shaft and therefore there should be every opportunity of running the workers at any required speed. These experiments suggest that this is a useful provision and that higher speed running will result in better carding. It is also interesting to note that on these newer cards provision is made to run the workers on the same part at different speeds and that it is the practice to run the first two workers faster than the others. The argument advanced for this is that these earlier workers have more work to do and this gives them a better chance to do it. If this does in fact increase the performance of the first two workers why not give the others the same advantages by speeding them up ? In view of the fact that we have found that it is the later workers which find difficulty in lifting the wool off the swift we would suggest that it is these workers which should be speeded up so that they will clear the swift more effectively and do more like a fair share of the work on the card.

The reason why increasing worker speed increases the power of the worker to lift the wool is fairly clear, it must be because in a given short interval of time more clean points are presented to the swift and therefore there is not the same tendency for the worker teeth to become clogged with wool.

It appears from these experiments that as wool goes round the swift some of it gets pushed into the teeth of the swift clothing by the pressure on the wool either under the workers or under the strippers and it becomes more and more firmly embedded there as indicated by the fact that successive workers find more and more difficulty in lifting it ; some wool must, in fact, go round the swift without being touched by a worker. It is therefore in the interests of good carding to get this material to the top again where the workers can deal with it, and card it, and this is, of course, done by the fancy and doffer and feed rollers to the next swift. There is also another result immediately seen in our tests. As soon as the material has been dug out of the swift and laid *on the top* of the wire of the next part the ability of the workers to lift it is immediately increased. We have noted, for example, that the first worker on, say the intermediate always has a greater collecting power than the fourth scribbler worker. If a higher value of p is, as has been suggested, an aid to more thorough carding, then transferring the wool from the scribbler swift to the top of the intermediate has assisted matters.

It will therefore be seen that in these two respects the removal of wool from one part to another by a fancy-doffer arrangement is an action which is not without its benefits in the actual opening action. A natural conclusion which can be drawn from this statement is that, for example, *other things being equal*, three swifts with four workers each will give better carding than two swifts with six workers each, a conclusion which seems to favour English carding methods.*

Mixing on the Card

Although the opening of the material is the most important function of the workers, it should not be forgotten that they do perform another useful service, that is to say they do, by their action of taking some of the wool off the swift, holding it up and laying it down after a few seconds, mix the material as it passes forward. By so doing they level out variations in hopper weighings as well as mix different types or colours of fibres. It has been suggested that higher values of p will give increased carding power but whether this is so or not there is no doubt that higher values of p will give better mixing.

Consider Fig. 3 and the way in which a tuft of wool, weight M, was split up between one worker and a swift. Suppose that this tuft was a red tuft

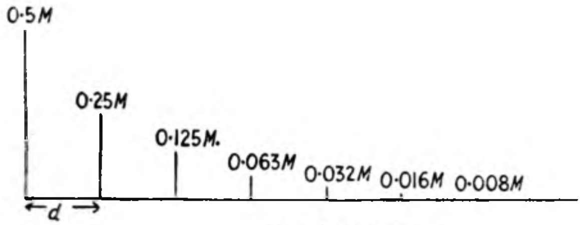
* An interesting development that I have recently heard of with regard to this point is that a small fancy has been fitted in place of the 3rd worker on a swift to lift the material and enable the 4th worker to do more effective work. It might also be noted that if the customary 12 in. fancy was replaced by a 6 in. fancy, it would probably provide room for a second small fancy to be fitted amongst the workers.

amongst some white wool then the successive amounts of red passing forward on the swift at each division at the point C would be :

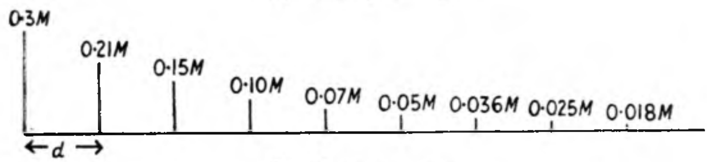
when $p=0{\cdot}5$: $0{\cdot}5M$, $0{\cdot}25M$, $0{\cdot}125M$, $0{\cdot}063M$, $0{\cdot}032M$, $0{\cdot}016M$, $0{\cdot}008M$, $0{\cdot}004M$, $0{\cdot}002M$, Total $1{\cdot}000M$.

when $p=0{\cdot}7$: $0{\cdot}3M$, $0{\cdot}21M$, $0{\cdot}15M$, $0{\cdot}10M$, $0{\cdot}07M$, $0{\cdot}050M$, $0{\cdot}036M$, $0{\cdot}025M$, $0{\cdot}018M$. Total $0{\cdot}953M$.

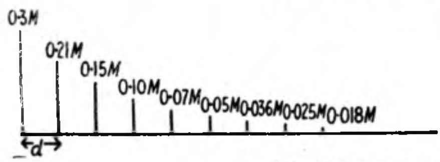
Fig. 4
The distribution of successive fractions of a tuft, weight *M*, passing out from under one worker on a swift



(a) when $p = 0{\cdot}5$



(b) when $p = 0{\cdot}7$



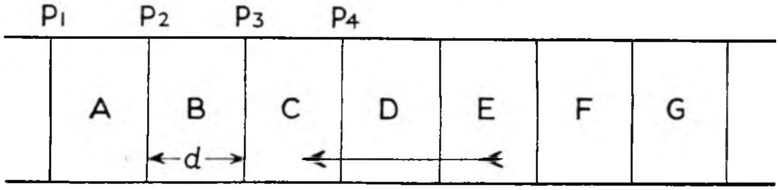
(c) when $p = 0{\cdot}7$
and the worker speed is double that for Fig. 4 (a) and (b).
d = distance delivery sheet moves whilst the red wool is making a circuit of the worker.

In the first case when $p=0{\cdot}5$ practically all the red wool has emerged after nine turns of the worker but when $p=0{\cdot}7$ after nine turns nearly 5 per cent. still remains to come out and the red wool which has emerged is more uniformly spread. This is illustrated diagrammatically in Figs. 4a and 4b. The only point about this analysis is that if the increase in p is effected by speeding up the workers the mixing may suffer because although the worker picks up more red wool it returns it quicker to the swift, i.e., nearer to that part red from which it was separated so that the red wool will not be so widely dispersed in the delivered web. This is illustrated by Fig. 4c, assuming that the increase in p from 0·5 to 0·7 is a result of doubling the worker speed.

The fact is therefore that although increased values of p give better mixing and levelling increased worker speeds tend to defeat the same object. It has already been mentioned that increasing the speed of the workers on the carder part gave a very twitty yarn.

Take another example. Suppose that a uniform thickness of wool as shown in Fig. 5a is arranged to a swift with one worker and stripper. This feed is in successive blocks A, B, C, D, etc., all of different colours, the blocks being each of length "d" ; $-d$ is such that when that part of the wool between P_1 and P_2 which is picked up by a worker has been carried once round, it will be laid down between P_2 and P_3 as this part approaches. That part which is picked up and carried round for a second time will be laid down between P_3 and P_4, etc.

Fig. 5(a)



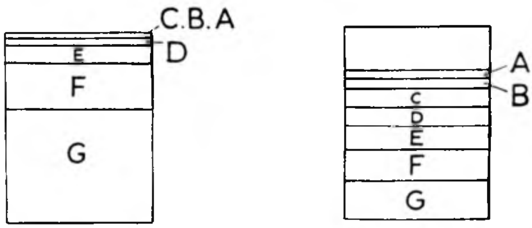


Fig. 5(b) Fig. 5(c)

If in the first case the collecting power of the worker is 0·4, then it will be possible to represent one cross-section of the web which emerges by the diagram of Fig. 5(b) made up of 0·6 parts of section G which has just passed under the worker, plus 0·24 parts of F, i.e., that part of F which has been once round the worker and has escaped another circuit plus 0·096E, plus 0·0384D, plus, etc.

Fig. 5(c) shows the constitution of the section of the web which emerges just as section G has gone through in the case when $p=0{\cdot}8$. This higher value of p has led to a much better blending and mixing of the constituent parts of the feed.

Another point with regard to mixing which is incidental to this discussion is that one would expect better mixing from running the workers on the same part at slightly different speeds than from running them all at the same speed which is common practice. Consider the red tuft in the white wool again. When it reaches the first worker it is split into two parts A and B (Fig. 6), A goes round the worker while B passes on to the 2nd worker where it is again split into two parts C and D.

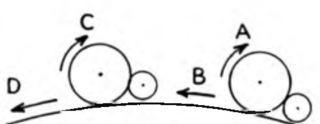


Fig.6

When A is replaced on the swift it will be split again at the first worker and one part will pass on to the second worker, where, if the two workers are equal in size and speed, C will be superimposed exactly on it. Every time that a fraction of the red tuft escapes the first worker it will find itself exactly in place to receive another piece of red from the second worker from which it had previously been separated. This effect mitigates against good mixing

Footnote.—Note that in Fig. 5 (c) the comparatively large area shown above A consists of sections of feed which preceded A into the card. Their individual contributions are too small to show separately, but together they form an appreciable amount of the material leaving the card as the first section of G is emerging.

which would be helped by running all workers on a part at slightly different speeds.

All the experimental conditions except one which have been found to lead to higher values of p are therefore conditions which will give better mixing, the one exception being the condition of an increased worker speed. Obviously although in this case more wool is picked up by the worker which leads to better mixing it is not delayed so long in its passage over the worker and therefore mixing may be reduced. Whether mixing is improved or not depends upon which effect is predominant, and what may be true in one set of circumstances may not be true in another.

In conclusion one may say that however interesting and suggestive the results which have been described may be it is most likely that the chief value of this work lies in the provision of a new technique for examining the action of workers and also in indicating new lines on which such matters can be investigated. In order to facilitate further experiments on this subject a one part experimental carding swift has been erected at Torridon and further work is proceeding. Readers may also be interested to know that on this machine a worker and stripper unit has also been fitted underneath this swift and by observing the difference in the behaviour of the worker below and those above some very interesting information has been obtained on the behaviour of the fancy and doffer, for example, on what fraction of the wool on the swift the doffer removes and how this is affected by doffer speeds and settings. In view of the fact that the doffer behaves like a large worker, it was expected that the results which have been found to apply to workers would also apply to doffers—notably the increase of collecting power with surface speed. This has been found to be so.

The author wishes to express his indebtedness to Mr. Hewitt, Mr. Wright and Mr. Green for their work in connection with these tests and also acknowledges the permission of the Council of the Wool Industries Research Association to publish this paper.

APPENDIX 1

The Calculation of Collecting Power of a Worker

Refer to Fig. 1

x is the uniform rate of feed past A in oz./min. A steady state has been reached and x oz. per min. is also leaving on the swift in the direction of the arrow.

m is the weight of wool on the worker in oz.

n is the number of r.p.m. of the worker.

r is the radius of the worker.

θ is the angle subtended at the centre of the worker by that part of its surface carrying the wool.

If f is the fraction of the worker surface covered with wool then $f = \frac{\theta}{360}$

The wool on the worker has been collected during the time that the worker has turned through the angle θ i.e., $\frac{\theta}{360n}$ min.

During this time—

(1) The wool reaching B from A $= \frac{x\theta}{360n}$

(2) The wool laid down at B by the stripper $= m$

(3) $\therefore$ the amount of wool reaching $C = m + \dfrac{x\theta}{360n}$

(4) But the amount of wool collected by the worker at $C = m$

$\therefore$ Collecting power of worker $p = \dfrac{m}{m + \dfrac{x\theta}{360n}}$

$$p = \frac{m}{m + \dfrac{xf}{n}}$$

APPENDIX 2

Calculation of p for a Blend of Wool when the Collecting Power of the Worker is known for each Component

Given two lots of wool A and B treated separately and then treated when blended in equal proportions by weight the blend being called C.

Suppose the rate of feed is x oz./min. in each case.

$$m_A = \frac{p_A \ xf}{(1-p_A)n}; \ m_B = \frac{p_B \ xf}{(1-p_B)n}; \ m_C = \frac{p_C \ xf}{(1-p_C)n}$$

m_C is made up of two parts m'_A and m_B' ($m_C = m_A' + m_B'$)

m'_A is collected from a feed of $x/2$ oz. per min. of A and m'_B from a similar rate of feed of B. Therefore if the treatment of A is unaffected by the presence of B and vice versa

$$m'_A = \frac{p_A \ xf}{(1-p_A)2n}; \quad m'_B = \frac{p_B \ xf}{(1-p_B)2n}$$

$$\therefore m_C = \left(\frac{p_A}{1-p_A} + \frac{p_B}{1-p_B}\right)\frac{xf}{2n}$$

$$\therefore \frac{p_C}{1-p_C} = \frac{1}{2}\left[\frac{p_A}{1-p_A} + \frac{p_B}{1-p_B}\right]$$

Table 6 gives the values of p_C for each worker calculated by means of this equation from the experimental values of p_A and p_B for the two types of wool used in experiment 3 and compares these with the experimental values obtained with the 50/50 blend.

Table VI

SCRIBBLER	p_A	$\frac{p_A}{1-p_A}$	p_B	$\frac{p_B}{1-p_B}$	$\frac{p_C}{1-p_C}$	p_C (calculated)	p_C (experimental)
1st Worker ...	0·430	0·754	0·606	1·538	1·146	0·534	0·533
2nd Worker ...	0·346	0·529	0·473	0·897	0·713	0·416	0·418
3rd Worker ...	0·304	0·437	0·414	0·706	0·572	0·364	0·368
4th Worker ...	0·253	0·339	0·375	0·600	0·470	0·320	0·318
ITERMEDIATE							
1st Worker	0·346	0·529	0·441	0·789	0·659	0·397	0·400
2nd Worker ...	0·323	0·477	0·380	0·613	0·545	0·353	0·353
3rd Worker ...	0·309	0·447	0·346	0·529	0·488	0·328	0·332
4th Worker ...	0·238	0·312	0·221	0·284	0·298	0·230	0·240

The agreement between the experimental and calculated values of p_0 is exact. The two lots A and B are therefore each treated independently by the workers in a way which is unaffected by the presence of the other component of the blend.

APPENDIX 3

The Combined Effect of Several Workers on a Card

During the course of the paper when questions involving the re-distribution of wool by a card has been considered, attention has always been confined to the action of a single worker on a swift, for example, Figs. 3a and 3b illustrate how a certain section or sections of wool would be split up and re-distributed by a single worker with specified properties. This has made the argument simple to follow and it is really sufficient as it is clear that an alteration which will improve the action of one of a group of workers will raise the efficiency of the group as a whole and if it is applied to all the beneficial effect will be multiplied.

It is possible, however, to provide a solution to the problem, how will a number of workers arranged in series on a card re-distribute the wool fed in when the collecting power of each individual worker is known ?

To answer this question we want to know what courses are open to the wool, and what proportion takes each course.

The courses open to any fibre during one circuit of a swift are (1) that it can go right round the swift without being picked up by any worker, (2) that it can go round the swift and be picked up once by a worker so being delayed in its passage by a time $t = \theta/360n$ (see appendix 1), (3) that it can go round the swift and be picked up twice by a worker, either twice by the same worker or once by each of two different workers, in which case it will be delayed in its passage by a time $2t$, (4) it can make three circuits of a worker being delayed $3t$, and so on.

Some of the wool will take each course and a series of fractions M_0, M_1, M_2, etc., of the original quantity M will be fed out with time intervals between them, viz.

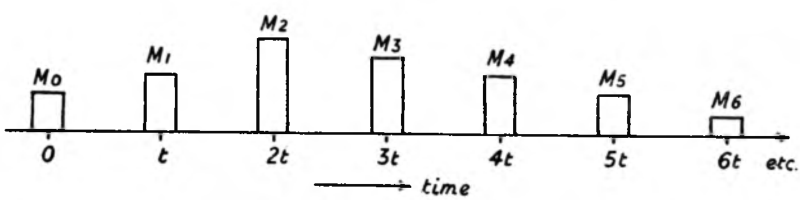


Fig.7. (Appendix)

(the suffixes indicate the number of circuits of a worker which the fraction makes).

That part of the bulk which will take any particular course is the probability of a single typical fibre taking that course times the size of the bulk, e.g., (1) if P_0 is the probability of a single fibre escaping all workers $M_0 = MP_0$, (2) if P_1 is the probability of a single fibre making one circuit of a worker $M_1 = MP_1$, etc. Suppose there are n workers on a card numbered 1, 2, 3,...............n, and that their collecting powers are respectively p_1, p_2, p_3,...............p_n.

The probability of a fibre being picked up by the 1st worker $= p_1$ and the probability of it escaping the first worker $= (1 - p_1)$, etc.

$\therefore$ P_0 the probability of it escaping all workers $= (1-p_1)(1-p_2)(1-p_3)\ldots\ldots(1-p_n)$.

The probability of a fibre being picked up by the 1st worker and of then passing under all the subsequent workers $= p_1 (1-p_1)(1-p_2)(1-p_3)\ldots\ldots(1-p_n) = p_1 P_0$.

The probability of a fibre being picked up by the 2nd worker only $= (1-p_1)\ p_2\ (1-p_2)(1-p_3)\ldots\ldots(1-p_n) = p_2 P_0$, etc.

$\therefore$ The probability of a fibre being picked up once only by any one of the workers $= P_0(p_1+p_2+p_3+\ldots\ldots\ldots p_n) = P_0\ \Sigma_1^n p_1$.

Similarly it can be shown that the probability of a fibre making two circuits of a worker

$$P_2 = P_0\ (\Sigma p_1^2 + \Sigma p_1 p_2)$$
$$P_3 = P_0\ (\Sigma p_1^3 + \Sigma p_1^2 p_2 + \Sigma p_1 p_2 p_3), \text{ etc.}$$

In fact, the probability of a fibre escaping by any path $= P_0 \times \mathrm{f}\ (p_1, p_2, p_3\ldots\ldots)$ where $\mathrm{f}\ (p_1, p_2, p_3\ldots\ldots)$ is a function of the path taken, being a function of the rth power of p's for r circuits of a worker.

The probability of the fibre ultimately escaping $= P_0\ \Sigma\ \mathrm{f}\ (p_1\ p_2\ p_3\ldots\ldots)$
$= 1$

$$\therefore \Sigma\ \mathrm{f}\ (p_1, p_2, p_3\ldots\ldots) = \frac{1}{P_0} = \frac{1}{(1-p_1)(1-p_2)(1-p_3)\ldots\ldots\ldots\ldots(1-p_n)}$$

The probability P_r of a fibre making r circuits of a worker, is, therefore, the term containing the rth power of p's in the expansion of

$$\frac{1}{(1-p_1)(1-p_2)(1-p_3)\ldots\ldots\ldots\ldots(1-p_n)}$$

i.e., P_0 times the coefficient of x^r in the expansion of

$$\frac{1}{(1-p_1x)(1-p_2x)(1-p_3x)\ldots\ldots\ldots\ldots(1-p_nx)}$$

which equals

$$\frac{1}{x^{n-1}}\left[\frac{1}{(1-p_1x)(p_1-p_2)(p_1-p_3)\ldots(p_1-p_n)} + \frac{1}{(1-p_2x)(p_2-p_1)(p_2-p_3)\ldots(p_2-p_n)} + \ldots\ldots \frac{1}{(1-p_nx)(p_n-p_1)(p_n-p_2)\ldots(p_n-p_{n-1})}\right]$$

$$= \frac{1}{x^{n-1}}\left[\frac{1+p_1x+p_1^2x_2+p_1^3x_3+\ldots\ldots}{(p_1-p_2)(p_1-p_3)\ldots\ldots(p_1-p_n)} + \frac{1+p_2x+p_2^2x^2+p_2^3x^3+\ldots\ldots}{(p_2-p_1)(p_2-p_3)\ldots\ldots(p_2-p_n)} + \ldots\ldots + \frac{1+p_nx+p_n^2x^2+p_n^3x^3+\ldots\ldots}{(p_n-p_1)(p_n-p_2)\ldots\ldots(p_n-p_{n-1})}\right]$$

$$\text{The coefficient of } x^r = \left[\frac{p_1^{n+r-1}}{(p_1-p_2)(p_1-p_3)\dots(p_1-p_n)} + \frac{p_2^{n+r-1}}{(p_2-p_1)(p_2-p_3)\dots(p_2-p_n)} + \dots\dots + \frac{p_n^{n+r-1}}{(p_n-p_1)(p_n-p_2)\dots\dots(p_n-p_{n-1})}\right]$$

$$\therefore\ P_r = P_0\left[\frac{p_1^{n+r-1}}{(p_1-p_2)(p_1-p_3)\dots\dots(p_1-p_n)} + \frac{p_2^{n+r-1}}{(p_2-p_1)(p_2-p_3)\dots\dots(p_2-p_n)} + \dots\dots + \frac{p_n^{n+r-1}}{(p_n-p_1)(p_n-p_2)\dots\dots(p_n-p_{n-1})}\right]$$

and $M_r = M\ P$

The calculation of the size of the successive fractions is therefore a simple matter knowing the values of p_1, p_2, p_3......etc. First of all P_0 is calculated then each denominator of the fractions.

For example if $n = 4$ and $p_1 = 0{\cdot}6$, $p_2 = 0{\cdot}5$, $p_3 = 0{\cdot}4$, $p_4 = 0{\cdot}3$.

$$\begin{aligned}
\text{Then } P_0 = (1-p_1)\ (1-p_2)\ (1-p_3)\ (1-p_4) &= 0{\cdot}084\\
(p_1-p_2)\ (p_1-p_3)\ (p_1-p_4) &= 0{\cdot}006\\
(p_2-p_1)\ (p_2-p_3)\ (p_2-p_4) &= -\ 0{\cdot}002\\
(p_3-p_1)\ (p_3-p_2)\ (p_3-p_4) &= 0{\cdot}002\\
(p_4-p_1)\ (p_4-p_2)\ (p_4-p_3) &= -\ 0{\cdot}006
\end{aligned}$$

$$\therefore\ P_r = 0{\cdot}084\left[\frac{0{\cdot}6^{\,3+r}}{0{\cdot}006} - \frac{0{\cdot}5^{\,3+r}}{0{\cdot}002} + \frac{0{\cdot}4^{\,3+r}}{0{\cdot}002} - \frac{0{\cdot}3^{\,3+r}}{0{\cdot}006}\right]$$

$$\begin{aligned}
\text{when } r = 0\quad P_0 &= 0{\cdot}084\ [36 - 62{\cdot}5 + 32 - 4{\cdot}5] &&= 0{\cdot}084\\
P_1 &= 0{\cdot}084\ [36p_1 - 62{\cdot}5p_2 + 32p_3 - 4{\cdot}5p_4]\\
&= 0{\cdot}084\ [21{\cdot}6 - 31{\cdot}25 + 12{\cdot}8 - 1{\cdot}35] &&= 0{\cdot}1512\\
P_2 &= 0{\cdot}084\ [21{\cdot}6p_1 - 31{\cdot}25p_2 + 12{\cdot}8p_3 - 1{\cdot}35p_4]\\
&= 0{\cdot}084\ [12{\cdot}96 - 15{\cdot}625 + 5{\cdot}12 - 0{\cdot}405] &&= 0{\cdot}1722
\end{aligned}$$

etc.

As an example take the behaviour of scribbler workers on the Torridon card as shown in Tests 1 and 2 of experiment 1 in the paper. From the values of p_1 to p_4 given in Table 2 and using the above equation the size of each successive fraction coming from the scribbler if an amount M is fed in can be computed as follows :

Fractions	Test 2 Workers Speeds 6 r.p.m.	Test 1 Worker Speeds 20 r.p.m.
M_0	0·210 M	0·068 M
M_1	0·262 M	0·130 M
M_2	0·216 M	0·158 M
M_3	0·141 M	0·154 M
M_4	0·082 M	0·132 M
M_5	0·044 M	0·109 M
M_6	0·023 M	0·080 M
M_7	0·013 M	0·057 M
M_8	—	0·040 M
M_9	—	0·027 M
M_{10}	—	0·018 M
M_{11}	—	0·012 M
M_{12}	—	0·008 M
Total	0·991 M	0·993 M

It is evident that the conditions of Test 1 (high values of p due to higher worker speeds) lead to much more material making many circuits of the workers and consequently being treated at more carding points. If each fraction is multiplied by the number of times it passes a carding point between worker and swift as a measure of this effect and the total mass times carding points is calculated for each test we find

Test 2 ... Mass times carding points = $5{\cdot}86\ M$

Test 1 ... Mass times carding points = $7{\cdot}78\ M$

It seems reasonable to suppose that the conditions of Test 1 will lead to better carding.

Wool Industries Research Association.

20—THE INVESTIGATION OF PERIODICITIES IN THE PRODUCTS OF COTTON SPINNING

THE DRAFTING WAVE

By G. A. R. Foster

I. INTRODUCTION AND SUMMARY

Measurement of the evenness of cotton slivers and rovings from several mills and from the Shirley Institute machinery room has shown that the irregularity of these products decreases steadily from the card sliver to the third draw frame sliver but that this decrease is not as great as would be expected from the amount of doubling which is performed at these frames. After the third draw frame the variability rises rapidly through the speed frames until the roving is two or three times as irregular as the sliver from the third draw frame and there is a further increase in irregularity on the spinning frame. Obviously, the machines introduce irregularities which are not entirely smoothed out by doubling. It is of great importance to investigate in what way these irregularities are introduced, first, in order to explore the possibility of spinning more uniform yarns and, secondly, because the strength of a yarn is partly determined by its irregularity and therefore a knowledge of the nature and causes of the irregularity is necessary in connection with the study of the dependence of the spinning quality of a cotton upon the properties of the fibres.

The production of irregular slivers and rovings may be due to purely mechanical causes, such as uneven rollers, or stretching of the roving between the front rollers and the bobbin, which could be avoided by perfecting the mechanism of the machines, or it may be due to the cotton itself. For, as is well known, the drafting rollers can only be set so as to control the longer fibres, and unless the shorter fibres move in a perfectly regular manner during the time when they are not gripped by either line of rollers, the resulting drafted product must be irregular. It is the purpose of this paper to discuss whether any important irregularities can be ascribed to the motion of these floating fibres.

It is shown in the first place that the motion of the floating fibres would be expected to produce a regular succession of equally spaced thick and thin places, that is to say to cause periodic variations in the thickness of the drafted product. Such periodicities have been detected in the products of all the drawing and speed frames. They are particularly pronounced when a single card sliver is drafted on the draw frame with only two lines of rollers in operation. A graph of the variations in thickness of a Sakel sliver drafted in this way is given in Fig. 1, which reveals the wave-like grouping of the thick and thin places very clearly. It will be noticed, however, that the wave is very prominent in some parts of the sliver while here and there it can hardly be distinguished; in other words, its amplitude varies considerably.

This paper mainly consists, first, in showing that this is the true character of the "drafting wave" with the addition that its length as well as its amplitude is variable, that is, the thick and thin places are not quite equally spaced; secondly, in describing methods of measuring the average length and amplitude of the wave; and thirdly, in bringing forward experimental evidence that the wave is, in fact, caused by the floating fibres in the manner suggested.

The work of Balls,[1] to whom the term "drafting wave" is due and who has arrived at many of the conclusions reached in this paper, partly by somewhat different experimental methods and partly from theoretical reasoning, is also very briefly described.

It will be seen from Table III that the mean length of the wave, that is the average distance apart of the thick places, depends upon the variety of cotton and upon the degree of parallelisation of the fibres in the sliver before drafting and, with normal roller settings and a draft of five, it varies from about two to three inches (5·6 to 7·6 cm.) and decreases as the staple length decreases. The amplitude (half the average difference in thickness of the thick and thin places) under the same conditions is about 7 per cent. of the mean thickness of the sliver, when a card sliver is drafted, but is less than this when draw frame slivers are employed. This decrease in amplitude as the fibres become more parallel and less entangled reveals the importance of the parallelisation of the fibres in the draw frames and by the comber. The latter, of course, has the additional effect of reducing the number of floating fibres.

As the cotton passes through the drafting machinery each process introduces its own drafting wave and, except in so far as the variations are smoothed out by doubling, the irregularity of the drafted product steadily rises. In the absence of mechanical defects in the machines the irregularity of the yarn is thus the resultant of the drafting waves introduced at the spinning frame and at all the earlier drafting processes.

II. PERIODIC IRREGULARITIES DUE TO FLOATING FIBRES

The investigation of irregularities in cotton slivers and rovings which may possibly be caused by the lack of control of the short fibres during drafting will obviously be greatly facilitated if we can show that these irregularities are of some particular type; for they could then easily be identified and probably separated from other irregularities and their magnitude measured. The first step, therefore, was to consider how the shorter fibres were likely to move during the time when they were not gripped by either line of rollers and what kind of variation in the thickness of the drafted product this motion would produce.

Taking in the first place a sliver in which the fibres are straight and parallel and all of the same length, then, if the rollers are set to this length, the fibres start to move with the speed of the front rollers immediately they are released by the back ones, and the effect of the drafting is simply to space out the fibres without otherwise affecting their arrangement so that the sliver is drawn out without increasing its irregularity. When, however, the fibres vary in length, the drafting is still uniform provided that the short fibres continue to move with the speed of the back rollers up to the moment when they are gripped by the front ones; for the motion is then perfectly regular and is, in fact, very similar to that obtaining when the fibres are uniform in length. But some of the floating fibres may be dragged forward by the more rapidly moving fibres which are already gripped by the front rollers. This produces a thin place between the rollers. The thin place moves forward, and when it reaches the front rollers, the number of floating fibres being dragged forward, which obviously depends upon the amount of cotton gripped under the front rollers, falls. A thick place is now formed between the rollers, which moves forward in its turn, causes an increase in the number of fibres being dragged forward and thus the whole process repeats itself. The floating fibres therefore give rise to a regular succession of thick and thin places or, in other words, the variations in the thickness of the drafted product are periodic.

III. PERIODIC IRREGULARITIES IN DRAFTED PRODUCTS

In searching for periodicities in slivers and rovings, the variations in thickness along the length of the sliver were measured by means of the sliver regularity tester[2] in which the sliver is pressed down into a groove of rectangular cross section in the rim of a slowly rotating wheel by an upper wheel, which is carried on a pivoted arm and so is free to rise and fall as the sliver varies in thickness. The movements of the upper wheel are magnified and recorded photographically and thus a graph of the variations in thickness is obtained.

Some of the curves from the regularity tester are given in Figs. 1 to 3. Fig. 1 shows the result of applying a draft of five in one operation to a Sakel card sliver. The periodicity is very well marked, but appears to be partly entangled with other probably random variations. The slivers represented by Figs. 2 and 3 were produced in the same way, but the card sliver was replaced by first and third draw frame slivers, respectively. In these the short periodicity corresponding to that in Fig. 1 is not so pronounced and, in addition, there are signs of longer periods, which have evidently been introduced during the previous drafting.

It cannot, of course, be concluded at once that the periodic variations are caused by floating fibres; periodic variations may possibly be due to a number of causes such as eccentric or uneven rollers, or periodic slipping of the top rollers or of some other part of the frame. To distinguish between these it is necessary to study the effects of roller setting, draft, parallelisation of the fibres and variety of cotton upon the length and amplitude of the periodicity. Methods of measuring the length and amplitude are therefore required.

FIG. 1 TEST F1

FIG. 2 TEST F2

FIG 3 TEST F3

In Fig. 1 the length of the period can obviously be found, at least approximately, by direct measurement of the curve. The amplitude, however, appears to vary considerably and, since these variations may only be apparent and due to the superimposition of random variations upon the periodic one, we cannot, without further evidence that the variations in amplitude are real, deduce the amplitude directly by measuring the maxima and minima of the curve. Further, in Figs. 2 and 3 the amplitude of the short periodicity is so much less than the other variations that neither it nor the length of the period can be found by direct measurement. It is evident, therefore, that before the periodicities can be measured they must be separated from one another and from the random variations. The usual way of carrying out this analysis of the curves is the Periodogram method, an outline of which is given in another paper.[3] For our present purpose it is only necessary to know that this method of analysing the curves effects a more or less complete separation of the periodic and random parts and measures the lengths and amplitudes of the periodicities.

The periodogram was first of all employed to examine the variations in thickness of the normal products of the drawing and speed frames and it revealed the presence of a number of periodicities in each product, but with the rather surprising result that the number of distinct periodicities was much greater than would be expected if only one were introduced during each drafting process. Evidently, either the effect of the floating fibres was much more complicated than had been anticipated, or periodicities from other sources were also present. A much more thorough investigation under the simplest possible conditions was obviously necessary.

Since the labour involved in the periodogram calculations was so great that progress was extremely slow, a "Grating Periodograph" was designed which performed the greater part of the analysis automatically. This instrument has already been described.[3] It separates the various periodicities, measures their lengths and allows their relative amplitudes to be roughly estimated. If, however, these are required accurately, they must be calculated from measurements of the curves; this is a comparatively simple operation once the periodic lengths are known.

The conditions of experiment were then simplified as much as possible by performing the drafting on the draw frame with the top rollers removed from the two back lines, so that a single draft was applied, and by putting up only one end of card sliver. This entailed the disadvantage of working with a sliver in which the fibres were not straight and parallel, but it was essential to use one which had not previously been drafted.

Table I

Test No.	Roller setting	Draft
D.1	3·81 cm.	3
D.2	5·08 ,,	3
D.3	3·81 ,,	5
D.4	3·81 ,,	3
F.1	3·96 ,,	5

Among the tests made in this manner, those which have been most thoroughly examined on the periodograph are detailed in Table I, which will serve to indicate the range of conditions covered. The cotton was a commercial sample of Sakel of maximum staple length about 3·8 cm. ($1\frac{1}{2}''$).

Test D.4. was a repetition of the first test on a different frame and in test F.1. a different sample of Sakel was used.

The type of curve obtained on the regularity tester is shown in Fig. 1. All the curves were very similar in general appearance to the one illustrated.

Taking test D.1. as typical; the curve from the regularity tester represented 280 cm. of the drafted sliver. When this was examined on the periodograph no less than 30 distinct periods were found ranging in length from 3·6 to 38 cm. Many of these were of low amplitude, but there was nevertheless no doubt as to their presence. In order to see if simpler results could be obtained the curve was next divided into four equal sections, each representing 70 cm. of sliver, and these were examined separately on the periodograph. The reciprocals of the lengths of the periods observed, or their wave numbers, are given in Table II, those for the first 70 cm. in the first column and so on. The results are presented in this form because the accuracy with which the reciprocals of the periodic lengths are determined by the periodograph is constant, and because the wave numbers are more convenient to deal with.

Table II. Test D.1. Reciprocals of Lengths of Periods in centimetres

Number of section				Mean	Harmonics of 84·9 cm.	
1	2	3	4		1/Length	Number
...	·361	·364	...	·362	·365	31
·352	·348	...	...	·350	·354	30
·328	·327	·332	·330	·329	·330	28
·309	·307	·304	·307	·307	·307	26
·295	...	...	...	·295	·295	25
·279	·277	·281	·280	·279	·283	24
·265	...	·263	·265	·264	·260	22
·250	...	...	...	·250	·248	21
...	·240	·243	...	·242	...	...
·234	...	...	·236	·235	·236	20
·217	·214	...	·220	·217	·213	18
·200	...	...	...	·200	·201	17
...	·192	·189	...	·190	·189	16
·180	...	...	·177	·178	·177	15
...	·172	...	...	·172	...	...
...	...	·164	...	·164	·164	14
·144	·141	·146	·144	·144	·142	12
...	·120	...	·118	·119	·118	10
...	·093	·088	·093	·091	·094	8
·079	...	...	·078	·078	·082	7
...	·071	...	·069	·070	·071	6
·049	·053	...	·050	·051	·048	4

It will be noticed that a number of periodicities are present in each section of the curve, that only five of these appear to persist throughout the whole of the curve in that they are present in all four sections, and that the remaining periodicities are absent from one or more of the sections and some seem to disappear over a length of the curve and then crop up again farther along. The behaviour of the periods is, however, rather more complicated than this; for the curve was also examined in three different consecutive sections of 70 cm., the first commencing in the middle of section 1 of the table and extending to the middle of section 2 and so on. It was then seen that some of the periodicities which seem to persist throughout the curve in Table II were absent from these intermediate sections.

The lengths of the periods may, however, be connected by a simple law. If their mean wave numbers are plotted against the corresponding whole numbers in the last column, the resulting points with two exceptions lie fairly closely on a straight line passing very nearly through the origin and of slope 1/84·9 cm., showing that the wave numbers are multiples of 1/84·9 and therefore the periods themselves are sub-multiples or harmonics of 84·9 cm. The calculated harmonics of this fundamental period appear in the sixth column of the table. The agreement with measured wave numbers is fairly good, but the differences are nevertheless greater than the error of the periodograph, which in this test was not greater than 0·0014 $cm.^{-1}$ for the individual results and, of course, less than this for the means. This error, however, is only that in the setting of the instrument and takes no account of the random variations in the curve, which are not entirely averaged out by the analysis and no doubt have some effect upon the measured wave numbers of the periodicities. It must also be remembered in all periodogram analyses that random variations may accidentally resemble periodic ones so that some of the observed periods may have no physical significance. This may be the explanation of the two exceptional periods in Table II.

With these two exceptions, then, the periods are simply related to one another and may therefore all be attributed to one cause, which, whatever it may be, appears to constrain them to the harmonics of a long fundamental period.

But, as has already been mentioned, when the whole curve was analysed on the periodograph 30 periods were found. The observed lengths of many of these were approximately the same as the periods in Table II and except for a few longer ones the remainder were of intermediate lengths. All except three of low amplitude were harmonics of a fundamental of length 120 cm. When 100 cm. of sliver were tested, the length of the fundamental was 90 cm.

Similar results were obtained for the other tests described in Table I; thus test D.2. gave fundamental periods of 45, 45, 75 and 100 cm. when lengths of 41·5, 83, 100 and 166 cm. of sliver, respectively, were examined. Altogether, eleven analyses were made on the periodograph on these tests using various lengths of curve. In most of them the agreement between the harmonic series and the measured wave numbers was as close as, and often rather closer than, that exhibited in Table II, but with the longer lengths of sliver the agreement was in three tests not quite so good. Usually only two or three, instead of several as in test D.1, of the harmonics were absent.

The only definite fact which emerges from all these results is that nearly all the periods in each of the slivers can be arranged, usually fairly accurately, as harmonics of a fundamental period; the particular harmonics present, however, vary in a haphazard manner from one portion of the sliver to another and the fundamental period depends upon the length of material examined, and cannot therefore be regarded as characteristic of the drafting periodicity. Obviously there is practically no definite basis of comparison of one test with another and the results in this form are thus quite useless for our purpose, which, it will be remembered, is to measure the effects of various drafting conditions upon the periodic variations in the sliver.

But the fact that with a few exceptions, which are nearly always of low amplitude, all the periods in any one test are harmonics is strong evidence that they are due to one cause and suggests that we are dealing with a wave of some particular form, which, however, varies somewhat along the length of the sliver. If we can find this form, it may be possible to devise a means of measuring it, which will yield results which are, within reasonable limits, independent of the length of sliver tested.

Balls[1] has obtained equally confusing results. He started with the observation that an automatic record of the strength of consecutive lengths of yarn showed a wave-like grouping of alternately weak and strong breaks. He then explained this by a theory which is essentially the same as that described in section II of this paper and attempted to analyse the "drafting wave," as he calls it, by means of the periodogram method. The behaviour of the periods was so complicated that the attempt at analysis was shelved and the effects of various experimental modifications of the usual arrangement of rollers upon the drafting wave were studied. These experiments strongly suggested that the wave was independent of elementary mechanical causes and so must be ascribed to the cotton itself; but they were necessarily only qualitative and therefore to some extent inconclusive. His final conclusion is that "*progress in the study of drafting will continue to be slow until the construction of the drafting wave is understood analytically so that the effects of such experiments can be expressed in terms of lengths and amplitudes of the waves.*"

There are thus three questions to be answered:—

(1) What is the form of the drafting wave?

(2) How is it to be measured?

(3) Is it caused by the floating fibres?

IV. THE FORM OF THE DRAFTING WAVE

It has already been remarked that in the curves from the regularity tester the drafting wave appears to be a simple periodicity which varies considerably in amplitude, but that these variations may only be apparent and due to the presence of random variations as well as periodic ones. It seems worth while to see what kind of results a wave of this type would give on analysis by the periodogram or, what amounts to the same thing, on the periodograph.

In order to do this it is necessary in the first place to assume that the variations in amplitude are themselves periodic. If the wave number of this amplitude period is $q/2\pi$ then the amplitude, since it is periodic, may be represented by a Fourier series:—

$$a_0 + a_1 \cos(qx+\epsilon_1) + a_2 \cos(2qx+\epsilon_2) + a_3 \cos(3qx+\epsilon_3) \text{ etc.}$$

The amplitudes, a, and the phases ϵ, determine the form of the amplitude variation. The only condition which they must satisfy is that the amplitudes of the later terms should be small; for these terms represent short period variations, shorter than the drafting wave itself, and if their amplitudes were not small compared with those of the earlier terms we should not describe the wave as one which simply varied in amplitude.

Let the wave number of the drafting wave be $k/2\pi$. Then its equation is:—

$$\begin{aligned} y &= \{a_0 + a_1 \cos(qx+\epsilon_1) + \ldots\ldots\}\cos kx \,. \\ &= a_0 \cos kx + a_1 \cos(qx+\epsilon_1)\cos kx + \ \ldots\ldots \\ &= a_0 \cos kx + \tfrac{1}{2}a_1[\cos\{(k+q)x+\epsilon_1\} + \cos\{(k-q)x-\epsilon_1\}] \\ &\qquad + \tfrac{1}{2}a_2[\cos\{(k+2q)x+\epsilon_2\} + \cos\{(k-2q)x-\epsilon_2\}] + \ldots\ldots\ldots \end{aligned}$$

$$\text{i.e. } y = a_0 \cos kx + \tfrac{1}{2}[a_1 \cos\{(k+q)x+\epsilon_1\} + a_2\cos\{(k+2q)x+\epsilon_2\} + ..]$$
$$+ \tfrac{1}{2}[a_1 \cos\{(k-q)x-\epsilon_1\} + a_2\cos\{(k-2q)x-\epsilon_2\} + ..] \quad (1)$$

We have thus resolved the wave of variable amplitude into a series of simple components. Now the effect of analysing such a wave by the periodogram is, besides separating it from the non-periodic variations, to split it up into its simple components. Accord to equation (1) these components have wave numbers which may be arranged as follows (omitting the constant $1/2\pi$):—

$$\ldots\ldots(k-3q),\ (k-2q),\ (k-q),\ k,\ (k+q),\ (k+2q),\ (k+3q)\ldots\ldots$$

and amplitudes:—

$$\ldots\ldots\tfrac{1}{2}a_3,\ \tfrac{1}{2}a_2,\ \tfrac{1}{2}a_1,\ a_0,\ \tfrac{1}{2}a_1,\ \tfrac{1}{2}a_2,\ \tfrac{1}{2}a_3\ldots\ldots$$

The difference between consecutive wave numbers is constant and, when plotted against a series of whole numbers, the wave numbers therefore lie upon a straight line, whose slope is the wave number of the amplitude period. They are, however, only harmonics of a fundamental period when k is a multiple of q. When this condition is satisfied a wave whose amplitude varies periodically would give the kind of results which have been obtained, but the simple components would be present throughout the whole of the curve and the drafting wave cannot therefore be exactly of this type.

The disappearance and reappearance of many of the component periodicities in the different sections of the curve as shown in Table II may, however, easily be accounted for by assuming that the variations in amplitude are not actually periodic. For, over a finite length of the curve, a non-periodic variation is indistinguishable from a perodic one whose period is of the same order as the length of the curve and is therefore resolved by the periodogram analysis into a series of simple harmonic components. Another section of the curve also behaves as though the variations in amplitude were periodic but the form of the variation is different and therefore the particular components present are not necessarily the same as those in the first section. In addition, since a longer curve includes a greater range of variation in amplitude, the length of the apparent fundamental period depends upon the length of the curve examined.

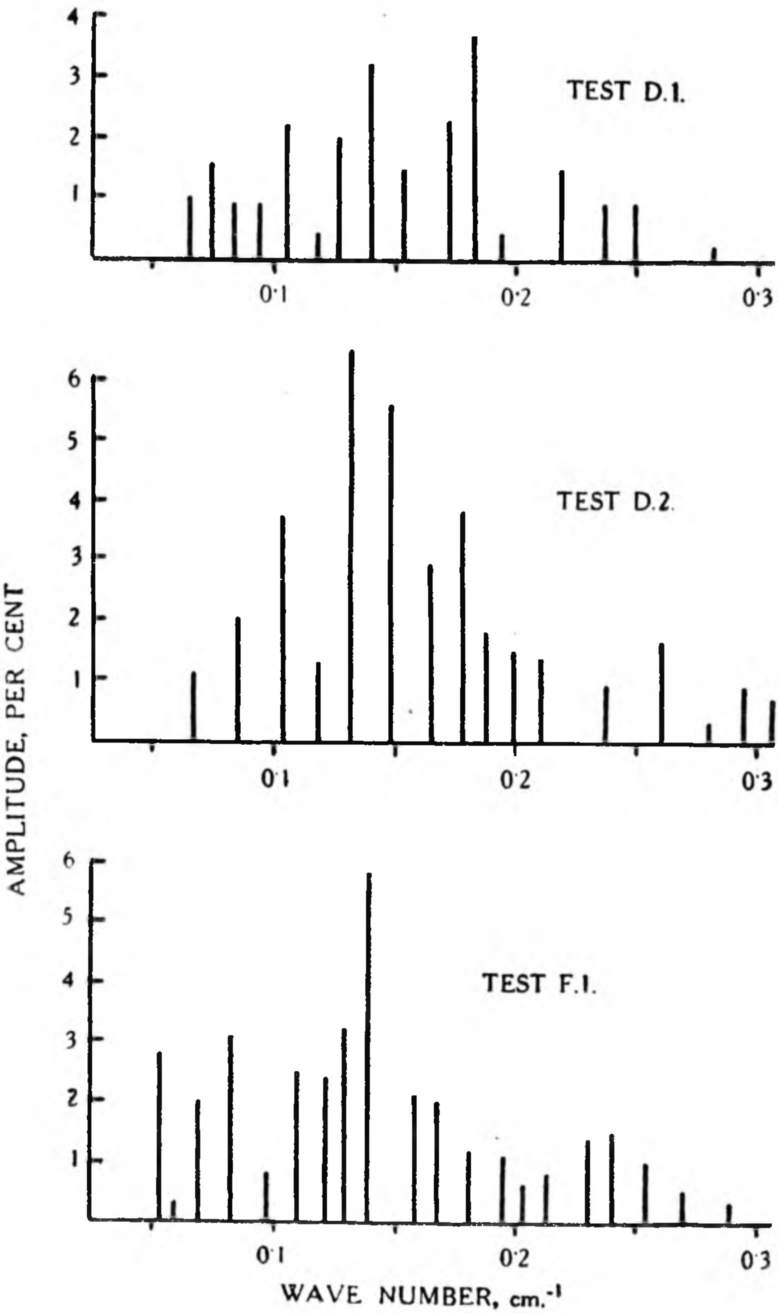


Fig. 4.

We have still to consider the amplitudes of the components. From the list of amplitudes above it is seen that these are symmetrical about the middle of the range and also that they are greatest in the middle and small at the ends. In order to compare this prediction with the actual amplitudes, 100 cm. lengths of sliver for tests D.1. and D.2. and a 150 cm. length for test F.1. were analysed on the periodograph and the amplitudes of all the observed periodicities (except a few short ones of very low amplitude) were then calculated in the usual way[3] from measurements made on the curves. The amplitudes, expressed as percentages of the mean thickness of the sliver, are plotted in Fig. 4, in which they are represented by the heights of the vertical lines erected above the corresponding wave numbers. The amplitudes are greatest in the middle of the range but they are not symmetrical. The meaning of this departure from symmetry may be seen by reversing the calculation given above. Taking equation (1) as representing the sum of the observed components, the first step is to combine corresponding terms of the two expressions in square brackets. When the amplitudes are symmetrical, the amplitudes of the terms to be combined are equal and their resultant is a periodicity of wave number $k/2\pi$ whose amplitude undergoes a simple periodic variation. When, however, the amplitudes of the terms to be combined are unequal, it can be shown[4] that their resultant fluctuates slightly in length as well as in amplitude. We therefore conclude that the asymmetry of the amplitudes in Fig. 4 is the result of variations in the length of the drafting wave as well as in its amplitude.

The amplitudes of the periodicities in the remaining tests in Table I have not been calculated, but inspection on the periodograph was sufficient to show that these amplitudes were greatest in the middle of the range.

The differences between the periodograph analyses of different portions of sliver and the dependence of the length of the apparent fundamental period upon the length of sliver examined compel us to assume that the variations in length and amplitude of the drafting wave are not strictly periodic. They do not, however, seem to be entirely random; for the results for different sections of the sliver do resemble one another to some considerable extent and this can only be so if the amplitude and length variations in the different sections are somewhat similar. Also, the fact that periodicities form a harmonic series appears to show that there is some connection between the length of the drafting wave and its fluctuations. It should be noted that the best straight lines, as judged by eye, through the points obtained by plotting the wave numbers against the series of whole numbers, did not pass exactly through the origin. In all except one test, however, for which the intercept was 0·4 unit, their intercepts on the whole number axis were less than a fifth of a unit. These are questions which would require a much more extensive investigation for their answer and which at present are of minor importance; there is little doubt that the drafting wave is a simple wave which varies considerably in amplitude and also somewhat in length. This conclusion is confirmed by the work described in the rest of the paper.

V. THE MEASUREMENT OF THE DRAFTING WAVE

It is now evident that the periodogram method is not suitable for the measurement of the drafting wave because it is intended for the separation of strictly periodic variations from purely random ones, whereas the drafting wave falls between these two categories; it is a variation which, on account of its fluctuating amplitude and length can only be regarded as approximately periodic, but is nevertheless not random. The periodogram has served the purpose of revealing the true nature of the drafting wave by separating it, at least partially, from the purely random variations in the sliver but it cannot be used to measure the wave exactly. A method is needed which does not depend upon the wave being constant in amplitude and length.

In Fig. 1 it is possible to pick out most of the wave crests and measure their distances from the beginning of the curve. From these distances the mean length of the wave is easily calculated and the mean amplitude can be obtained, now that we know the variations to be real, by measuring the heights of the curve at the maxima and minima and subtracting the mean minimum from the mean maximum. The mean amplitude is half this difference. It will be noticed, however, that there are several regions in the curve where the maxima and minima cannot be determined with any certainty, and in addition, in measuring the heights of the curve there is a tendency to take the highest point between two minima as the crest of the wave and *vice versa;* this, on account of the random variations which may also be present in the sliver, over-estimates the mean amplitude.

The method which has been employed is therefore a refinement of this simple method, which to a great extent, though not completely, overcomes these difficulties. It consists in smoothing the curve one period at a time and finding the positions of the maxima from the smoothed curve. The smoothing is done by fitting a cosine curve to the sliver curve by the method of least squares. This process may be carried out automatically on the grating periodograph by screening the whole of the grating except the central line. The grating is set to correspond approximately with the length of the wave and the centres of the bright fringes are brought in turn on to a vertical line on the (vertical) ground glass screen by moving the curve. A scale on the curve holder gives the distances of the wave crests from the beginning of the curve. These are then numbered in order and their distances plotted against the numbers. The graph obtained from test F.1., for which Fig. 1 is a portion of the curve, is typical and is shown in Fig. 5. The circles represent the positions of the maxima as measured. If the length of the wave were constant and all the maxima were observed, the points would lie on one straight line whereas actually they fall fairly closely on a series of nearly parallel straight lines. Referring to the lowest curve which represents the amplitude, it is seen that the gaps between these lines always occur near to regions of low amplitude and it seems, therefore, reasonable to

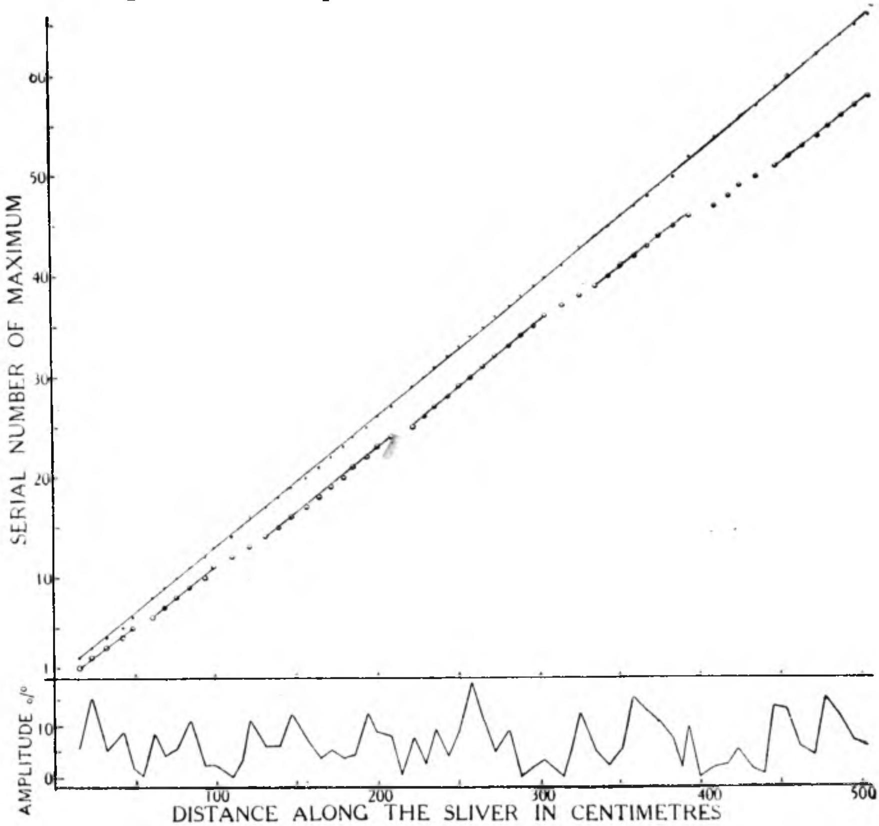


Fig. 5. Test F1.

assume that in these regions one or perhaps more maxima have escaped detection so that the numbering is incorrect. Making this assumption, we can deduce the mean length of the wave from the average slope of the short straight lines and draw one straight line of this slope. By inserting extra maxima in the gaps the points are brought very nearly on to this line as shown by the dots in the figure. These new points do not, however, lie exactly on the line and the deviations are greater than the experimental error, thus showing that there are slight variations in the length of the wave. If the wave length obtained from the slope of the line should be considerably different from that corresponding to the original setting of the grating on the periodograph the grating is reset to the new length and the work repeated.

Having determined the positions of the maxima, including the unobserved ones, they are marked out on the curve and, since the wave length does not change very rapidly the minima are assumed to be half way between them. The mean amplitude is then calculated in the manner described above. In order to obtain the variations in amplitude the mean height of two adjacent minima is subtracted from the height of the maximum between them. This method has been shown to give results which agree fairly closely with those obtained by fitting cosine curves arithmetically one period at a time by the method of least squares, but it rather underestimates the variations because the amplitude changes somewhat even during one period. The lower irregular curve in Fig. 5 was obtained in this way. The amplitude varies rapidly and considerably.

The above method of measuring the drafting wave is very much superior to the simple method described in an earlier paragraph; it enables curves to be analysed upon which the simple method breaks down and has so far given consistent results. In spite of this, the fluctuations in amplitude and length of the wave put rather severe limitations upon the work. It is only when the amplitude is high compared with the other irregularities in the sliver that the wave can be completely measured. In slivers where the amplitude is low, the length of the wave can sometimes be found from short portions where it is more pronounced, but the mean amplitude cannot be determined. In addition, there are occasionally fairly large sudden changes of phase, which, combined with the uncertainty that all the maxima have been observed, sometimes make the estimation of the length of the wave rather difficult. However, in most of the following tests these difficulties were not serious and the results are accurate enough to enable definite conclusions as to the cause of the wave to be drawn.

VI. THE CAUSE OF THE DRAFTING WAVE

The variations in length and amplitude of the drafting wave show definitely that it is not caused by any defect in the positively driven parts of the draw frame (assuming of course that these are not so badly worn that the drive is no longer positive) and strongly suggest that it is due to a periodic slipping of the floating fibres or of some part of the frame such as the top rollers.

The following tests were devised so as to give more definite evidence. The procedure was the same as in the earlier tests; the back two lines of top rollers of the draw frame were removed and a single sliver was given a calculated draft of 5·03 between the front two lines. The other details and results of the tests are given in Table III.

In tests F.1, 2 and 3, a Sakel card sliver, a first head sliver and a third head sliver, respectively, were drafted under the same conditions. Inspection of the regularity photographs, Figs. 1, 2 and 3, is sufficient to show that there is a progressive decrease in amplitude through the three tests, in fact, although the wave can be clearly seen in parts of the curves for the last two tests, the amplitude is so low that the curves cannot be analysed. This decrease in amplitude as the fibres in the entering sliver become more parallel and less entangled further supports the conclusion that the wave is due to slipping; for the slivers in which the fibres are more parallel require less force to draft them. Incidentally these tests show the importance of the parallelisation and disentanglement of the fibres in the draw frames and in the comber in securing good drafting.

Table III

Test No.	Entering sliver	Roller setting	Mean length of wave	Mean amplitude	Maximum fibre length
		cm.	cm.		cm.
F.1	Sakel card	3·96	7·6	6·4	3·8
F.4	Sakel card	,,	7·6	7·6	...
F.5	Sakel 1st draw frame ...	,,	6·3	...	...
F.6	Sakel 3rd draw frame ...	,,	6·7	...	...
F.7	Sakel card	5·08	10·2	12·9	...
F.8	Sakel 1st draw frame ...	,,	8·6	9·2	...
F.9	Sakel 3rd draw frame ...	,,	7·6	3·9	...
C.1	Sakel card	3·81	7·5	7·0	3·8
C.2	American card	,,	7·0	14·5	2·9
C.3	American card	2·86	5·6	8·9	...
C.4	Indian card	,,	5·6	...	2·2
F.10	Sakel card	3·81	7·4	6·8	...
F.11	American card	,,	7·0	16·8	...

Calculated draft = 5·03 in all tests.

Tests F.4, 5 and 6 were a repetition of the first three tests. The wave lengths for F.4 and F.1 agree very well and the difference between the amplitudes is within the limits of error, which, on account of the large variations in amplitude, are moderately wide even when as in all these tests about 50 complete waves are measured. It was this time possible to measure approximately the wave lengths in tests F.5 and 6. The parallelisation has reduced the wave length as well as the amplitude.

The next step was to distinguish between slippage of parts of the draw frame and slippage of the floating fibres as possible causes of the wave. This was done by increasing the roller setting. If the wave is due to floating fibres this should increase the amplitude, whereas if it is due to the slipping of parts of the frame, increasing the setting should, if it has any effect at all, decrease the amplitude, since with a wide setting the sliver should draft more easily.

Tests F.7, 8 and 9 were accordingly a repetition of the previous tests with a wider setting. The amplitude for the card sliver has considerably increased and it was possible to measure that for the first and third head slivers. These again show a reduction in amplitude as the fibres become more parallel. As might perhaps be expected, the wider setting produces a longer wave. The effect of the setting on American cotton is shown in tests C.2 and C.3.

These tests also provided further conclusive evidence for the floating fibre theory. The amplitude was so great that the periodic variations in thickness could be seen in the sliver. Photographs of short lengths of the drafted slivers from tests F.7, 8 and 9 are given in Fig. 6 while Fig. 7 shows the result of a similar experiment on Indian cotton. In the slivers produced directly from card sliver the phase of the wave is clearly not the same all the way across the sliver, showing that the different longitudinal sections of the sliver draft more or less independently. This can only be satisfactorily explained on the floating fibre theory, according to which the only constraints tending to keep the different sections of the sliver in phase are the friction betwen the fibres and fibres which cross from one section to the next. We should therefore expect the comparative independence of the different sections to be greater than when the fibres are straight and parallel. This can be fairly clearly observed especially with the Indian cotton. In the sliver drafted from card sliver, the thick and thin places form a fairly definite pattern showing that there is a certain amount of correlation between the different sections. This pattern changes at intervals indicating changes of phase in one or more of the sections and hence that the variations in length of the drafting wave are not entirely due to stretching of the sliver after it leaves the rollers. In the slivers drafted from the first and third draw frame slivers there is no definite pattern; the sliver has a mottled appearance but the wave can be picked out here and there.

The illustrations only represent very short lengths of sliver, which have been selected as being as nearly as possible typical; but these effects have been repeatedly observed over long lengths and on different varieties of cotton. It is only when the roller setting is wide that the drafting wave is sufficiently pronounced to enable them to be seen, but since the wave is always of essentially the same character there is no doubt that they are also present when normal roller settings are employed.

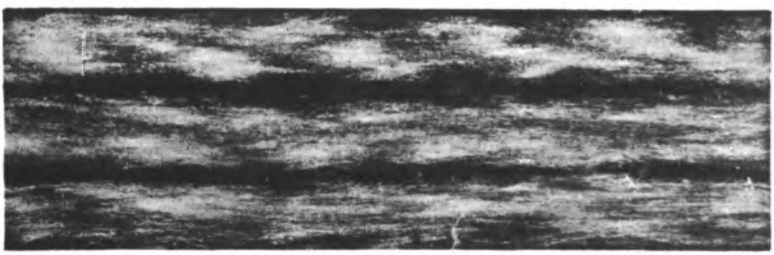

F7
F8
F9

FIG 6

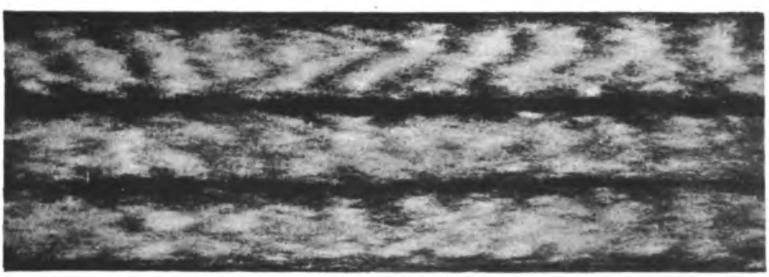


FIG 7

It follows that the effective amplitude of the wave as measured on the regularity tester or by the variations in weight of the sliver is an average of those of the more or less independent waves in the different sections of the sliver and is therefore least when individual waves are most independent. This is another reason, besides the less entangled condition of the fibres, why the parallelisation of the fibres produces more uniform drafting. It leads also to the conclusion that the effective amplitude of the wave will be considerably greater in finer products and will decrease as the number of fibres in the cross-section of a product of given weight increases, that is as the fibres become finer. This is probably one reason why the fibre weight per centimetre is such an important property in determining the spinning quality of a cotton. These conclusions have also been arrived at by Balls[1] from purely theoretical considerations.

The amplitude is then large in those portions of the sliver where the individual waves happen to agree in phase and small where they are out of phase. The variations in amplitude of the resultant wave are thus partly the result of the phase changes, that is of the variations in length, and we have only to account for these latter variations to make our explanation complete. Returning to the simple theory of section II, it is seen that the formation of a regular succession of thick and thin places is the combined result of the motion of the floating fibres and the dependence of this motion upon the thick and thin places themselves. If the entering sliver were uniform this would no doubt be a perfectly regular process, but variations in this sliver cause an abnormal rise or fall in the number of fibres gripped by the front rollers, produce corresponding changes in the number of floating fibres being dragged forward, and so disturb the regularity of the wave. Changes in the average properties of the fibres due to imperfect admixture of the cotton and entanglements such as neps would also cause fluctuations in the length and amplitude of the wave.

The above observations show conclusively that the drafting wave is the result of the dragging forward of the floating fibres by those gripped by the fast rollers. It is therefore characteristic of the drafting of cotton by means of the ordinary roller system and its amplitude and length should depend only upon the draft, roller setting, the properties of the cotton and the condition in which the cotton is presented to the rollers, and should be independent of the frame upon which the drafting is performed. Tests C.1 to C.4 (Table III) were all made on the same frame. Allowing for the fact that the setting employed is a wide one for the short staple Indian cotton (it was the closest which could be obtained) and remembering that this increases the wave length it will be seen that the wave lengths are in the same order as the staple lengths. The amplitudes cannot be regarded as depending upon the cotton because they are so sensitive to the roller setting in relation to the staple length. That for the Indian cotton could not be calculated as the drafted sliver was so weak that it broke down at frequent intervals while passing through the regularity tester. Tests F.10 and F.11 were repetitions of C.1 and C.2 upon another frame, with larger rollers and different gearing. The lengths and amplitudes are not significantly different.

REFERENCES

[1] Balls, W. L. "Studies of Quality in Cotton" (London, 1928), Ch. VIII.

[2] Anderson, Cavaney, Foster and Gregory. *Shirley Inst. Mem.*, 1945, **19**, No. 11, and *J. Text. Inst.*, 1945, **26**, T191-T196.

[3] Foster. *Shirley Inst. Mem.*, 1929, **8**, 115-126, or *J. Text. Inst.*, 1930, **21**, T18-28.

[4] Poynting and Thompson. "Sound," 6th Edn. (London, 1913), p. 150.

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THE JOURNAL OF THE

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ABSTRACTS

1—FIBRES AND THEIR PRODUCTION

(C)—Vegetable

Cotton Plant: Nutrient Uptake. J. J. Skinner, J. G. Futral and N. McKaig, Jr. *Georgia Sta. Bul.* 235, 1944, 21 pp. (through *Exp. Sta. Rec.*, 1945, **92**, 649). Profitable increases in yields of seed cotton have been produced by neutralising the fertilizer with dolomitic limestone on most of the principal soil types of the south-eastern Cotton Belt, including some soils in Georgia. Neutralising the fertilizer does not materially affect the crop's requirement for K, for cotton made essentially the same yield increase regardless of the K content of the fertilizer. Fertilizers neutralised with dolomitic limestone, in general, did not materially change the composition of cotton plants as compared with plants grown with acid-forming fertilizers, except in Mg content. In addition to the N, P and K taken up by cotton plants, large amounts of Ca and appreciable amounts of Mg were absorbed. The larger plants with increased yields produced by fertilizers that do not develop acidity contained larger amounts of nutrients per plant. Cotton fertilized with such fertilizer made larger and earlier growth and absorbed more nutrients per plant early in the season than plants receiving an acid-forming fertilizer. Increasing amounts of applied K (0, 3, 6, and 9 per cent. K_2O) increased the K percentage in the plant and reduced the Mg percentage at all growth stages. There were consistent but small decreases in the percentages of N, Ca, and P in the plant as K applications increased, although the total amount of all nutrients per plant rose with the amount of K applied. The effect on plant composition of K was greater than that of dolomitic limestone in fertilizers with exception of the greater Mg content from dolomitic limestone. C.

Upland Cotton: Inheritance of Lint Strength. J. O. Ware and D. C. Harrell. *J. Amer. Soc. Agron.*, 1944, **36**, 976-987 (through *Exp. Sta. Rec.*, 1945, **92**, 649). Parental lines were grown along with F_1, F_2 and F_3, first-generation back-crosses, and second-generation back-crosses from a cross of Florida Green Seed and Rowden cotton for comparisons and for use in further crossing and back-crossing. The F_1 was repeated in the second and third years. The first back-cross was made with F_1 in 1939 to both parental lines. In 1940, plants in the respective first-generation back-crosses were back-crossed again to corresponding recurrent parental plants. Florida Green Seed stock had the higher Pressley strength index by about 1 unit. Inheritance of strength appeared to be intermediate with slight tendency to weak dominance; in repeated back-crossing the level of strength is easily shifted in either direction. Strength in F_3 progenies from plants selected out of the several F_2 class intervals did not exhibit as much uniformity as shown by either parent, but these F_3 plants tended to maintain the F_2 level of origin. In 1939 and 1941 the respective parental lines were at about the same level, but higher in 1940. In several hybrid groups the 1941 level was lower than the 1940 level. Environment was a factor and doubtless contributed to expression of variability and in changing season mean levels, yet the yearly combination or set-up permitted reliable genetic measures. C.

(D)—Artificial

Holocellulose: Preparation. B. B. Thomas. *Paper Ind. and Paper World*, 1945, **26**, 1281-1284 (through *Chem. Abstr.*, 1945, **39**, 1982[8]). Details are given of an improved method for the large-scale laboratory preparation of holocellulose, which consists essentially in carrying out the initial chlorinations of the wood meal in suspension in cold (about 5°) carbon tetrachloride, eliminating the use of water as far as possible, and then completing delignification by the method of Van Beckum and Ritter. A quantity of polysaccharide amounting to 1·5 per cent. of the weight of the original wood was recovered from the water washings (by concentration under reduced pressure and precipitation into alcohol). The holocellulose as obtained showed only 0·4 per cent. lignin, but the nitrogen content (about three times that of wood) indicated that some monoethanolamine or ammonium salts were retained. It was assumed that there was also some undetected lignin retained in combination with the holocellulose. In terms of the total wood substance, 97·8 per cent. was accounted for as follows: lignin 18·9, water-soluble (recovered during the holocellulose isolation) 1·4, holocellulose ("lignin-free") 77·5. Three sources of probable error are not considered in this summation: not all the "water-soluble" material initially removed was recovered; some of the wood meal was lost mechanically in handling, and some degraded lignin (not detected by analysis) was probably present in the holocellulose. C.

Casein Fibres: Production and Strength. R. F. Peterson, T. P. Caldwell, N. J. Hipp, R. Hellbach and R. W. Jackson. *Ind. Eng. Chem.*, 1945, **37**, 492-496. A report is given of a study of the production of fibres from acid-precipitated casein with a laboratory spinning machine. A spinning solution containing 20 per cent. protein and having a *p*H of 9·2 was employed in most of the experiments, and the fibres were given a final hardening treatment with formaldehyde. Stretching the tow issuing from the spinneret, either in the precipitating bath or between godet wheels in air, gave a tensile strength of about 0·7 g. per denier. Under these conditions of stretching, the addition of aluminium sulphate to the precipitating bath containing sulphuric acid and sodium sulphate did not affect the strength of the fibre. The presence of aluminium sulphate in the precipitating bath was, however, advantageous when stretching was carried out simultaneously with partial hardening with formaldehyde and further improvement was effected by adding aluminium sulphate to the formaldehyde bath also. With the latter at a temperature of 85° C., it was possible to obtain fibres having a dry strength of 1 g. per denier and a wet strength of 0·5 g. per denier. Comparative measurements of tensile strength of artificial protein fibres which will be exposed to moisture are best made after the fibres have been swollen in water and dried. C.

Orientated Sodium Pectate Fibres: Production. G. Stork. *J. Amer. Chem. Soc.*, 1945, **67**, 883-884. A 1 per cent. solution of pectic acid was titrated to *p*H 5·0 with sodium hydroxide. The resulting solution was then forced through a 1-mm. nozzle into a coagulating bath consisting of 85 per cent. ethyl alcohol in 1N. hydrochloric acid. The resulting wet fibre was strong enough to be handled readily. The hydrated fibre was held in a 60 per cent. alcoholic, 0·1 N. sodium hydroxide solution overnight and then immersed for 24 hours in 60 per cent. ethyl alcohol. The fibre was then removed and slowly elongated 38 per cent. while drying. The dry fibre was strong and pliable, showed good molecular orientation, and was remarkably crystalline. The identity period in the fibre direction was approximately 13·1 A. The symmetry of the galacturonide chain in pectin evidently approximates to that of a threefold screw axis, but with the angle between the plane of the pyranose rings and the fibre axis somewhat larger than occurs in cellulose and its derivatives. C.

Patents

Albuminous Filaments: Dry-spinning. R. Signer (Berne, Switzerland). B.P.569,662 of 17/3/1943:4/6/1945 (Conv. 16/1/1942). A method of producing artificial threads from albuminous substances by extruding an aqueous solution of an albuminous substance through a nozzle into a spinning shaft, is characterised in that the thread on emerging from the spinning nozzle is kept at a temperature of approximately the mean value of the spinning interval (range within which spinning is practicable) in an atmosphere saturated with water vapour in the upper part of the spinning shaft, whilst in the middle part of the spinning shaft it meets a current of air having a temperature in the vicinity of the aforesaid temperature and towards the outlet end of the spinning shaft is subjected to a current of cold or warm dry air. C.

Thread Stretching Apparatus. British Celanese Ltd. B.P.569,669 of 27/7/1943:4/6/1945 (Conv. 29/7/1942). An apparatus for drawing and forwarding thread at a speed depending on the tension in the thread comprises a conical roller, guides for directing the thread round the roller and for determining the part of the length of the roller round which the thread passes, and means for urging the guides against the tension of the thread towards the larger end of the roller so as to cause the thread to be drawn and forwarded at a speed varying inversely with the tension in the thread. This apparatus is particularly well adapted to be used as part of an apparatus for stretching thread in a softening medium, the stretching apparatus comprising, in addition to the apparatus according to the invention, thread feeding means, a stretching chamber for containing the softening medium and means for taking up the thread after it has been stretched, the apparatus according to the invention being disposed after the stretching chamber so as to withdraw the thread from the chamber and forward it to the collecting means and being driven in timed relationship with the feeding means. The invention is applicable to the stretching of thermoplastic threads, particularly threads of cellulose derivatives or linear polyamides. C.

2—CONVERSION OF FIBRES INTO FINISHED YARNS

(A)—Preparatory Processes

Cotton: Selection for Carding and Spinning. H. E. Helliwell. *Textile World,* 1945, **95**, No. 4, 118-9, 192-8. Advice is given on the selection of cotton, with reference to staple, proportion of short fibre and grade. The importance of good carding is stressed and it is suggested that the carder should collaborate with the buyer in the selection of cotton. A table is given of suitable staples for spinning warp and weft, carded and combed qualities, in various ranges of count up to 100s. Another table reproduces the Sheldon figures for lea strengths of carded warp yarns spun in counts 10-30 from cottons of ⅞ to 1⅜ in. staple. C.

Rayon Staple: Processing on the Cotton System. Victor Ring Traveler Co. *Rayon Textile Monthly,* 1945, **26**, 182-183. Practical advice is given on the tinting, scutching, carding and drafting of 3-den., 1½-in. rayon staple, with recommended machine settings and speeds. C.

Noble Comb: Correct Dabbing. D. Anthony. *Canadian Text. J.,* 1945, **62**, No. 9, 45, 55. The functions of the dabbing brush are discussed in relation to the production of first quality tops. Late dabbing decreases the yield of top and increases the noil. The main causes of late dabbing are excessive circle speed in relation to the reciprocations of the brush, and the use of brushes in which the bristles are badly worn at the point of contact of the circles. The former can be avoided by calculating the relevant speeds, formulæ for which are given, and the latter by the replacement of badly-worn brushes. W.

Dabbing on the Noble Comb. "H.D." *Text. Rec.,* 1945, **62**, No. 747, 43-44. The causes of poor dabbing results are discussed, especially the theoretical and practical aspects of the relative speeds of the circles and of the dabbing brush. Mention is made of the ways by which the useful life of dabbing brushes may be extended, and the alternatives to dabbing brushes which have been suggested are listed. A single eccentric dabbing motion is shown in detail. The depth to which the material must be dabbed into the pins has to be varied to suit a number of factors. For various reasons, which are discussed, the fibres should lie ⅛-¼ in. below the tips of the pins. W.

(B)—Spinning and Doubling

Cotton Spinning Mill: Management. H. L. Pratt. *Textile World,* 1945, **95**, No. 4, 113-5, 192-4. Practical advice is given on the following topics: (1) selection of cotton, (2) travellers, (3) roller covering, (4) draft and twist, (5) atmospheric conditions, and (6) laboratory tests and control, and observations of "ends down." C.

Patents

Chenille Yarn Producing Machine. K. Bauer. B.P.569,288 of 18/11/1943: 16/5/1945. In a machine for the production of chenille yarn of the type in which core threads are wound off a number of bobbins or cheeses and the chenille yarns wound on to bobbins by flyers which impart the necessary twist thereto, the pile yarn being cut by a grooved roller co-operating with a plain roller, the flyers are secured to the bobbin spindles by means that will permit of their ready removal instead of by screw tops, thereby increasing the speed at which the flyers can be removed and replaced, allowing the spindles and flyers to be rotated in either direction according to the direction in which it is desired that twist should be inserted into the yarn and permitting the flyers to be accurately located on the spindles so that the circle in which a flyer rotates can intersect the circles in which the adjacent flyers rotate, and the bobbin spindles are arranged in a series of stepped tiers one behind the other. C.

Spinning and Doubling Rings: Securing to Ring Rails. A.-G. J. J. Rieter & Cie (Winterthur, Switzerland). B.P.569,425 of 16/7/1943:23/5/1945 (Conv. 1/9/1942). An arrangement for securing the traveller rings in ring spinning and doubling frames, which bear with a flange on the ring rail, is characterised in that each ring is formed below the flange with a downwardly widening conical outer circumference which is pressed on one side against the bore of the ring rail, the bore being preferably likewise conically reamed on the lower face. The ring rail is preferably provided with conical bores for the reception of conical nuts which bear against the flanges of the rings. Each ring flange is preferably recessed in conformity with the shape of the nut. C.

Spinning Frame Traverse Motion. W. Gibson. B.P.569,490 of 18/6/1943: 25/5/1945. A traverse motion for a textile machine, e.g. a spinning frame, comprises a rotatable driven cam member having an internal space presenting a continuous inwardly facing surface of which one half constitutes a working cam or eccentric surface and the other half a similarly-shaped complementary cam surface and comprises spaced followers attached to a reciprocal rove or yarn traverse guide member and diametrically located in the space so as to be successively engaged by the working cam surface to impart a to and fro, preferably uniform motion, with a quick reversal to the traverse guide member, the follower which is not in contact with the working surface being in contact with or very close to the complementary surface to prevent backlash of the traverse guide. C.

Doffing Comb Driving Mechanism. Aktiebolaget Svenska Kullager-fabriken (Goteborg, Sweden). B.P.569,572 of 18/10/1943:30/5/1945 (Conv. 21/10/1942). An improvement in driving mechanism for doffing combs of carding engines, in which two shafts are mounted in anti-friction bearings and in which a rotating movement is imparted to one of the shafts and through a crank and connecting rod operates an arm on the second shaft to impart an oscillating movement to the second shaft, is characterised in that all bearings of both shafts are located on one and the same side of the arm of the oscillating shaft. C.

Drawing Roller Clearing Arrangements. S. Ackroyd and H. I. Haigh. B.P.569,602 of 1/7/1943:31/5/1945. In clearing arrangements for the rollers of textile drawing apparatus, a cylindrical or semi-cylindrical brush or brushes is or are rotatably mounted in proximity to the bottom roller or rollers, the brush or brushes being positively driven by chain, belt or other suitable means from any suitable going-part of the apparatus, means such as a comb or the like being provided for removing waste fibres from the brush or brushes. The brush or brushes or the means for supporting the same may be adjustable relative to the bottom roller or rollers and the brush may not contact with the rollers but may be constructed so as to create a draught sufficient to raise waste fibres on the roller into engagement with the bristles, wire clothing or the like of the brush or brushes. The latter may be constructed or driven in such a manner as to remove waste fibres intermittently from the bottom roller, and means such as a comb or the like is associated with the brushes for removing waste fibres therefrom. If desired, the comb or combs may be adjustable relative to the brush or brushes and may be pivotally or otherwise mounted for ease of manipulation. C.

Card Grinding Roller Differential Motion. S. W. Dronsfield and Dronsfield Brothers Ltd. B.P.569,679 of 5/11/1943:4/6/1945. A differential motion for traversing textile card grinding rollers, in which a pair of coaxial shafts, one driving the grinding roller whilst the other operates its traverse, are interconnected by gearing, including a gear wheel eccentrically mounted on a fixed end plate, is characterised by the feature that the end plate is connected to a casing which with the end plate wholly encloses the gearing and which may enclose the shaft ends and itself be provided with a handle coaxial with the shafts. C.

Chenille Yarn Producing Machine. K. Bauer. B.P.569,682 of 18/11/1943: 4/6/1945. In a machine for the production of chenille yarn of the type in which core threads are wound off two sets of bobbins or cheeses and the pile yarn is supplied from a single front spindle by means of conveyor threads which carry it to cutting rollers, the front spindle is driven from a driving shaft through a pair of cone pulleys and a belt movable thereon, whereby the speed of the spindle can be varied to alter the pile, and the delivery and cutting rollers are driven from the same shaft. The grooved cutting roller is preferably driven at a slightly greater or less surface speed than the plain roller co-acting therewith to produce a rubbing or shearing action for cutting the pile threads. C.

3—CONVERSION OF YARNS INTO FABRICS

(A)—Preparatory Processes

Monofilament Yarns: Preparation for Weaving. Albert Frantz. *Textile World,* 1945, **95**, No. 4, 123-7, 198, 200. Practical hints are given on the preparation of monofilament warps for weaving with particular reference to a nylon netting of leno construction. Cone creels are not satisfactory because of the tendency of the yarn to whip into a wide balloon. For finer monofilaments the writer recommends using a double bobbin creel having, say, a front bank to take 480 1-lb. bobbins and a taller, longer back bank for 520 bobbins, leading to a horizontal warper that is reinforced with angle iron to prevent crushing. For coarser monofilaments a suitable plan is to proceed as for sizing though without applying any size. The yarn is fed from a V-creel through a reed over a size roller and round the large cylinder, which is warmed to maintain the yarn soft and pliable. C.

Weft Pirns: Stripping and Cleaning. H. E. Wenrich. *Rayon Textile Monthly,* 1945, **26**, 177-179. Practical advice is given on the maintenance of the weft supply to a weaving shed, with special reference to selecting, stripping and cleaning the pirns. C.

(C)—Weaving

Braced Loom Frame: Advantages in Increasing Loom Speed. Mountain City Foundry and Machine Co. *Textile World,* 1945, **95**, No. 4, 151-2. Illustrations are given of improvements to the Draper Model E loom whereby the speed may be safely increased by 7½ to 18 per cent. The frame is braced by a cast-iron beam or "spreader" and a fly-wheel drive is fitted. Particulars are given of several American mills where the improvements have proved their value. C.

Carpet Mill: Management. A. J. Green. *Textile World,* 1945, **95**, No. 4, 101-103. An account is given of the organisation at the Thompsonville plant of the Bigelow-Sanford Carpet Co. for dealing with problems and suggestions for better planning of the mill and technical developments. A chart shows the relationship of a permanent Research Board to various *ad hoc* committees. Other illustrations include a page of the minute book of the Board and a table of costs that were worked out as evidence for the Board, and relate to various plans for handling the incoming raw materials. C.

Multiple V-belt Loom Drives: Advantages. W. L. Fluke. *Rayon Textile Monthly,* 1945, **26**, 188. Mention is made of mill tests in which 12 Draper tyre cord looms and 16 Crompton and Knowles heavy duck looms have been driven by multiple V-belts for several years. The advantages claimed are (1) lower maintenance costs, (2) longer life, about 2 years instead of 6 months for gear drives, (3) smoother running, (4) less noise, (5) easier and cheaper replacement, (6) better shock absorption, and (7) better conservation of loom parts through the absorption of peak loads. The power absorbed is about the same as for gear drives. With a variable pitch pulley, the loom speed may be changed quickly and easily. C.

(D)—Knitting

Circular Knitting Machine: History and Development. W. B. Dall. *Textile World,* 1945, **95**, No. 4, 104-8, 202. Evidence is given that the first American invention of a circular knitting machine is that of Erasmus French in 1845. To celebrate the centenary short articles on recent and prospective developments in knitting are supplied by (1) J. W. Hughes, on seamless hose, (2) M. C. Miller on problems in knitting fully-fashioned hose and underwear, (3) E.

Grossman on the prospects for circular-knit outerwear, (4) R. Kretser on combinations of warp and "weft" knitting, and (5) T. H. Johnson on tricot warp knitting. C.

(G)—Fabrics

Granite and Crêpe Weaves: Designing. George Wakefield. *Textile World,* 1945, **95**, No. 4, 116-117. A number of diagrams are given to show that a large variety of granite weaves can be derived from basket weaves by a simple transposition of warp and weft risers, and that crêpe weaves of large repeats are easily obtained by superimposing plain weaves on a base design. C.

Leno Shirting Fabrics: Production. Thomas Nelson. *Textile World,* 1945, **95**, No. 4, 137-139. The U.S. Quartermaster Depôt invited tenders for 50 million yards of a cotton marquisette in 1942. The writer offers suggestions with weaving plans, for the quick change from such leno fabrics for military purposes to fancy summer shirtings. C.

Patents

Machine Knitting Needles: Production. H. W. Donisthorpe and F. N. F. Limited. B.P.569,269 of 8/11/1943:15/5/1945. A machine knitting needle is manufactured by a method in which one end of a tube is flattened, a substantial longitudinal portion of the flattened end is removed, and the resultant edge portion is bent to form a hook. Advantageously, the end of the tube, before being flattened, may be offset to lie parallel to and to one side of the body of the tube. A grinding operation may be employed to open one side of the tube at the point where the associated tongue is to pass out of the needle shank to the point at which it is to overlap the hook. A machine for performing these operations is described. The initial tube may be of circular, elliptical or similar cross-section. The needles are particularly suitable for warp knitting machines, but they may also be used in circular and like machines in which the needles are individually mounted in tricks. In the latter case each needle shank is provided with a butt to be acted upon by the appropriate cam track, and the associated tongue is also provided with a butt for co-operation with another cam track. C.

Wearing Apparel Buoyant Lining. British Celanese Ltd. B.P.569,430 of 17/11/1943:23/5/1945 (Conv. 18/11/1942). Wearing apparel is provided with a buoyant lining of material flexible in at least one direction, the material having a basis of an organic derivative of cellulose and comprising at least two flexible films or foils, united so that there are a number of discrete air spaces between adjacent films and foils. The lining material may be constructed by uniting two relatively thin films or foils, of a film-forming composition having a basis of an organic derivative of cellulose, which are so shaped that when the films or foils are united, the joined films will comprise a continuous sheet containing a multiplicity of air pockets or chambers. These air pockets impart heat insulating and buoyant properties to the lining, and the buoyancy of the material remains unimpaired even after prolonged immersion in water. The union of the films can be effected by an adhesive, a solvent, or heat and pressure. C.

Circular Knitting Machine Pouch Compensating Mechanism. Wildt & Co. Ltd. and H. H. Holmes. B.P.569,668 of 26/7/1943:4/6/1945. A pouch compensating mechanism for a circular knitting machine comprises a slotted weight provided with at least one claw or equivalent arranged for engagement with the fabric on the side thereof where a pouch is formed, a member upon which the weight is supportably mounted suchwise that by reason of the slot the weight is capable of lateral movement bodily to position the claw or equivalent in readiness for engagement with the fabric, means for effecting such movement and normally maintaining the weight in an outwardly tilted position, and means for so controlling the aforesaid member as to permit the weight to fall freely at the appropriate time thereby bringing the claw or equivalent into engagement with the fabric and also moving the weight clear of the first-mentioned means so that the claw or equivalent is free to follow the path of the fabric and the weight functions under gravity to apply tension to the work. A cam or abutment is provided for effecting lateral outward movement of the weight and for maintaining the latter in its outwardly tilted inoperative position. C.

4—CHEMICAL AND FINISHING PROCESSES

(B)—Boiling, Scouring, Degumming and Washing

Aralac: Production, Properties and Processing. D. G. Carmichael. *Amer. Dyes. Rept.*, 1945, **34**, 171-176. A general account is given of the history, manufacture and properties of Aralac and of the desizing, scouring, dyeing and finishing of Aralac-rayon and Aralac-wool combinations. C.

(E)—Drying and Conditioning

Radiant Gas Heating Apparatus: Use for Industrial Drying. H. R. Hughes, Jr. *Southern Power and Ind.*, 1945, **63**, No. 3, 92-93, 114 (through *Chem. Abstr.*, 1945, **39**, 1787[3]). At least 40-50 per cent. of the heat input into gas burners or electric lamps is absorbed by the material dried—in the case of paints the colour is an important factor in the amount absorbed. When inflammable vapours are evolved electric lamps are best, whilst radiant gas heaters are best where large amounts of moisture are to be removed. Applications of radiant gas heating include textile drying, continuous brazing, annealing, glassware, processing specially treated paper, textile coatings, etc. C.

(G)—Bleaching

Kamyr Pulp Bleaching System. E. V. Ullmann. *Paper Trade J.*, 1945, **120**, *TAPPI*, 193-194. The Kamyr bleaching system was developed for bleaching stock to a high grade α-pulp for rayon production Chlorination, neutralisation, washing (or diffusion), and in certain cases acid treatment are carried out in three to four towers, arranged in series. Between each stage the stock is thoroughly washed on a filter usually of the pressure type. Each tower contains a circulating pump so placed as to receive all the pulp in the bottom of the tower and to bring it into a rotating movement around a guide vane dividing the bottom part in two. As new stock enters the tower near the suction part of the impeller, the stock in the tower is forced upwards and eventually overflows over the top. The pump is designed with a capacity six to eight times the incoming stock so that every fibre passes through the pump six to eight times before it eventually starts its upwards journey through the tower. The chemicals are added just prior to the entrance of the pulp into the pump and a thorough mixing is thus ensured. The number of stages and the sequence may be varied. The final stage of hypochlorite treatment may occur in batch bleachers or in an additional tower. For stock of high consistency a tower is recommended in which the stock enters at the top and slowly sinks down without any circulation. In another high-density system the towers are equipped with a screw in the bottom which presses the stock upwards and simultaneously concentrates it. Special batch bleachers can be used instead of towers where desired. C.

Sodium Hypochlorite Solutions: Effect of Vat Dyes on Stability. K. S. Bhujang, S. H. Mhatra and G. M. Nabar. *Current Science*, 1944, **13**, 281-282 (through *Brit. Abstr.*, 1945, B II, 110). Cotton dyed with Ciba Blue 2B was kept in contact with suitably buffered sodium hypochlorite solution (about 2·5 g. of available chlorine per l.). After 10 min. the material had faded somewhat. The sodium hypochlorite in the remaining liquid was determined. A blank solution was found to decompose less rapidly than that used in the bleaching. In 20 min. after removal of the material, the sodium hypochlorite buffered at *p*H 7 lost 4 per cent. of the available oxygen, the blank losing only 1 per cent. This rapid decomposition lasted for 2 hours, after which the rates of decomposition of the treated solution and the blank became the same. The increased rate of decomposition depends on *p*H and on the amount of dye present on the fibre. C.

(I)—Dyeing

Dyes and Finishes: Removal from Rags. H. W. Wilkinson, Jr. *Paper Trade J.*, 1945, **120**, 205-206. Reference is made to difficulties experienced by paper manufacturers who use textile waste as raw material. The types of dyes and finishes encountered on the textile materials are discussed and notes are given on methods of removal. C.

Nylon Yarn: Dyeing with Direct Cotton Dyes. J. H. MacGregor and C. Pugh. *J. Soc. Dyers & Col.*, 1945, **61**, 122-125. A report is given of investigations of the dyeing of nylon yarn with Chlorazol Fast Orange AGS and

Diphenyl Blue M2B in the presence of alkylamine acetates, alkyl ammonium and pyridinium bromides, and monostearyl-*as.*-diethylethylenediamine methosulphate. The results show that, when the dyeing is carried out in an acid bath, cationic paraffin-chain salts increase the rate of dyeing when present in quantities less than 1·0 per cent. of the weight of nylon, but inhibit dyeing when present to the extent of 5 per cent. or more. The effects depend on the number of carbon atoms in the hydrocarbon chain in the cation of the salt. Salts with very short chains behave like neutral inorganic salts, i.e. they decrease the rate of dye absorption. The increase begins to be appreciable when the hydrocarbon-chain cation contains about 8 carbon atoms and is fully evident in the dodecyl and hexadecyl salts. The phenomena do not depend on whether the salt is formed from a strong or a weak base. The addition of small quantities of such cationic paraffin-chain salts is of particular value when used to decrease the time required to exhaust very slow dyeing direct cotton dyes on nylon from an acid bath. C.

Naphtol AS-S and Brenthol BA: Constitution. R. J. Moualim and K. Venkataraman. *J. Sci. Ind. Res.* (*India*), 1945, **3**, 447-451. Details are given of experimental work carried out for the determination of the constitutions of Naphtol AS-S and Brenthol BA. Naphtol AS-S is identified as the 2-hydroxy-3-naphthoyl derivative of 2-amino-3-methoxydibenzofuran, and Brenthol BA as the 4-bromo-*o*-anisidide of 2-hydroxy-3-naphthoic acid. Measurements of the substantivity of Naphtol AS-S are also reported, and it is suggested that the high substantivity of this product, compared with that of other members of the Naphtol AS series, is due to the presence of the furan ring. C.

(J)—Printing

Photographic Printing on Textiles. L. C. Reynolds. *Textile World*, 1945, **95**, No. 4, 133-135. The writer discusses the possibility of applying modern methods of colour photography to printing on textiles, with the aid of resins as binding agents. C.

(K)—Finishing.

Elastic Bitumens: Production and Properties. D. C. Broome. *J. Soc. Chem. Ind.*, 1945, **64**, 149-151. Schemes for increasing the elasticity of bitumens by oxidation are briefly considered and the production, physical properties and uses of rubber-bitumen mixtures and sulphurised bitumens are discussed. Data are quoted showing the effect on mechanical and electrical properties of the partial replacement of rubber, reclaimed rubber and synthetic rubber of the GR-S type by elastic bitumen. C.

Paper Machine Felts: Guiding. J. B. Gough. *Paper Trade J.*, 1945, **120**, *TAPPI*, 178-181. The two principles that can be used to guide felts or wires, e.g. wet press or drier felts or Foudrinier wires, are explained. An actual felt and felt roller arrangement is analysed and the effects of varying the position of the guide roller are noted. Attention is called to the defects of the so-called "swing guides," and the causes, effects and reduction of "warped" and "bowed" felt seams are briefly discussed. C.

(L)—Proofing

Cotton Canvas: Rot-proofing. P. da Rocha Azevado and F. J. Maffei. *Anais assoc. quim. Brasil*, 1944, **3**, 120-127 (through *Chem. Abstr.*, 1945, **39**, 1993^7). In laboratory tests the most effective treatment of cotton canvas consisted in immersing the canvas in a 10 per cent. solution of copper sulphate, wringing out the excess and immersing in a 10 per cent. caustic soda solution; after thorough washing the canvas was heated for one hour at atmospheric pressure. For an accelerated rotting test strips were cut and interlayered with strips of rotten canvas; the treated and untreated strips thus inoculated were stored under conditions of tropical warmth in a moist atmosphere for 60 days. In this test the treated strips lost nothing in breaking strength whilst the untreated were practically disintegrated. C.

Cotton Yarn: Mildew Proofing with Naphthenates. M. C. Brock. *Textile World*, 1945, **95**, No. 4, 141. For the application of Cu or Zn naphthenate to yarn the writer recommends using a solution in dry-cleaning solvent. One American specification stipulates, for example, a mixture of 8 parts of 8 per cent. Cu naphthenate to 5 parts of spindle oil; this could be diluted with

Stoddard solvent. Hanks and warps are easily treated, but further work is necessary on the treatment of yarn packages. C.

Fabrics: Water Repellency. H. Wakeham, W. B. Strickland and E. L. Skau. *Amer. Dyes. Rept.*, 1945, **34**, 178-182. The factors involved in water repellency are analysed, and the importance of contact angle and the influence of the size of the openings in fabrics are discussed. Details are given of the tensiometric method of determining the contact angle of water with a fabric surface described previously by Wakeham and Skau. The constructions, spray-test ratings, hydrostatic pressures, Gurley Densometer air-permeability values and tensiometric contact angles for 26 experimental and commercial fabrics are compared. The data indicate that for fabrics of the same construction, the water repellency is, up to a certain point, a function of the concentration of finish on the fabric. The hydrostatic pressure value of a fabric is, in general, directly related to the Densometer air-permeability value for a given surface finish. Contrary to generally accepted belief, the spray-test rating may depend somewhat upon the construction and weight of the fabric. The contact angle seems to be the most specific test in that it evaluates primarily the waterproofing finish on the fibres and yarns. The conclusion is reached that adequate evaluation of water-repellent fabrics requires testing by each of the four methods. C.

Rubberised Rayon Fabric: Limiting Concentrations of Metallic "Poisons." (1) P. Kluckow. (2) Kehren. *Textilberichte*, 1943, **24**, 84-85, 85-86 (through *Brit. Abstr.*, 1945, B II, 110). (1) The Cu + Mn content of rayon to be used for rubberised waterproofs should not be greater than 0·002–0·005 per cent., particularly if a mixture of natural and artificial rubbers is used. (2) Co, Cr, Fe, and fatty acids have either not been found in rayon in appreciable quantities, or their effects as "rubber poisons" when present in relatively small concentrations have not been fully substantiated. There is evidence, however, that other substances of unknown nature may also act as poisons. C.

Tent Cloth: Proofing. L. E. Carpenter Co. *Chem. and Eng. News*, 1945, **23**, 838. A coating compound which seals the open weave of tent cloth and renders it waterproof, and acts as a binder and carrier for flame-proofing and mildew-proofing agents includes a group of alkyd resins known as Paraplexes which remain rubbery over wide temperature ranges. Amberol resins combined with the Paraplex form a durable vehicle. The treated cloth remains flexible at sub-zero temperatures. C.

Textiles: Mould and Bacterial Attack; Incidence and Control. R. G. Fargher. *J. Soc. Dyers & Col.*, 1945, **61**, 118-122. A discussion of cotton as a medium for growth of micro-organisms, mildew-proofing of yarns and fabrics, the results of examinations of mildew antiseptics and the properties sought in such preparations, causes of incomplete protection, the requirements of an ideal rot-proofing agent, the behaviour of cotton during exposure to the weather, the use of Cu and Cr compounds as rot-proofing agents and problems arising in their use. C.

Patents

Knitted Fabric Edges: Stiffening. M. S. Striker and A. Eddy. B.P.568,854 of 25/5/1943:24/4/1945. A process of treating a knitted open-mesh fabric in order to facilitate finishing operations consists in applying along the edge portion a plastic stiffening material in such a way that curling of the edge is substantially prevented, while leaving the major portion of the fabric unstiffened. Thermoplastic materials, such as cellulose derivatives, synthetic resins, rubbers, waxes and glues, are particularly suitable for this purpose. The material may be applied in the molten state by means of a nozzle, brush or roller, or strips of stiffening material may be applied to heated edge portions of the fabric. C.

Anthraquinone Dyes: Production. F. Irving, A. Livingston and Imperial Chemical Industries Ltd. B.P.568,933 of 3/8/1943:26/4/1945. Anthraquinone vat dyes are made by introducing into the 1- and 4-positions of the anthraquinone molecule two different alkane- or phenylalkane-sulphonylbenzoylamino groups. The introduction of these two groups may be effected either stepwise or simultaneously, and if stepwise the two groups may be introduced in either order. Suitable procedures are described. The products dye cotton in fast shades of red which are of good colour value. In particular they are notably fast to kier-boiling. C.

Hosiery Wet Treatment Apparatus. E. J. Berger and H. W. Matthews (U.S.A.). B.P.568,946 of 20/5/1943:27/4/1945. Apparatus for the treatment of textile articles, particularly hosiery, with a fluid medium under pressure in order to shape them or set them against subsequent distortion, comprises a treating chamber with a door at the front thereof, spaced aligned horizontal stationary track sections extending lengthwise of the front of the chamber and respectively beyond opposite sides thereof, an auxiliary track section mounted on the back of the door and capable of registry with the stationary track sections in the interval between them, carriages for the textile articles individually associated with the two stationary track sections, and reversible means to effect transfer of the carriages from one track section to the other. C.

Stenter Driving Mechanism. J. Dalglish and K. S. Laurie. B.P.568,965 of 22/10/1943:27/4/1945. The stenter chains are driven by individual means, one for each chain, designed so that with increase of drag torque the speed reduces, and *vice versa,* and a mechanical synchronising connection is provided between the two driving means, the arrangement being such that if either driving means tends to vary in speed in relation to the other a correcting torque is applied by the mechanical interconnection. Preferably the driving means take the form of drooping characteristic electric motors. The mechanical connection between the motors may comprise a synchronising shaft which is geared to rotary shafts driven by the respective motors and is adapted to transmit speed-correcting torque from either motor to the other. The invention may be applied to stenters having stenter chains supported by side rails adapted to receive longitudinal jigging motion from jigging mechanism and also to stenters having mechanism for adjusting the widthwise space between the stenter chains to suit the width of the cloth to be stentered. C.

Embossing Machine. Hunt & Moscrop Ltd. and E. F. Hunt. B.P.568,987 of 24/12/1943:30/4/1945. In a machine for embossing fabric, paper, etc., each of the gear wheels is mounted on a short shaft, the axes of the two shafts being parallel, carried in stationary bearings so that the shafts do not move vertically with the bowls, the shaft of one wheel being connected to the shaft of the engraved bowl by a universal or equivalent joint and the shaft of the other wheel being connected to the shaft of the compressed fibre bowl by a second universal or equivalent joint, the shaft carrying one of the wheels being driven by a belt, motor, or in other suitable way. C.

Rayon Cartridge Bag Fabrics H. Dreyfus. B.P.569,040 of 24/12/1940:2/5/1945. Fabrics in which after ignition neither flame nor after-glow persists for more than a few seconds, which do not leave a sticky residue, and which are suitable for the production of cartridge bags, are composed of fine filaments or fibres of regenerated cellulose impregnated with guanidine or a guanidine salt, especially guanidine metaphosphate, carbonate or sulphate. The filaments or fibres may be impregnated in loose filament or fibre, roving, yarn or fabric form. The impregnated fabrics may contain in addition to the regenerated cellulose filaments or fibres, filaments or fibres of animal origin, e.g. silk or wool, or artificial proteinaceous filaments or fibres. C.

Tolidine Derivative Azo Dyes: Production. E. I. Du Pont de Nemours & Co., W. B. Reynolds, S. S. Rossander and D. E. Kvalnes. B.P.569,080 of 23/6/1943:3/5/1945. The intermediate, 2:2′-dichloro-3:3′-dimethylbenzidine-5:5′-disulphonic acid, is made by sulphonating 2:2′-dichloro-3:3′-dimethylbenzidine. Azo dyes are produced by diazotising this intermediate and coupling with components particularly of the 1-phenyl-3-akyl-5-pyrazolone series. If desired, the dyes containing phenolic groups may be ethylated or acylated with arylsulphonyl halide. The dyes obtained dye wool in level shades of good fastness to light and to wet treatments such as fulling, washing, perspiration, salt water and carbonising. The dyes which contain not more than two sulphonic acid groups have good affinity for nylon and have the same good fastness properties as on wool. C.

Moisture Repellent Laminated Fabric Materials: Production. J. C. Nicholson and British Artificial Resin Co. Ltd. B.P.569,116 of 25/6/1943:4/5/1945.

Laminated fabrics and/or fibrous material, in which the laminations are united by a thermoplastic or a thermosetting resin, are protected from water or moisture by applying in the uniting operation an outerlayer or lamination of fabric having an outer weave of glass filaments and an inner interlocking weave of cotton or other absorbent fibres, the outer layer or lamination being coated with or occluded in a thermosetting water-resistant resin, which is cured in the uniting operation. C.

Fur: Carrotting. American Hatters and Furriers Co. Inc. B.P.569,146 of 7/5/1945. Under ordinary conditions, the lowest concentrations of the ingredients of the carrotting solution claimed in B.P.551,705 (these *Abs.*, 1943, A305) are 0·5 per cent. each by weight of the solution for sulphuric and nitric acids, and 1·0 per cent. each for chloric acid and hydrogen peroxide. Upper limits depend on the many variables involved, but certain generalizations are formulated as a guide in selecting strengths and proportions of the ingredients. Specific examples are given of applications of the solution to produce different felting characteristics. W.

Methylcellulose Pastes. Atlas Powder Co. B.P.569,189 of 25/3/1943:11/5/1945 (Conv. 12/3/1942). Compositions which may be used as thickening agents in printing comprise combinations of soluble methylcellulose and a butylated sulphonated diphenyl- or phenyl-phenol compound in such quantity as materially to thicken the methylcellulose. The compositions may also be employed as coatings or sizes. C.

Wood Pulp and Paper: Treatment to Increase Durability and Resistance to Water. E. Bader. B.P.569,475 of 8/4/1943:25/5/1945. Fibrous material, particularly wood pulp, paper or leather waste, is treated with a solution or aqueous dispersion of a sulphurised oil, soluble in organic solvents, obtained by the action of sulphur chloride on fatty oils, and the solvent or water is removed by drying at room or elevated temperatures. Curing agents may be incorporated in the fibres or surfaces to be treated or in the solution or dispersion. The solution or dispersion may also contain other materials such as waxes, resins, rubber, casein, gelatin, etc. Treated materials and articles made from them have increased resistance to tearing, bending, water, moisture, fungi, acids, solvents, etc. Treated paper and boards exhibit almost equal tensile strength in all directions. C.

Dyed Cellulose Ester and Ether Materials: Treatment to Reduce Gas Fading. H. C. Olpin and S. A. Gibson. B.P.569,557 of 22/2/1943:30/5/1945. Cellulose ester or ether materials dyed with a soluble dye that is not normally fast to the combustion products of coal gas, e.g. an amino-anthraquinone dye, have incorporated in them a small proportion of an insoluble resinous condensation product of an aldehyde with an aminotriazine, the proportion being insufficient to modify substantially the handle of the material, in order to improve the fastness of the dyeings to such combustion products. The condensation products may be applied to the materials before, during or after dyeing. Instead of applying a condensation product as such, the components from which it is formed, with or without a catalyst or potential catalyst, may be applied to the material and condensation effected on the material at an elevated temperature. C.

Glass Fibre Water- and Gas-proof Garments: Production. Elizabeth C. and Ursula C. Maxwell. B.P.569,663 of 22/4/1943:4/6/1945. Waterproof and/or gas-proof garments are made from glass or vitreous material which has been treated with suitable proofing materials. The fabrics used may be woven or knitted from fibres, threads or filaments of glass or similar vitreous material, or such fibres may be arranged in parallel and united by an adhesive, which may itself have the properties of a proofing medium. As a suitable proofing medium, a polymerisable drying oil such as linseed oil may be used, or a varnish having a linseed oil or other similar base. Alternatively, a polymerisable synthetic resinous composition, a cellulose ester, a bituminous composition, a non-drying polymerisable oil such as castor oil, or a composition with a castor oil base may be employed. A composition including drying oil such as linseed oil and glycerin-phthalic anhydride resin, or a composition including such resin and nitrocellulose or vinyl resin and nitrocellulose may be used. C.

5—ANALYSIS, TESTING, GRADING AND DEFECTS

(A)—FIBRES

Fibres: Moisture Relations. W. G. Schaposchikow. *Textilberichte,* 1943, **24,** 120-121 (through *Brit. Abstr.,* 1945, B II, 105). Samples of wool, cotton, silk and flax were exposed to atmospheric conditions and their moisture content (M) was measured daily. The observed values of M were greater than those calculated from the Müller formula: $M=(\alpha+\beta\phi)(100-\theta)^{\frac{1}{4}}$, where α and β are coefficients depending on the nature of the fibres, ϕ is the relative humidity, and θ the air temperature. This formula is not therefore applicable to fibres under natural conditions, i.e. changing atmospheric conditions. C.

Resin-treated Fibres: Electron Microscope Study. D. H. Reynolds and J. A. Rich. *J. Applied Physics,* 1945, **16,** 263-266. Titles and abstracts are given of 28 papers presented at a meeting of the Electron Microscope Society of America. One of these reports a study of fibres from resin-treated fabrics, particularly light cotton sheet and 50/50 acetate-viscose fabric. The fabrics were broken down mechanically by high-speed stirring in aqueous suspension, with careful avoidance of any chemical disintegration. The resulting " disintegration pattern " shown by the electron microscope was found to correlate well with observed physical properties of the treated fabrics. C.

Staple Fibre: Tests for Use in the Wool Trade. H. Böhringer. *Textilberichte,* 1943, **24,** 117-120 (through *Brit. Abstr.,* 1945, B II, 105). Comparative measurements of strength and elongation, elasticity, crimpiness, resistance to bending and twisting, breaking strain, water absorption, and density were made on wool of 3A quality and fibres of viscose, cellulose acetate, and casein. The results are expressed graphically. C.

Cellulose Fluidity Test Solution Tumbling Device. S. A. Simon. *Textile Research J.,* 1945, **15,** 82-83. A tumbling device for preparing cellulosic dispersions in pipette viscometers provided with metal plungers, consists of a heavy base casting supporting a horizontal shaft which is driven at approximately 4·5 r.p.m. by an oil-immersed 80:1 worm reduction from the slow-speed shaft of a common form of laboratory stirrer. The horizontal shaft carries two cylindrical cases, one at each end, in which a total of 24 viscometers can be placed and held securely in a cheesecloth packing. End covers with bayonet locks on the cylinders close the assembly and exclude light. Mounting rings hold the cylinders between fixed collars and friction springs guard against undesired rotation. Fixed to each cylinder is an 8-spoke star wheel made of projecting pins which engage a fixed pin, suitably located on the frame of the instrument, on each revolution about the horizontal axis. Through this arrangement each cylinder is rotated on its own axis, carrying the viscometers within it through the same motion, one-eighth revolution for each complete end-over-end cycle. C.

Electrical Moisture Meter. *Electrical Review,* 1945, **136,** 619-620. A report is given of a discussion of an electrical moisture meter (National Physical Laboratory) for the testing of seeds and grain, food products, straw, fibre, etc. In this instrument a constant alternating current is applied to a sample of the material contained in a small vessel that may be regarded as a fixed air condenser, or in some instances as a conductive cell. The current passing through the sample is measured by a sensitive thermionic ammeter of special construction, which can be adjusted to indicate either the capacitance, proportional to the dielectric constant of the sample, or the conductance, proportional to its AC conductivity; alternatively some function of both the former values may be indicated. The current selected is that which shows the most favourable variation with moisture content. Reference is made to other moisture meters based on similar principles. C.

Fibres: Microscopy; Nitrogen Dioxide Pretreatment. Mary. L. Rollins. *Textile Research J.,* 1945, **15,** 65-77. Fibres which had been treated with nitrogen dioxide were observed under the microscope during swelling with lyotropic reagents. Nineteen sets of photomicrographs made at various stages in the swelling processes are reproduced and discussed. Cotton fibre sheath (primary wall and " winding layer ") splits into fine fibrils or into broad spiral bands, depending on the degree of oxidation. Reversals were observed in the fibre sheath; these may be in the "winding layer" or inner sheath beneath the primary wall, but caused to adhere to it by the nitrogen dioxide treatment. The fibre sheath appeared to have a banded structure when not ruptured by swelling of the cellulose beneath it. No spiral structure was observed in any layer of the secondary wall of cotton below the inner sheath, but the lamellæ of the secondary wall seemed to disintegrate into fine fibrils lying more or less parallel with the fibre axis. Spiral fibrils were observed in the secondary wall layers of treated ramie fibres and milkweed bast fibres, but the angle of their spiral orientation with respect to the fibre axis was several times greater than the slight angle of orientation seen in X-ray diffraction patterns. This was no doubt due to the extreme swelling to which the fibre was subjected for microscopical study. The spiral angle in the primary wall also varies with the degree of swelling, that for a ramie fibre varying from 28 to 45°, and for a flax fibre from 37 to 44°. C.

Fibres: Swelling. B. R. Roberts. *Textile Research J.*, 1945, **15**, 46-53. The application of a combination of ultramicroscopy, micromanipulation, kinemicrography and selective swelling to the study of fibre structure is described. Kinemicrographs showing Brownian movements within swollen starch grains and cotton fibres and the eruption of colloidal masses from ruptured walls, and also Brownian movement within swollen wool scales, are presented and discussed. C.

Comparison of the Yields of Side Samples from Weanling and Yearling Sheep. C. T. Blunn and J. O. Grandstaff. *J. Animal Sci.*, 1945, **4**, 122-127. Data on the clean wool yields of side samples collected at weanling and yearling ages from 461 crossbred ewe lambs during a 5-year period were analysed. Average yields at yearling age were 6·5-22·8 per cent. lower and much more variable than the weanling yields for the same sheep. The relation between the weanling and yearling yields for individual years and progeny groups varied greatly. The correlation between the yields of weanling and yearling samples, independent of the effect of years and rams used within years, was 0·45, a highly significant value. The regression equation calculated from these data had, however, little practical value for estimating yearling yields from weanling data because of the extreme variations resulting from environmental conditions. W.

Influence of Location and Size of Sample in Predicting Whole Fleece Clean Yields. E. M. Pohle, L. N. Hazel and H. R. Keller. *J. Animal Sci.*, 1945, **4**, 104-112. Fleeces of 20 Rambouillet and 20 Columbia yearling ewes were halved, one half being scoured intact and the other half being separated in 56 small sample of approx. 35 g. each before scouring. Correlations between clean yield of the half fleece and the 56 small sample yields showed that the most accurate sampling locations were on the side and the adjacent shoulder and breech. The influence of sample size upon accuracy of sample yield was studied in three ways:—(1) By deriving theoretical correlations expected between whole fleece yield and samples of varying size; (2) by combining the 56 small sample yields into larger groups and calculating correlations between these and half fleece yield; (3) by combining the 12 small sample yields from the side in several ways and calculating correlations between these and whole fleece yield. Accuracy of sample yield was increased by taking samples larger than 35 mg., but the rate of increase became progressively smaller as the size of sample increased. The location of the sample was as important as the size. The same general trend in clean yield and in accuracy throughout the fleece appeared to hold for breeds differing widely in fineness and in staple length, and the middle of the side is suggested as a standard sampling location. A standard sample size is advisable only for routine operations where extreme accuracy is not required. W.

Hairy Lambs: Monthly Changes in Fineness, Variability and Medullation. E. M. Pohle, H. R. Keller and L. N. Hazel. *J. Animal Sci.*, 1945, **4**, 37-46. Cross sections of the fleeces of 69 lambs classed as hairy at docking time were examined monthly until yearling age. The number of hairs constituted only a small fraction of the total population, and diminished rapidly as the lambs increased in age. Fewer hairs were found on the side than on the thigh or back. Fibre diameter decreased between 6 and 11 months of age, and then increased slightly. Percentage medullation decreased very rapidly from 2 to 5 months, and then more slowly. Medullation was not a constant property, and varied considerably from month to month for individual lambs. No important differences were found in the yearling fleeces of hairy and non-hairy lambs as regards hairiness, mean diameter, variability or percentage medullation. W.

Sampling Wool Clips for Clean Yield by the Cone Boring Method. A. W. Nordskog, R. T. Clark and L. Van Horn. *J. Animal Sci.*, 1945, 4, 113-121. The cone boring method of Wollner and Tanner (these *Abs.*, 1942, A143) was used to sample the clean yield of a wool clip representing about 2,700 fleeces which were graded and packed into bags. The data consisted of 264 core samples on which individual clean yields were obtained. The intragrade variance in clean yield of the aged ewe wool and yearling ewe wool was 30·0 and 12·0, respectively, the difference being statistically significant. The number of cores required to represent lots of wool within specified limits of error was calculated from these estimates of variance. For the ewe wool, the sampling error of the mean of 29 cores was 2 per cent., 115 cores being required for an error no greater than 1 per cent. Only 12 and 46 cores of yearling ewe wool were required for sampling errors no greater than 2 per cent. and 1 per cent., respectively. About 17 per cent. and 24 per cent. larger samples of ungraded than graded aged ewe and yearling ewe wool, respectively, would be necessary for the same level of accuracy. W.

(B)—Yarns

Load/Extension Recording Impact Testing Machine. E. R. Schwarz. *Rayon Textile Monthly*, 1945, **26**, 169-170. A verbal description is given of a new impact testing machine installed in the Slater Memorial Research Laboratory of the Massachusetts Institute of Technology, for testing yarns, cordage or fabrics. The load capacity can be varied from 1 to 5,000 lb. There are two weights, 25 lb. and 500 lb., which are raised to their guides by means of appropriate tackle and can be allowed to fall from a height of many feet. The base of the machine is a shock absorber weighing about 3 tons and consisting of a 2-ton block of lead resting on 36 heavy steel springs. The stress is indicated by an electric gauge, and the variation in voltage is converted, through an oscillograph device, into a record on the film of a high-speed camera. The events occurring within one-hundredth of a second can provide a trace several inches long and ½ to ¾-in. in amplitude. C.

High Tenacity Viscose Rayons: Properties. L. Rose. *J. Soc. Dyers & Col.*, 1945, **61**, 113-118. The production of "Tenasco" and "Durafil" rayons is briefly described and the tensile and dyeing properties of these fibres are discussed and compared with those of ordinary viscose rayon. Stress/strain diagrams, X-ray fibre photographs, and photo-micrographs are given and discussed. The uses of "Tenasco" and "Durafil" are described, and details are given of the advantages of "Tenasco" for use in tyres. C.

(C)—Fabrics

Shiefer-Kline Tautness Meter. S. W. Frazier. *Rayon Textile Monthly*, 1945, **26**, 197. An illustration is given of a new model of the "instrument for estimating tautness of doped fabrics on aircraft" developed by Kline from Shiefer's compressometer. The sensitive parts are totally enclosed for protection from dust and dirt and from mechanical damage. C.

"Taber Abraser" Wear Testing Instrument. Taber Instrument Corporation. *Rayon Textile Monthly*, 1945, **26**, 197. An illustration is given of a new model of this "flat-iron" type of wear tester, which with accessories, including an illuminated magnifier, is now offered as a complete testing set. C.

Clothing: Scientific Minimum Standards. D. Dickins. *Rural Sociol.*, 1944, **9**, 341-349 (through *Exp. Sta. Rec.*, 1945, **92**, 723). Clothing is used in the main for "psycho-social welfare" and, therefore, minimum standards should be based on these aspects. Two stumbling blocks to the development of a criterion for determining scientific minimum standards for goods used in the main for "psycho-social welfare" have been (1) leaving formulation of minimum standards to physical and biological scientists who have attempted to apply health and efficiency criteria to goods not used primarily for health and efficiency; (2) neglect of the inventory study which gives goods owned and functions of these goods to the family. Without such information it is difficult to develop an hypothesis on which to base minimum standards. Social participation is proposed as a criterion for determining minimum standards for clothing. C.

Cotton Stockings: Distensibility and Bursting Strength. Margaret S. Furry and A. M. Hansen. *Rayon Textile Monthly*, 1945, **26**, 173-176. An account is given of the behaviour on the Frazier testing machine of stockings knitted in six different constructions (32-42 courses per inch in the welt, 36-46 courses per inch in the leg) from (*a*) 60s and (*b*) 120s/2 combed long-staple American-Egyptian cotton, (*c*) 40s and (*d*) 80s/2 combed medium-staple Peeler cottons, and (*e*) 40s carded short-staple cotton. The knitting process was the same for all, and details are given. The stockings were washed in a Launderometer, and boarded. Yarn test and Frazier test results are tabulated and some of the differences are expressed graphically. The main conclusions are as follows: (1) More force is required to distend the stockings as the number of courses per inch is increased. (2) The distending force decreases in the order 80s/2 combed, 40s combed or carded, 120s/2 combed, 60s combed. (3) In bursting tests the doubled, combed yarns gave stronger stockings than corresponding singles, 40s and 80s/2 were better than 60s and 120s/2, and 40s carded gave much weaker stockings than any of the combed yarns. (4) The finer ply yarns were preferred by wearers of the stockings because of the tighter fit. C.

Dyed Fabrics: Colour Transfer and Crocking Test. D. P. Knowland and W. A. Holst. *Amer. Dyes. Rept.*, 1945, **34**, 166. In this report of the Sub-committee on Transference of Colour, American Association of Textile Chemists and Colorists, a rating method for crocking tests carried out on the Crockmeter by the usual technique (10 revolutions or 20 strokes) is proposed which is based on the use of Munsell chips in 3 ranges of 6 colours (including gray, red, yellow, green, blue and purple), namely at value 9, chroma 1, value 8, chroma 2 and value 7, chroma 2. A convenient method of mounting the chips is briefly described. It is suggested that the cotton material used in the crocking tests should have a degree of whiteness equivalent to Munsell value 9·3–9·5, and brushing to remove loosely adhering coloured fibres before rating is recommended. C.

Rayon Lining Fabrics: Resistance to Abrasion. J. H. Tait. *Textile World*, 1945, **95**, No. 4, 218; *Rayon Textile Monthly*, 1945, **26**, 171-172. A summary is given of the results of tests with the Taber machine on more than 1,100 rayon lining fabrics, a photographic standard being used to judge the end-point of the abrasion. The following are the main conclusions. (1) The warp yarn always wore out first. (2) Abrasion resistance increased with compactness of weave, up to a point. (3) Resistance increased with warp count up to about 150 den.; further increase in denier brought little further gain. (4) The number of filaments per thread was without appreciable influence. (5) A loose weave and long floats of warp yarn made for lower resistance to abrasion, but higher tensile strength. (6) Changes in weft count and number of picks per inch had little effect, especially in twill and satin weaves; variations in design can most readily be effected in the weft. (7) Increasing the twist in the warp yarn lowered resistance to abrasion. (8) Fabrics woven from spun-dyed yarns were stronger, but less resistant to wear than comparable piece-dyed fabrics. (9) Fabrics of high-tenacity rayon were no better than ordinary materials. (10) The greater the extensibility of the finished fabric, the greater the resistance to abrasion. (11) All-viscose materials were superior to unions. (12) Fabric finished at its natural, shrunk length gave much better wear than stretched fabrics. C.

(D)—Other Materials

Regenerated Cellulose Film: Properties and Uses. W. Berry. *"Times" Trade & Eng.*, 1945, **57**, No. 975, 10-11. A general account is given of the appearance, life, strength, extensibility, softness, resistance to oils and gases, moisture-vapour resistance, and stability of regenerated cellulose film. The sealing of films by heat and by means of adhesives is discussed, and uses of regenerated cellulose films are indicated. C.

Plastics: Impact Testing. D. Telfair and H. K. Nason. *Modern Plastics*, 1943, **20**, No. 11, 85-88; 1945, **22**, No. 8, 145-149, 186-188. (1) It is shown that the standard Izod and Charpy test methods do not give satisfactory results with plastics and a modified test, which measures the energy required just to initiate fracture in a test specimen, is proposed. The results obtained by this modified test rank materials in order of their known shock-resisting qualities and correlate well with service experience. (2) It is shown that the energy to fracture depends on both the force required and the deformation produced, and for brittle materials is approximately equal to the external work W done by the load and $W=(PS)/2$, where P is the value of the load at the point of failure and S is the distance through which it has moved. The deformation may or may not be ductile, depending on the material and on the conditions of temperature, speed and the state of stress. If the failure is brittle, the energy absorbed may be correlated directly with the dimensions of the specimen, the elastic modulus, and the maximum tensile stress which the material is capable of supporting. Experimental results are given showing the influence of specimen dimensions, notching, speed and temperature on the energy required to fracture various types of specimens. Evidence is given that for many plastics the tensile strength is a linear function of the logarithm of the stressing rate over a relatively wide range of the latter. C.

Buna N Type Synthetic Rubbers: Properties. R. G. Newton. *J. Rubber Research,* 1945, **14**, 63-80. In a general discussion of the proporties of oil-resisting rubbers of the Buna N type, which are co-polymers of butadiene and a polar compound containing nitrogen, e.g. acrylic nitrile, consideration is given to the properties of the crude co-polymers, processing characteristics and methods, properties of the vulcanisates, and the identification of vulcanised synthetics. Tables are presented showing plasticity figures, relative swelling resistances, influence of various liquids on swelling, and tensile and mechanical properties. Details are given of the processing characteristics and properties of specific types, including Perbunan, Hycar OR, Chemigum types and Thiokol RD. C.

Rubber: Identification by Weber Colour Test. I. F. C. Parker and W. C. Wake. *Analyst,* 1945, **70**, 175-176. The authors discuss the nature of the reaction in the Weber colour test for natural rubber, which depends on the development of violet colour on heating brominated rubber with phenol in carbon tetrachloride, and show that this colour reaction appears to be specific for an active methylene group next to a double bond, as in the grouping $-CH_2.C(CH_3):C<$ occurring in linear polyisoprenes, of which natural rubber is the best known example. The grouping occurs also in methyl-rubber and in co-polymers containing isoprene. The test is useful for identifying natural rubber (except as alkali reclaim), although caution must be used where an isoprene co-polymer is likely. In tests with various materials methyl-rubber, Neoprene FR, gutta-percha and balata produced a strong violet colour, and a very faint violet colour was obtained with some samples of Bune 85, Pliofilm and Butyl B. C.

PATENT

Fibrous Material Moisture Content Testing Device. N. E. Brookes (Heberlein & Co., A.-G., Wattwil, Switzerland). B.P.569,439 of 7/9/1943:24/5/1945). In an apparatus for determining the moisture content of fibrous materials, when stationary or in motion, the material is located in a D.C. circuit—in series with a safety-resistance, if desired—which circuit serves for charging a condenser that is bridged by a gas-discharge lamp the ignition voltage of which is lower than the voltage of the D.C. circuit. The fibrous material is coupled into the circuit by means of bow-shaped, metallic, insulated scanning devices. An arrangement for supervising the moisture content of fabric passing through a drying apparatus is described. C.

7—LAUNDERING AND DRY CLEANING

(A)—CLEANING

Stained Garments: Cleaning. National Association of Dyers and Cleaners. *Rayon Textile Monthly,* 1945, **26**, 176. The weaknesses and fallacies of a number of popular methods of stain removal are exposed. They include the use of milk for ink stains, coffee for the neck-bands of dresses, and so forth. C.

8—BUILDING AND ENGINEERING

(A)—Construction and Maintenance of Buildings and Plant

Bituminous Emulsions: Application. E. M. Lorenzini. *Paper Trade J.*, 1945, **120**, *TAPPI*, 181-183. The use of bituminous emulsion as internal sizing in the production of weather-proof boards is discussed, and its advantages are pointed out and shown in strength data for V-board components. Emulsions of bitumen in the form of fine dispersions made stable to heat and acids are used as extenders for so-called weather-proof glues, such as starch-urea formaldehyde resin or polyvinyl alcohol types of adhesives. The extension is made by simple admixture to a finished adhesive and results in both a reduction of cost and improvement of waterproofness of the glue line. C.

Composite Laminates: Production and Uses. J. Delmonte. *Modern Plastics*, 1945, **22**, No. 8, 95-97, 190-192. A general discussion of the production and uses of various types of composite laminates, including plywood materials with decorative plastic surfaces, metal-wood assemblies, composite assemblies involving rubber to metal or rubber to plastic composite laminates, and composite laminates incorporating transparent plastics. C.

Paper Base Phenolic Laminates. R. W. Barber. *Paper Trade J.*, 1945, **120**. 190-193. Cellulose materials used in the production of laminates are discussed and paper base phenolic laminates are studied. Tables are given showing the effect of paper construction on the strength of laminates, and the physical properties of phenolic laminates with Mitscherlich sulphite, sulphate kraft, alpha and rag stock paper bases and a cotton fabric base. The effects of the type and thickness of the paper are discussed, and it is pointed out that the fabric base laminate is superior to the paper base products only in impact and bonding strength. Various uses of paper laminates are described and their advantages and limitations are outlined. C.

Plastics: Properties and Uses in Packaging. K. Gottstein. *Chemical Products*, 1945, **8**, 44-45, 43. A review of the properties and applications of the plastic materials most frequently used in packaging, including phenol-formaldehyde, urea-formaldehyde, melamine, and plasticised polyvinyl chloride resins, nitrocellulose, cellulose acetate, ethylcellulose, polystyrene, methylmethacrylate and rubber hydrochloride. C.

Polythenes: Properties and Uses. (1) E. Hunter and W. G. Oakes. (2) R. B. Richards. (3) E. L. Midwinter. *British Plastics*, 1945, **17**, 94-98, 146-151, 208-215, 228. (1) A brief account is given of the history, mechanical and electrical properties, and uses of polythenes, and of extrusion and dipping methods of application. (2) The resistance to chemical attack, water absorption, solubility, absorption of organic liquids and swelling of polythenes are discussed. (3) Methods of processing polythenes, including extrusion, moulding, hot melt coating, melt flowing and casting, powder spraying, solvent casting, and fabrication from sheets and tubes are described. C.

Mixing Machines: Agitation Effect and Power Requirement. J. P. Asquith. *Industrial Chemist*, 1945, **21**, 203-206, 262-267. Mixing in liquid-liquid and liquid-solid systems is considered and the theoretical approach to mixing problems is discussed. Results obtained by various workers, using different methods of measuring the effect of agitation, and investigations of power requirements are reviewed. An outstanding feature of the results is the existence of a critical point, which generally takes the form that at lower speeds increase of speed of agitation produces an increased effect of agitation, which is greater than the increase obtained for a corresponding increase in speed above the critical. A discontinuity in power requirement is also observed, and after the critical point power requirements go up more rapidly than the agitation effect. Five types of agitator in common use are briefly discussed. C.

Continuous Conveyor Weighing Machine. Adequate Weighers Ltd. *Engineer*, 1945, **179**, 436. Illustrations are given of a self-contained unit that gives the totalised weight of material passing over any type of belt or bucket conveyor. A steel ball sits in the valley between two steel rollers, one cylindrical, the other conical. A 3-pole magnet beneath the assembly pulls the ball into the wedge. The parallel roller is rotated by a chain and gear in sympathy with the movement of the conveyor and the ball in effect acts as a gear wheel to drive the conical roller. The rollers are connected through a spur differential gear train so that any inequality in their revolutions is transferred through a radiating train of gears to the dial weight recorder. The ball is automatically rolled along the two rollers in sympathy with the weight of material on the conveyor. The device can be modified for " shuttle " services to weigh the load passing in each direction separately. C.

" Micarta " Phenolic Laminates: Properties. H. C. Guhl. *Mechanical Engineering*, 1945, **67**, 175-179. Types of phenolic laminates, the characteristics of the resin and fabric components, and the heat-distortion properties of laminates, forming procedure, forming dies and their construction, and the forming of deep-drawn parts are discussed. Photographs of forming dies and formed parts, viscosity/time curves for phenolic resins, heat-distortion and hardness curves of laminates, curves showing thermal effects on tensile and impact strengths, hot-plate, infra-red and oven rate of heating curves for laminates of different thicknesses, and tables showing the physical properties of laminates (Micarta), woods and metals are presented. C.

Plastics: Use for Preservation and Packing. *British Plastics*, 1945, **17**, 122-126, 129. An account is given of the production and properties of Pliofilm and its uses, particularly for the protection of aircraft engines from corrosion and of the preparation, properties, sealing and use as a packaging material of Saran film. The use of hot-dip ethylcellulose plastic coating for the preservation of metal parts is discussed and the principal methods of applying the coating are outlined. The use of Bakelite sleeves and blanking caps for the protection of "Merlin" aircraft engines for despatch overseas is also mentioned. C.

Bleachworks Machine Shop: Organisation. *Textile World*, 1945, **95**, No. 3, 106-107. An illustrated account is given of the organisation and staffing of the machine shop at the Union Bleachery, Greenville, S.C., which is responsible for maintenance of the plant and of the workers' houses. C.

Corrosion Measuring Apparatus. M. Cohen. *Electrochem. Soc. Preprint*, 1945, **87**, No. 19, 221-226. Apparatus for an accelerated, total-immersion corrosion test is described and shown in a photograph and diagram. The test piece is placed in a horizontal glass tube which is connected by lengths of rubber tubing to two vertical tubes. The solution in the tubes is caused to circulate by moving one of the vertical tubes up and down. Results of tests on steel panels in three different waters, and data showing the increase in weight loss with time are presented. C.

Steels: Corrosion in Marine Atmospheres and Sea Water. C. P. Larrabee. *Electrochem. Soc. Preprint*, 1945, **87**, No. 12, 123-139. Low-alloy high-strength steels, with superior corrosion resistance in industrial atmospheres, are also more resistant in marine atmospheres, but to varying extents. To obtain untarnishable steel, a very high alloy content is necessary. Slight rusting usually mars the appearance of the lower grade stainless steels in sea-coast atmospheres, but in most cases the attack is only superficial. Zinc-coated steel products are highly satisfactory under many conditions. In sea water, plain and low-alloy steels have an average corrosion rate of about 22 mg./dm.^{2}/day (0·004 in./year average penetration). Pitting attack characterizes the corrosion of stainless steels although the presence of 2 per cent. to 3 per cent. molybdenum in the 18/8 type or very high alloy content diminishes this tendency. C.

Pipelines and Fittings. E. Ingham. *Power & Works Engineer*, 1945, **40**, 156-7. The layout of a piping installation can have considerable influence on its performance and this article considers briefly a number of points, including simplicity and directness, accessibility, supporting the pipes, flexibility and drainage. La.

Bearing Lubrication. I. C. De Martonfalvy. *Mech. World*, 1945, **117**, 709-11. The lubrication of ball and roller bearings is exceedingly important but it is frequently overlooked. Anti-friction bearings require different lubrication from plain bearings, as in the former the high unit pressure between rolling elements and races prevents the formation of an unbroken oil film. The essential properties of lubricants for these bearings are briefly discussed and frictional data are quoted; a comparison between ball and roller bearings is also made. An oil selection chart and a viscosity-temperature chart are included. La.

Split Pulleys. W.M.S. *Mech. World,* 1945, **118**, 17. In a short note the advantages of split over solid pulleys are pointed out. G. H. Pearson. *Ibid.* 73. The advantages of split pulleys are also possessed by split gear wheels, which are here briefly described. E.F.C. *Ibid.* 103. A further short note on the fitting of split pulleys. La.

Roller Conveyors. *Production & Engineering Bulletin,* 1945, **4**, 197-202. The simple roller conveyor has many uses and this article indicates some of its forms and functions. La.

Lined Bearings. *Power & Works Engineer,* 1945, **40**, 173-5. The bearing is one of the most important engineering items and its repair and adjustment occupies a considerable proportion of the time and attention of the maintenance engineer. In this article the composition and structure of bearing metals is examined in some detail and causes of failure are considered. La.

Pipes. E. Ingham. *Power & Works Engineer,* 1945, **40**, 187-8. Materials and construction, types of joints and jointings, etc., are discussed from a practical point of view. La.

(B)—Fire Prevention

Fire Extinguishing Solutions: Efficiency. J. Bryan. *Engineering,* 1945, **159**, 457-460, 497-500. A review is given of methods for testing the efficiency of aqueous solutions of chemicals as fire extinguishers, a method employing a 1-cwt. stack of timber is described, and results obtained with familiar agents are compared. The following are some of the general conclusions. (1) The resistance of a fire to extinction is proportional to its temperature and heat content rather than to the rate of heat production. (2) There are several effective fire-extinguishing chemicals and they are also the known fire-proofing agents; mono-ammonium phosphate is perhaps the best. (3) The fire-fighting power of water can be increased 2- to 5-fold by adding 1·6 to 19 per cent. of ammonium phosphate to the water. C.

Smoking Rooms: Provision in Cotton Mills. H. S. Knowlton. *Textile World,* 1945, **95**, No. 3, 104-105. The writer discusses the problem of permitting smoking by workers in a cotton mill and advocates the provision of special, isolated rooms for the purpose. A suitable room would be 18 x 20 ft. and at least 8 ft. high for 25 employees at a time. It should have a 10-in. ventilating fan and four such rooms should be provided per 1,000 workers. Some illustrations are given of facilities of this kind in large American mills. C.

(C)—Steam Raising and Power Supply

Gas Specific Heat and Energy Charts. E. W. Geyer. *Engineering,* 1945, **159**, 381-382, 423-425. Tables of new quantum specific-heat data and related graphs are provided for nitrogen, oxygen, carbon dioxide and water vapour. They cover practical problems in connection with internal combustion and other engines. C.

Transformers: Installation and Care. *Silk & Rayon,* 1945, **19**, 549, 553. Advice is given on measures to prevent over-heating in a transformer, on secondary switch isolation and on the testing and care of oil for transformers. C.

Coal: Sampling. R. L. Brown. *British Coal Utilisation Res. Assoc. Bull.,* 1945, **9**, 97-10 Published work is reviewed and it is shown that advances in coal samplin ory may be traced from four notable contributions: (*a*) The size/weight theory, propounded by Bailey in 1909; (*b*) the application of statistical methods in sampling for ash content, first attempted by Grumell and Dunningham in 1930, and subsequently developed by other workers; (*c*) the theory of sampling for size analysis given by Manning in 1937; (*d*) the more recent theories of systematic sampling and of variability in ash content due to mixing in handling the coal, proposed by Landry in 1944. C.

Textile Mill Electric Power Plant: Operation. "Plant Engineer." *Textile Recorder,* 1943, **60-61**, Jan., 59-60; Feb., 55-56; March, 53-54; May, 55-56; June, 54-55; August, 52-54; September, 57-58; November, 59-60; December, 54-56; 1944, Jan.; 68-69; April, 64-65; **62**, June, 66-67; July, 75-76, 79; August, 68-69; September, 68-70. A practical review under the headings: (1) Control gear for electric installations; (2) The operation of transformers; (3) Installation and protection of transformers; (4) Maintenance of transformers; (5) Medium voltage A.C. main switchboards; (6) Electrical distributing systems; (7)

Requirements of A.C. motor starters; (8) Starters for 3-phase A.C.-motors; (9) Resistance starters for A.C.-motors; (10) Starters for special types of 3-phase A.C.-motors; (11) Maintenance of motor control gear; (12) Squirrel cage A.C. motors; (13) Variable-speed A.C. motors; (14) Power transmission shafting; (15) Principles. C.

Valves: Antifriction Devices. G. H. Pearson. *Industrial Heating Engineer*, 1945, 7, 55-7. All valves should be capable of being operated at any time by one man unaided. Typical methods of reducing the effort required to operate valves are described and illustrated. These include a ball-bearing cross-head for a non-rising-spindle type valve, ball-bearing cross-head for parallel slide valve of rising spindle type. Axial thrust calculations connected with parallel slide valves are considered in detail and a number of other sources of friction and difficulty in operation are examined briefly. La.

Electric Supply. G. Barnard. *Power & Works Engineer*, 1945, **40**, 150-1. A brief discussion of the cost and layout of high-voltage and low-voltage equipment for a factory supply from high-voltage mains. The need for continuous factory operation is met by the minimum of standby equipment. La.

Power from Process Steam. W. A. Pain. *Mech. World*, 1945, **117**, 730-5; **118**, 22-5. A paper read before the Midland Section of the Institute of Fuel considers the subject in some detail. By using exhaust steam for process or heating, the efficiency of a super-power station could be raised from 29 per cent. to 80 per cent. Industries can be classified into three broad sections according as the power demand exceeds, balances, or is less than the corresponding process steam demand; and each section is considered. The effect of using back-pressure or condensing engines is shown by means of charts and comparison of the effects produced by raising the initial pressure or lowering the back-pressure is similarly made. Other points discussed include the effect of size of unit on steam consumption, boiler pressure, dry and superheated steam and pass out pressures. The choice of prime-mover, i.e. engine or turbine is considered by giving examples of plant including a 1500 KW condensing turbine and an 80 KW combined power and heating plant. Steam consumption, costs, etc. are examined and photographs and diagrams show details of equipment. La.

Flue Gas Analysis. J. Jennings. *Mech. World*, 1945, **118**, 63-5. Consistency in the results of analyses of combustion products is essential but not always easy to obtain. Apart from care in the experimental work, especially when using an Orsat apparatus, arithmetical checks should always be applied. Such checks are considered in this article and are deduced from the usual combustion equations. In solid fuels the ratio of hydrogen to carbon in the fuel analysis is required, but for most purposes assumed values are sufficiently accurate. A typical check formula is $O_2 = 21 - 1 \cdot 014\ CO_2$. The completeness or otherwise of the combustion can be taken into account. With gaseous fuels different formulæ, based on the fuel analysis, must be used. When the analysis of the dry products of combustion with minimum air has been calculated a simple formula can be applied to check the consistency. This formula can be applied to solid, liquid or gaseous fuels and examples of its use on a liquid fuel and the exhaust gas from a diesel engine are given. La.

Steam Engine Lubrication, IV. E. V. Paterson. *Steam Engineer*, 1945, **14**, 309-12. This article deals with cylinder lubrication, suitable equipment being illustrated and described. Hydrostatic, mechanical, loco and graphite lubrication are considered. La.

Boiler Water Gauges. E. Ingham. *Steam Engineer*, 1945, **14**, 313-4. Every steam boiler must be fitted with one or more suitable water gauges and this article discusses the fitting, use and maintenance of such important equipment. La.

Cast Iron Heating Boilers. A. J. T. Eyles. *Mech. World*, 1945, **118**, 32-3. Recently the repair of cast iron heating boilers by bronze welding has become prominent and this article discusses briefly the characteristics and technique of the process. La.

Synchronous A.C. Motors. G. W. Stubbings. *Mech. World*, 1945, **118**, 135-6. The synchronous motor is somewhat more difficult to start and to run than the 3-phase induction motor, but there are instances where its use is justified. The power factor of the input can be made to have its maximum value, and the efficiency is, therefore, high; the speed is constant, with a fixed frequency, over the whole range of load variation; the machine can be used for power factor correction; and the maximum output is proportional to the supply pressure. The design and working of such motors are considered in some detail. La.

Gauging of Streams. R. McAdam. *Power & Works Engineer*, 1945, **40**, 180-3. The most convenient measuring device for water discharges over 20 gallons per minute consists of a weir and a suitable head measuring arrangement. The fundamental equations are given for the vee-notch, suppressed rectangular weir and the fully contracted rectangular weir; features essential to accuracy are discussed and a nomograph is given to assist in routine measurements. La.

Industrial Supply Switchgear. *Power & Works Engineer*, 1945, **40**, 177-9. Sub-station electrical equipment in factories has become of much greater importance during recent years and careful thought should be given to its selection and layout. In the first part of this article the circuit-breaker is considered alone and in relation to the rest of the equipment. Before selecting switchgear a single line diagram of main connections for the proposed incoming and distribution schemes should be prepared. Safety to operators, adequacy for the power needs, accessibility and reliability of service are points on which great emphasis must be laid. La.

Dyeing: Steam Demand. W. Goldstern. *Steam Engineer*, 1945, **14**, 323-6, 345. Notes from a series of lectures given to the Foreman Dyers' Guild. A brief illustrated description of steam storage is included. La.

Boiler Blow-down. G. H. Pearson. *Mech. World*, 1945, **118**, 159-62. A critical review of *Fuel Efficiency Bulletin*, No. 35. Reasons for blowing down, when to do it and how much water to release are considered in detail. La.

Steam Plant Data. "Polytrope." *Mech. World*, 1945, **118**, 171-4. Steam plant operating data has been collected into formulæ, charts and graphs. The following are included:—Total heat-pressure, sensible heat saturation temperature, adiabatic heat drop for various steam temperatures and exhaust pressures, steam consumption (lb./k.w.hr.), thermal efficiency, coal consumption and station efficiency. La.

Small Boilers. G. H. Pearson. *Mech. World*, 1945, **118**, 209, 222. A critical review of *Fuel Efficiency Bulletin*, No. 37, dealing with the economical operation of small boilers, e.g. boilers for steam cranes, shunting engines, etc. La.

(D)—Power Transmission

Motor Bearings: Lubrication. C. G. Price. *Textile World*, 1945, **95**, No. 4, 120-121. Advice is given on the lubrication of motor bearings of the sleeve, ball-bearing and waste-packed types, with a general warning against over-oiling. Bearings of small loom motors are generally packed with waste and require 30-70 drops of oil at the end of a year's service and thereafter at intervals of 1,000 hours of service. Textile motors of the lint-free type should run for at least three years before the bearings need inspection. C.

Oils: Viscosity-Temperature Coefficient. (1) D. F. Wilcock. (2) A. Bondi. (3) D. F. Wilcock. *Mechanical Engineering*, 1944, **66**, 739; 1945, **67**, 201-202, 202. (1) A viscosity-temperature coefficient (V.T.C.), defined as $VTC = 1 - \eta_{210}/\eta_{100}$, is proposed as a logical means of comparing the viscosity-temperature mutations among a series of oils; η_{100} and η_{210} are the kinematic viscosities in centistokes at 100 and 210° F., respectively. The advantages of this coefficient over the present viscosity index and over the American Society for Testing Materials measure of the slope of the viscosity/temperature curve are demonstrated. (2) Advantages claimed for the viscosity/temperature coefficient are shown to be unfounded. Advantages and limitations of the viscosity pole height (V.P.H.) of Ubbelohde and Walther are pointed out, and it is suggested that of all constants now in use this will best serve the purpose of a group constant for lubricating oils. (3) Advantages of the V.T.C. are emphasized. C.

Pre-lubricated Sealed Ball Bearings for Motors. O. S. Williams. *Cotton (U.S.)*, 1945, **109**, No. 4, 113. Advantages are claimed for ball bearings that are put up in the form of greased cartridges which are protected by means of metal shields held in the races by means of snap rings. They are recommended for spinning frame motors, and it is reported that a random sample of 30 bearings collected from about 600 motors in six different mills were in good condition after running 24 hours a day for more than 4 years without renewing the grease. C.

Sliding Surfaces: Frictional Properties. (1) G. I. Finch. (2) D. Clayton. (3) R. E. Reason. (4) C. Timms. (5) A. J. Griggs. (6) W. A. Tuplin. (7) D. McConnell. (8) W. E. R. Clay. (9) F. Nourse. (10) E. Swain. (11) W. Ker Wilson. (12) F. C. Johansen. *Engineering,* 1945, **159**, 215-220, 237-239, 258-260, 277-280, 299. Abridged versions are given of the following papers read at a Symposium on Surface Finish, held at the Institution of Mechanical Engineers, 9th March, 1945:—(1) The structure of sliding surfaces. (2) Surface finish in relation to friction and lubrication. (3) Some principles and methods of surface measurement. (4) Measurement of surface waviness. (5) Drawing office specification. (6) Rational specification of surface finish. (7) Requirements in surface finish. (8) Surface finish on production methods. (9) Results of modern practice. (10) Continuity in the production of specified surface finish. (11) Effect on fatigue strength. (12) Locomotive practice. C.

Hand Tachometer. Standard Machinery Co. (Providence, R.I.). *Textile World,* 1945, **95**, No. 3, 133. An illustration is given of a compact tachometer that can be used single-handed to measure speeds of rotation from 500-3000 r.p.m. within 3 per cent. of the true value. The mechanism is enclosed in dust- and moisture-proof compartment, $2\frac{1}{4}$ ins. diameter, and the scale is in a tubular extension of the contact spindle. The instrument weighs $5\frac{1}{2}$ oz. C.

Rope Drives: Maintenance. *Textile Recorder,* 1945, **63**, June, 57, 61. A simple explanation is given of the mechanics of the rope drive, with a graph of transmitted horse-power plotted against rope speed (up to 7000 ft. per minute) for ropes of $\frac{3}{4}$ to $1\frac{3}{4}$ in. diameter. Advice is given on good driving conditions and a simple trip device is shown for stopping the motor if a rope breaks or jumps out of its groove. C.

Lubricated Metals: Adhesion. F. P. Bowden and A. J. W. Moore. *Nature,* 1945, **155**, 451-452. When a curved copper slider was allowed to slide once at low speed over a mild steel surface, the coefficient of friction was high ($\mu = 0{\cdot}6 - 0{\cdot}7$), when the surfaces were clean, and many tiny particles of copper were left adhering to the steel. A photomicrograph of a taper section of one of these particles shows that the copper is firmly welded to the steel, and that the shearing of the copper has caused a plucking up of the steel above the general level of the surface. When the metals were lubricated, the friction fell to about $\mu = 0{\cdot}15$. By means of a chemical development technique, patterns have been obtained after allowing a copper slider to pass once over polished steel (*a*) when clean and (*b*) when lubricated with 1 per cent. lauric acid in paraffin. They show that adhesion of copper to the lubricated surface is quite considerable. In experiments with copper on platinum, the friction was high and irregular (μ about $1{\cdot}8$) and the surface density of copper adhering to the platinum was 2×10^{-5} g. per sq. mm. of track with clean metals. When the metals were lubricated with solid potassium stearate the amount of copper adhering to the platinum was $1{\cdot}7 \times 10^{-7}$ g. per sq. mm. The copper was distributed irregularly over the surface of the track in a number of small discrete particles of varying size. C.

Toggle Friction Clutches. R. Waring-Brown. *Mech. World,* 1945, **118**, 29-31. A review of various toggle arrangements and their special characteristics. La.

(F)—Lighting

Fluorescent Lamps: Maintenance. H. Miedendorp. *Rayon Textile Monthly,* 1945, **26**, 185-187. The writer gives a list of faults in lighting installations, stresses the advantages of fluorescent lighting and provides a table of "symptoms," causes and remedies of faulty behaviour in fluorescent lamps. C.

Knitting Mill: Lighting. E. Mauldin and H. E. Reed. *Textile World,* 1945, **95**, No. 4, 109-110. An illustrated account is given of improved lighting systems for hosiery mills. One improvement is due to the installation of fluorescent tubular lamps. Another is the use of wire with the usual diameter of conducting copper, but thinner insulation of a higher dielectric strength. This "small diameter wire" has been approved in the United States. It can be drawn into existing conduits and given a higher load. A lighting system that provides about 18 ft.-candles may be stepped up to 35 f.-c. by painting the walls and ceiling and installing fluorescent lamps, or to 55 f.-c. by the additional change to "small diameter" wiring. The following lighting intensities are suggested: Fully-fashioned or circular knitting 50, looping 75, seaming 75, inspection 100, pairing 75, mending 75, folding 35, boxing 35, boarding 35, dyehouse 30, dyehouse laboratory 100. C.

Frosted "Aklo" Window Glass: Application. Blue Ridge Glass Corporation. *Cotton (U.S.)*, 1945, **109**, No. 3, 113. An illustrated note is given of a window glass that is said to absorb about 97½ per cent. of solar infra-red radiation and to give a high diffusion of sunlight without glare. C.

Fluorescent Lamps: Limitations. R. G. Slaur. *Electrochem. Soc. Preprint*, 1945, **87**, No. 18, 213-219. The rapid growth in the use of fluorescent lamps is mentioned, some basic electrical characteristics of fluorescent lamps are reviewed, and various electrochemical problems are discussed. Two basic defects of the mercury lamp are its limited temperature range for efficient performance and the production of a small quantity of visible light which results in colour distortion of phosphors present. A table showing phosphors in common use to-day and their characteristic colours and radiation peaks is given. A good red is lacking and it is not yet possible to reproduce daylight perfectly. New phosphors are desirable and better methods and control in preparing and compounding phosphors are needed. The use of fluorescent glass tubes and of plastic tubes might be considered. C.

Fluorescent Lamps: Starting. J. A. Linder. *Electrochem. Soc. Preprint*, 1945, **87**, No. 10, 105-114. Similar characteristics of fluorescent lamps and sterilising lamps (sterilamps) are discussed. Conversion of electric energy into ultra-violet and luminous radiations is considered. Starting characteristics are studied and it is pointed out that the starting voltage may be reduced by heating the cathode. A curve is given showing the starting voltage required by the 40-watt Mazda fluorescent lamp when increasing heating currents are passed through the cathode before the starting effort is made. The operation of a glow switch is explained. Data are presented to show how the starting voltage is lowered when a conductor of the same length as the lamp is placed parallel to it and brought closer to the bulb. The detrimental effect of high air humidity is examined, and curves showing breakdown voltage against relative humidity and lamp voltage against lamp current are presented and discussed. The use of a carbon strip along the outside of the bulb wall or of a water-repellent coating to reduce starting voltages at high humidities is discussed and certain disadvantages of these devices are pointed out. It is shown that increased breakdown voltage at high humidity seems to be related to a decrease in the resistance of the glass of the bulb. C.

Hot-cathode Fluorescent Lamps: Economic Implications. A. A. Bright. *Electrochem. Soc. Preprint*, 1945, **87**, No. 8, 83-93. A detailed analysis is made of the effects of the fluorescent lamp in America upon the national income, employment and investment. It is estimated that during the third year after the war there will be 92 million lamps sold, involving the employment of 31,000 individuals. The fluorescent lamp competes with the tungsten incandescent lamp. However, substantial increases in electric lighting are to be expected as a result of the lower cost of fluorescent illumination. The total lumen-hours represented by fluorescent lamps sold have exceeded the lumen-hour reduction in incandescent lamps sold. The fluorescent lamp has, in addition brought about a definite net increase in national income and a definite net increase in employment. C.

Efficient Factory Lighting. *Production & Engineering Bulletin*, 1945, **4**, 193-6. Efficient lighting installations require expert advice, and such help is always available at the Home Office Industrial Museum. Examples from exhibits are illustrated and described. La.

(G)—Heating, Ventilation and Humidification

Hair Hygrometer Adjustable Scale. W. Koch. *J. Sci. Instruments*, 1945, **22**, 94-95. A method is described for constructing and using a scale which compensates fairly well for calibration errors. The principle involves the use of three fixed points; the appropriate scale reading is determined by the intersection of a movable line with an arc passing through each point on the scale. The line is adjusted by reference to the fixed points. An application to a hair hygrometer is considered. C.

Knitting Mill: Air Conditioning. H. E. Reed. *Textile World*, 1945, **95**, No. 4, 111-112. An illustrated article on the advantages of installing a humidifying system of the duct type in a knitting mill. The loss on second-quality production may be reduced by about 10 per cent. at a running cost for the plant of about 2 per cent. of the manufacturing cost. The following percentage relative humidities are recommended:—

	Cotton.	Acetate.	Cupram.	Viscose.	Nylon.
Throwing	—	50	55	55	45
Knitting	65	55	65	65	50
Processing	—	50	55	55	45

C.

Radiant Heating: Principles and Applications. F. M. Tiller. *Chemical Products*, 1945, **8**, 35-40. The most important factors affecting the net rate of heat transfer in radiant heating, namely, (1) intensity of radiation, (2) overall absorptivity, (3) surrounding atmosphere temperature, (4) air circulation, and (5) surface factor are studied. Industrial applications are divided into the following major classifications: (1) metal heating; (2) localized heating; (3) vaporization processes; (4) radiation used as auxiliary heat, and (5) miscellaneous processes. Examples of each class are discussed. C.

(G)—Heating, Ventilation and Humidification

Art Treasures: Storage. (1) F. I. G. Rawlings. (2) P. Fletcher, *J. Inst. Heat. Vent. Eng.*, 1943, **11** (120), 175-185, 186-200 (through *Building Sci. Abstr.*, 1944, **17**, 178-179. Rawlings discusses the physical aspects and Fletcher the engineering aspects of the safe storage of art treasures during the war. Optimum atmospheric conditions aimed at were 60 ± 3 per cent. R.H. and 60-70° F. Soft wall boards and stored textiles or paper provided extra hygrometric compensation. Wax coatings were effective in preventing moisture penetration, but polyvinyl coatings were not effective against moisture or sulphur fumes. The fading of pigments was accelerated by moisture in the air. Varnishes and oils on modern paintings turned yellow in the dark, and darkness also promoted mildew growth. C.

Dielectric Heating Systems: Limitations. C. J. Madsen. *Cotton* (*U.S.*), 1945, **109**, No. 3, 111-112. The writer presents a clear statement of the limitations of dielectric heating, with respect to cost, nature of the material, dimensions and shape of the object, frequency, voltage and loss factor, and electrode systems. C.

Gas Air-conditioning Unit. H. C. Pierce. *Mechanical Engineering*, 1945, **67**, 171-174, 189. An all-year air conditioner designed to provide heating, humidifying, air cleaning and circulation in winter, and cooling, dehumidifying, air cleaning and circulation in summer consists essentially of an indirect steam-heating system, an absorption refrigeration unit, an air-filtering section, and a centrifugal-fan section. The unit contains a gas-fired boiler or steam generator. During the winter cycle, steam is delivered to a heating coil within the fan section of the unit assembly. During the summer cycle steam is delivered to the absorption refrigeration unit also contained within the unit assembly. Any of the functions of complete air conditioning is available, by selection, through a co-ordinated control system. Temperature conditions are automatically maintained as desired. The complete conditioner is compact and requires little space for installation. Models of different capacity will be available. Diagrams, and details of the construction, operation and performance are given. C.

Heat Pumps: Application. C. A. Meier. *Modern Power and Eng.*, 1945, **39**, No. 2, 41-43 (through *Chem. Abstr.*, 1945, **39**, 1577[8]). The use of a heat pump with ethyl bromide as the heat-carrying agent is discussed. With river water at 44° F., the water for the heating system can be raised to about 113° F. The heat pump should be close to the water source. The initial cost of heat pumps will probably be greatly reduced with large-scale manufacture, but owing to high costs, the load factor must be considered. This is helped by the use of the same machine for summer cooling. Several heat-pump installations using air as a heat source have been successfully made in Switzerland. The heat-pump cycle can be used to advantage in industrial plants where the waste heat from driers and evaporators can be reclaimed (as by the use of thermo-compressers) and brought back to the process. Applications to a rayon plant, to the evaporation of milk and in paper manufacture have been made. C.

Hot Water Systems: Safety Devices. S. G. Saunders. *Industrial Heating Engineer,* 1945, 7, 81-4, 92. The author considers that the provision of adequate safety devices on hot water systems is essential especially as relief valves do not always function when required. A number of layouts are considered from this point of view and suitable safety devices are suggested. La.

(H)—Water Purification

Coloured Water: Treatment with Activated Silica. R. E. Noreus. *Paper Trade J.,* 1945, **120,** *TAPPI,* 101-103. Activated silica is a stable silica sol formed by releasing most of the silica from the alkali in a sodium silicate solution (e.g. by treatment with ammonium sulphate), ageing for a period during which the silica micelle grows in size and then diluting at some point before the micelles have become large enough to form a gel. The use of this material in combination with the usual alum treatment for the treatment of highly coloured water containing colloidal particles derived from decaying organic matter results in filtered water of lower colour and turbidity and permits increased quantities of water to be treated in the same equipment. Successful operation of this method by a paper-making company is reported and details of the filter plant equipment are given. C.

De-ionized Water: Advantages. S. F. Alling. *Textile World,* 1945, **95,** No. 3, 121, 204-6. A chart is given to show the monthly fluctuations in hardness of two river waters that supply Philadelphia and the advantages of base-exchange treatment to remove both anions and cations are stressed. Illustrations are given of a plant capable of providing 3,000 gals. per hour of de-ionized water at a cost of about 4-10 cents per 1,000 gals., according to the nature of the raw water. C.

(I)—Waste Disposal

Lanolin Soaps. M. A. Lesser. *Soap,* 1945, **21,** No. 4, 41-44, 86. Because of its emollient properties lanolin is a superior material for superfatting purposes, and is extensively used as a protective agent in industrial occupations liable to cause dermatitis, e.g. those involving the use of oils, tars and solvents. 40 references are given to the relevant literature, taken from research on dermatology and toilet soap manufacture. W.

Cholesterol: Separation from Degras. L. Yoder, O. R. Sweeney and L. K. Arnold. *Ind. Eng. Chem.,* 1945, **37,** 374-377. Wool fat (degras) was saponified in 52·5 lb. batches by sodium hydroxide, and the unsaponifiable material extracted from the wet soaps by gravity separation with ethylene dichloride. Cholesterol of 97 per cent. digitonin precipitability was prepared from the unsaponifiable extract in 4 lb. yields per batch by a pilot process based on the formation of the oxalic acid addition product insoluble in ethylene dichloride solutions. By-products obtained per batch were 37 lb. fatty acids, 14 lb. oily unsaponifiable material, and 9 lb. isocholesterol wax. W.

Fly-Ash Disposal. "Observer." *Steam Engineer,* 1945, 14, 295-8, 303. A review of important investigations carried out by the Detroit Edison Co. concerning the disposal of fly-ash arising from pulverised coal firing. In general possible uses seem to be as mineral fillers in bitumastic road construction, in standard concrete, and possibly to make a light weight concrete, but the handling problem is very serious and the future outlook is not very promising. La.

Patents.

Cyclically-operated Machines: Automatic Control. Watson, Laidlaw & Co. Ltd. and W. L. B. Ingles. B.P.569,485 of 21/8/1943:25/5/1945. The system of control is based on the use of cams fitted to a rotating shaft and acting on hydraulic valves. Thrustors are employed to operate equipment or main valves and the safety devices are included in the scheme. As described here the system is applied to machines for the extraction of sugar and the operations controlled include filling, extracting at speed, reducing speed to a value suitable for the ploughing operation, and passing the effluent into various channels or tanks according to its nature. Machines can be controlled singly or in groups and the device could be fitted to washing or other types of machine. La.

Steam Boilers. Foster Wheeler Ltd. B.P.566,972 of 6/7/1943:22/1/1945. A steam boiler has two furnaces arranged side by side and they are separately fired by fuel burners. Baffles are arranged so that the furnaces are completely separated at the burner end, but at the uptake end the gases from one furnace are gradually distributed across the other furnace. La.

Fluid Purification System. American Cyanamid Co., W. W. Durant and W. A. Blann. B.P.569,660 of 22/1/1943:4/6/1945. A system of water purification involving the use of beds of cation and anion exchange material is arranged to give an indication and to take necessary action when the beds are exhausted and require reactivating. After passing through alternate beds of cation and anion exchange materials the water flows through a bed of anion exchange material, which is buffered, so that under normal working conditions the effluent has a known *p*H. This effluent passes through a glass electrode system or through a conductivity cell so that any change in *p*H or solid content is immediately apparent. When the beds are exhausted there is a sudden change in *p*H, which is not eliminated by the buffer bed and this condition is indicated by suitable means and made to actuate valves to stop the flow. The system is especially suitable for producing a high grade drinking water or water of distilled quality. La.

9—PURE SCIENCE

Chlorazol Black Stain: Use in Mycology. F. D. Armitage. *Trans. Brit. mycol. Soc.*, 1945, **27**, 131-153 (through *Rev. Appl. Mycol.*, 1945, **24**, 199). Directions are given for the use of chlorazol black E as a stain for fungi. The dye can be added to lactophenol mixtures for use as temporary mounts. Sufficient dye is added to produce a dense, black solution, and is allowed to stand two or three days before filtering for use. Permanent slides can be prepared by using a saturated stain in 70 per cent. ethyl alcohol or better still absolute methyl alcohol, the stain being allowed to act for at least three hours and the excess stain removed by washing in 70 per cent. alcohol before mounting in euparal. Dioxane-diethylene dioxide can be used as a dehydrating agent for specimens stained in alcoholic chlorazol black E. C.

Indicators for *p*H Determinations: Sources of Error. H. Seymour. *Industrial Chemist*, 1945, **21**, 243-249. Some general precautions to be taken in colorimetric *p*H determinations are outlined and errors due to different lighting, temperature effects, and absorption of carbon dioxide are considered. Buffer action, the nature of indicators, *p*H determinations in unbuffered or slightly buffered materials, the adjustment of indicators to the midpoint of their *p*H ranges, storage of indicators and sources of contamination, the disadvantages of universal indicators, the use of short range indicators, determinations of *p*H values of turbid materials, the dichromatism of indicators, the action of free chlorine and hypochlorites and the effect of solvents on indicators, and disadvantages of test papers and colour charts are discussed. C.

Nitric Oxide: Determination. W. R. Dudden. *Industrial Chemist*, 1945, **21**, 258-259. A method for the determination of small quantities of nitric oxide in coal gas depends on quantitative conversion of the nitric oxide to nitrogen peroxide by reaction with the nascent oxygen formed at the anode of an electrolytic cell. The nitrogen peroxide is made to react with Griess reagent, where it first appears to unite with water to form nitric and nitrous acids, the latter then combining with the reagent to give the coloured diazo compound. A diagram and description of the apparatus are given. C.

Dimethylaniline: Determination. J. Haslam and P. F. Hearn. *J. Soc. Chem. Ind.*, 1945, **64**, 152. The authors refer to a statement concerning the acid concentration in their method of determining dimethylaniline, made by Spencer and Brimley, and point out that it is the concentration of mineral acid which is important, the acetic acid having little influence on the test. Data showing the effects of hydrochloric and acetic acid concentrations are quoted. C.

Hydrocarbon Oils: Potentiometric Determination of H-ion Concentration. A. Gemant. *J. Chem. Phys.*, 1945, **13**, 146-154. The author discusses potentiometric measurements of hydrogen-ion concentration carried out in hydrocarbon oils that have attained high electrical conductivity (*a*) through oxidation in the laboratory, (*b*) through deterioration in service, (*c*) through addition of certain compounds. The e.m.f. data are interpreted by comparing them with those obtained from lauryl sulphonic acid solutions in oil. The results indicate that the hydrogen-ion concentration in the three types of oils is too low to account for the total observed electrical conductivity. The predominant mechanism of ion generation must, therefore, be different from the usual acidic dissociation. A bimolecular reaction leading to two organic ions is suggested on the basis of evidence from organic chemistry and a quantitative relation that follows from conductivity data presented in this paper. C.

Acetylated Castor Oil: Preparation and Thermal Decomposition. O. Grummitt and H. Fleming. *Ind. Eng. Chem.*, 1945, **37**, 485-491. Castor oil is easily and quantitatively acetylated by acetic anhydride. Acetic acid, in the presence of *p*-toluenesulphonic acid as catalyst, leads to hydrolytic splitting of the glycerides unless the water of esterification is immediately removed. With continuous fractional distillation during esterification, castor oil can be acetylated with acetic acid. Acetylated castor oil slowly decomposes at 250° C. to form acetic acid and an oil of greater unsaturation than castor oil. The rate of decomposition has been measured at 295°, 300°, 306°, 312°, 320°, 330° and 340° C. The process is first order with an energy of activation of 44·5 kg.-cal. The thermal polymerization which occurs during the reaction can be minimized by high temperatures (320-340° C.) and short reaction times. The product is a light yellow oil having about 30 per cent. of molecules containing a pair of conjugated double bonds and suitable for use as a drying oil in protective coatings. C.

DDT Insecticide: Development and Applications. T. F. Webb and G. A. Campbell. *Chemistry and Industry,* 1945, 156-158. The work on insecticides that led to the development of DDT is reviewed, and tests of its action on various pests and applications to the control of flies and mosquitoes are briefly discussed. C.

Tall Oil: Uses. W. H. Jennings. *Paper Trade J.*, 1945, **120**, *TAPPI*, 185-186. Tall oil is at present used in the preparation of soluble oils by sulphonation, the manufacture of industrial soaps, as an additive to laundry soaps, in the preparation of asphalt emulsions, and in the concentration of phosphate and other ores by flotation. The addition of sulphonated tall oil to soluble oils made from oleic acid tends to stabilize the mixture. Sulphonated tall oil is an ideal emulsifying agent for use in the manufacture of so-called cold water or casein paints. Attempts to separate the components have not yet been wholly successful. By fractional distillation under vacuum a fatty acid fraction containing up to 95 per cent. fatty acids and 5 per cent. rosin acids and a rosin fraction consisting of approximately 95 per cent. rosin and 5 per cent. fatty acids are obtained. The composition of tall oil varies with the species of wood, time of cutting and storing, cooking procedures, etc. Fatty acid fractions consist of linoleic acid 50-80 per cent., linolenic acid 5-15 per cent., oleic acid 17-45 per cent. By changing the linoleic acid over to its conjugated isomer and esterifying with glycerol, a drying oil is obtained which surpasses linseed oil in its drying properties. Possible uses of the separated fractions of tall oil are mentioned, and it is pointed out that, in addition to the rosin and fatty acids, about 3-4 per cent. of sterols may be obtained. C.

Zeolites: Use as Molecular Sieves for Separation of Mixtures. (1) R. M. Barrer. (2) R. M. Barrer and L. Belchetz. (3) R. M. Barrer. *J. Soc. Chem. Ind.*, 1945, **64**, 130-131, 131-133, 133-135. (1) Reasons are given for the unique selectivity in sorption of certain zeolites, and molecular size and shape factors are indicated which determine whether or not a molecule can be occluded by the zeolite. Three different classes of molecular-sieve zeolites are defined, examples are mentioned, and lists are given of molecules occluded and excluded by each type. (2) The use of chabazite to separate gaseous and liquid hydrocarbon mixtures is described. Hydrocarbons with one or two carbon atoms have been separated from higher paraffin and cyclic hydrocarbons at room temperature or below, and at higher temperatures quantitative separations of *n*-paraffins from admixture with *iso*-paraffins and aromatic hydrocarbons have been effected. Possible limitations of the molecular-sieve method are discussed. (3) Chabazite, mordenite, and calcium and barium mordenites, as representatives of the three classes of zeolites, have been used for the separation of polar molecules from mixtures containing them. It was possible to resolve mixtures the components of which had nearly the same boiling point, and others which were azeotropic. The scope and possible uses of the method are discussed. C.

Bubbles: Formation and Growth in Aqueous Solutions. J. B. Bateman and J. Lang. *Canadian J. Res.*, 1945, **23** E, 22-31. An account is given of a preliminary study of the formation of bubbles in simple and colloidal aqueous solutions containing dissolved nitrogen and carbon dioxide when subjected to decreased pressures in a simple dilatometer. The experiments support the view that all aqueous solutions contain a small number of foci for bubble formation. The presence of these foci is shown by a rapid transient evolution of gas immediately following a large rapid reduction of pressure. The nuclei are rather specific in character: the majority of the particles in suspensions of charcoal, blood corpuscles, and various hydrophobic substances, are unable to function in this manner. When decompression occurs in small steps, evolution of gas is mainly attributable to bubbles formed at preferred spots on the vessel wall, and observed variations in rate of growth are analysed in terms of the nature of the dissolved gases (nitrogen or carbon dioxide), the pressure gradient, and the relative importance of pure diffusion and convection under various conditions. In particular, the observed effect of carbon dioxide in accelerating the growth of nitrogen bubbles is attributed mainly to its high absorption coefficient rather than to any specific effect upon the number of gas nuclei. C.

Foams: Drainage. G. D. Miles, L. Shedlovsky and J. Ross. *J. Phys. Chem.*, 1945, **49**, 93-106. An account is given of measurements of the rates of liquid flow through foams as a function of the amount of liquid held in the foam with the liquid uniformly distributed throughout a column of foam at constant temperature, and of investigations of some of the effects of varying temperatures, bulk and surface viscosity and bubble size. Some typical measurements of drainage rates in homogeneous stable foams are also reported. The measurements were made with solutions of sodium lauryl sulphate, Igepon T and Syntex M. It was found that the rate of flow of liquid through foams of relatively uniform bubble size can be expressed by an equation of the form $y=ax^n$, where y is the rate of flow of liquid through the foam, and x is the volume of liquid in the foam. The rate of drainage of liquid through foams can be approximated to by an equation of the type obtained by considering the analogous, but much simplified flow of liquid in a vertical capillary. The rates of flow of liquid through foams decrease with increase in both surface and bulk viscosities. Decrease in bubble size causes a decrease in the rate of flow of liquid through the foam, and the changes become relatively greater at higher rates of flow or larger amounts of liquid in the foam. Temperature effects vary considerably for different solutions and differences in flow characteristics through foam are more pronounced at lower temperatures. These results indicate that methods of evaluating foam stability solely from observations of relative foam drainage of liquid are not generally valid and can be misleading. C.

Liquid/Solid Surface: Contact Angles. D. C. Pease. *J. Phys. Chem.*, 1945, **49**, 107-110. The significance of contact angles and their relation to the work of adhesion and the wetting characteristics of solids are discussed. It is emphasized that the junction of the air-liquid interface with the solid surface is fundamentally a one-dimensional system. This line of junction can occupy various possible parallel positions on the plane of the solid surface, and different positions allow different mean works of adhesion depending upon the configuration of the different groups exposed on the solid surface. The equilibrium contact angle is related directly to the line of least possible mean work of adhesion that the three-phase junction can assume. The receding contact angle is related directly to the line of greatest possible mean work of adhesion. The advancing contact angle is dependent upon the greatest possible amount of work necessary to wet the solid surface. This, in turn, is inversely related to the least possible mean work of adhesion. The conclusion is drawn that the over-all mean work of adhesion between liquid and solid cannot be determined by contact-angle measurements except, perhaps, in a few very special cases. C.

Sodium Lauryl Sulphate Solutions: Surface and Interfacial Tension Curves. G. D. Miles. *J. Phys. Chem.*, 1945, **49**, 71-76. The interfacial tension/concentration curve for solutions of pure sodium lauryl sulphate against benzene does not show a pronounced minimum, but solution of a mixture of pure sodium lauryl sulphate and pure sodium heptadecane-2-sulphate, 100 moles to 1, does exhibit such an effect. The bulk concentration at which this minimum occurs and the actual interfacial tension values observed for this mixture correspond to the bulk concentration where the greatest slope and the lowest interfacial tensions are observed for equivalent mixtures of pure sodium heptadecane-2-sulphate and sodium chloride. Minima in surface or interfacial tension/concentration curves have been produced by deliberate contamination of solutions of pure, surface-active primary or secondary alcohol sulphates with a second surface-active material. In all cases, attempts at selective adsorption at either an air-liquid or a benzene-liquid interface have shown these minima to occur at bulk concentrations where the relative surface concentration of the minor component is at a maximum. C.

"Megapermselective" Collodion Membranes: Electrochemical Properties. K. Sollner. *J. Phys. Chem.*, 1945, **49**, 47-66. The nature and action of membranes are discussed and a definition for physico-chemical membranes is suggested. The characteristic electrochemical properties of collodion membranes are shown to be due to the presence of anionic (i.e. acidic) impurities (oxy-nitrocellulose, "nitrocellulosic acid") in the collodion. Methods of electrochemical activation of collodion and collodion membranes are reviewed and improvements in technique are described. Collodion membranes of the dried type may now be prepared that combine extreme ionic selectivity with very great permeability for the unrestricted ion. Over wide ranges of concentration such electronegative "megapermselective" collodion membranes prevent the penetration of anions while readily permitting the exchange of alkali (and certain other) cations across their thickness. The absolute permeability of these megapermselective collodian membranes is three to four orders of magnitude greater than that of any previously described membranes of high ionic selectivity. The method for the preparation of electropositive membranes by the adsorption of protamine on highly porous collodion membranes has been improved. The preparation of electropositive "megapermselective" protamine collodion membranes is described. These membranes—except for a small leak of cations—are in their properties strict electropositive analogues of the electronegative "megapermselective" collodion membranes. C.

Capillary Viscometer with Variable Rate of Shear. C. M. Davies. *Rev. Sci. Instruments*, 1945, **16**, 98. The instrument comprises a manostat, a viscometer, and a flowmeter. The last two and their connecting tube are mounted in a frame and totally immersed in a thermostat-controlled water bath. A filter pump attached to a water tap provides a source of suction which is controlled to apply constant pressure to one limb of the viscometer by means of the manostat. The volume of liquid which is sucked through the viscometer capillary in a given time is measured by the flowmeter joined to the other limb. This consists of an inclined tube filled with thin paraffin. The filter pump is connected through a reservoir to one side of a rubber diaphragm in the manostat; if the suction becomes too great the diaphragm moves away from a flat ended tube on the other side and air leaks in. By using three diaphragms of different thickness, all pressures from 1 cm. water down to 15 cm. mercury below atmospheric can be controlled. Various manometers are used to measure the applied suction and to check its constancy. A diagram and details of the method of operation are given. C.

Cellulose Acetate Fractions: Intrinsic Viscosity and Molecular Weight. A. M. Sookne and M. Harris. *Ind. Eng. Chem.*, 1945, **37**, 475-477. A report is given of measurements of the intrinsic viscosities and osmotically estimated number-average molecular weights of a series of cellulose acetate fractions obtained from a starting material having an acetyl content of 38·6 per cent., an ash content of 0·06 per cent., a melting point of 250° C., and a char point of 301° C. Within the range of chain lengths investigated (number-average molecular weight up to 130,000), the number-average molecular weights are proportional to the intrinsic viscosities in acetone solutions, in agreement with Staudinger's rule and the results of Kraemer. An estimate is given of the relative homogeneity with respect to molecular size of the fractions and the starting material from which they were prepared. C.

Wheat Flour, Starch and Gluten: Separation. G. A. Adams, G. A. Ledingham and N. H. Grace. *Canadian J. Res.*, 1945, **23** F, 143-154. Starch and gluten were separated from wheat flour in a washing vessel, hemicylindrical in shape, oscillated 48 times per minute through 45°, accommodating 15 kg. of water plus the dough prepared from 3 kg. of patent hard spring flour. Washing action was provided by the combined movements of the vessel and an adjustable free-swinging rubber-covered roller. The starch suspension was continuously pumped into a settling tray, from which the overflow was recycled to the washing machine. Under these conditions 45 min. of washing with 40 kg. of water effected a recovery of about 95 per cent. of the starch and gluten present in the dough. About 70 per cent. of the starch was extracted in the first 10 min. washing period. Washing was more efficient at 37° C. than at lower temperatures, and dough mixing times of 9 min. gave better results than 3 min. The washing equipment provided results of a precision that permitted demonstration of statistically significant differences between starch yields differing by as little as 3 per cent. C.

Wheat Gluten: Effects of Processing Factors on Starch Content. N. H. Grace and K. A. Clendenning. *Canadian J. Res.*, 1945, **23** F, 155-160. The effects of dough mixing time, dough conditioning, and washing temperature and time upon the mechanical separation of starch and gluten were studied in duplicated factorial experiments in which straight and clear grades of hard red spring wheat flour were employed. Glutens of low starch content were obtained over a considerable range of processing conditions, washing time being the factor of greatest importance. After comparable washing periods of 45, 60 and 90 min., average starch contents were 7·3, 2·4 and 0·8 per cent., respectively. The practicability of employing water recirculation in the batch preparation of practically starch-free gluten has also been demonstrated. C.

Alkali Palmitates: Thermal Transitions. R. D. Vold and Marjorie J. Vold. *J. Phys. Chem.*, 1945, **49**, 32-42. Transition temperatures are reported for the complete series of alkali palmitates between 25°C. and the melting points, together with their approximate heat effects. The sets of transitions are closely related, though not exactly parallel for the five substances. For all, one of the transitions can be identified as that at which microscopic external crystal form gives way to a measure of fluidity. For lithium palmitate this temperature is the melting point to isotropic liquid, 223° C.; for the remainder of the sequence, loss of microscopic crystallinity occurs at progressively lower temperatures and occurs before complete melting. The temperature of formation of neat soap, for all soaps having this form, is very nearly independent both of the nature of the cation and of the length of the fatty radical, and is therefore believed to involve a special spatial equilibrium of attractive and repulsive forces between the chains. C.

Zein: Molecular Dimensions. J. F. Foster and J. T. Edsall. *J. Amer. Chem. Soc.*, 1945, **67**, 617-625. The theory of double refraction of flow and its application to the determination of molecular length is reviewed briefly. Through the use of a new apparatus providing velocity gradients as high as 30,000 sec^{-1} together with the technique of high-viscosity solvents (propylene glycol), it has been possible to study by this method the relatively short, corpuscular protein, zein. Experimental details are given and results are tabulated. The results are in satisfactory agreement with sedimentation, diffusion and viscosity measurements on this protein when compared on the basis of a prolate ellipsoidal molecule roughly 300-400 A. in length. C.

Zein and Gliadin: Partial Specific Volumes. J. F. Foster and D. French. *J. Amer. Chem. Soc.*, 1945, **67**, 687-688. A dilatometric technique for the measurement of partial specific volumes is described. Results are given for various zein preparations in 73 per cent. aqueous alcohol and for gliadin in 62 per cent. alcohol. The value of 0·776, obtained for the more purified preparations of zein, is the highest value yet reported for any unconjugated protein. The partial specific volume of zein appears to be independent of alcohol concentration over the range 52-73 per cent. A value of 0·724 was obtained for gliadin. C.

Infra-red Spectroscopy: Developments in Technique. G. B. B. M. Sutherland and H. W. Thompson. *Trans. Faraday Soc.*, 1945, **41**, 174-179. Developments in prism materials, optical systems and recording devices of infra-red spectrometers, and in methods of calibration, are reviewed. Double beam spectrometers are briefly discussed. Probable lines of future developments in infra-red spectroscopy are indicated. C.

Infra-red Absorption Spectroscopy: Use in Analysis. (1) H. W. Thompson and G. B. B. M. Sutherland. (2) D. H. Whiffen, P. Torkington and H. W. Thompson. *Trans. Faraday Soc.*, 1945, **41**, 197-200, 200-209. (1) The application of infra-red spectroscopy to qualitative and quantitative analysis is discussed and problems and advantages of this method are pointed out. (2) Examples are described of infra-red analyses of cresols and xylenols, anilines, methyl-anilines and toluidines, dimethyl-butadienes, mixtures of alkyl and aryl phosphites and phosphonates, mixtures of alkyl thiocyanates and isothiocyanates, and a mixture of four stereoisomers, and of the detection of impurities in 2:4-dichloro-benzoic acid, in solvents and analytical reagents, and in biological and pharmaceutical materials. C.

Polymers: Infra-red Spectra. H. W. Thompson and P. Torkington. *Trans. Faraday Soc.*, 1945, **41**, 246-260. The infra-red absorption spectra of compounds of high molecular weight, such as polythene, polyisobutene, rubber, Buna 85, polystyrene, polyvinyl acetate, polymethyl acrylate and methacrylate, polyvinyl alcohol, nylon, Novolac resin, cellulose acetate and aceto-butyrate, and various interpolymers are discussed and the conclusions that can be drawn from them regarding the structure of the polymers are considered. The use of infra-red spectra for following polymerisation and interpolymerisation processes, and for studying problems such as the determination of head to head or head to tail addition in the polymerisation of vinyl compounds is discussed. C.

Rubber: Elasticity. L. R. G. Treloar *Discovery*, 1945, **6**, 107-110. The author explains the elasticity of rubber on the basis of the randomly-kinked chain structure of its molecules, and discusses the structure of rubber in bulk, the effect of vulcanisation, the effect of low temperatures, the glassy and crystalline states of rubber, and the crystallisation of rubber on stretching. C.

Colour and Growth of Hair in Rabbits. C. W. Hale. *Nature*, 1945, **155**, 670-671. Hair growth on the rabbit appears to follow a similar course to that reported by Haddow *et. al.* for the rat (these *Abs.*, 1945, A 358). In rabbits with coloured hair the waves of rapid growth, disposed symmetrically about the longitudinal axis, are observed on the depilated animal as raised coloured areas 0·5-5·0 cm. wide. When the hair ceases active growth, the pigment is restricted to the distal part. In the Flemish Giant each hair shaft has bands of different colour which always appear in the same order; hence, by noting the colour of the shafts just emerging from the skin, the direction of the growth wave may be estimated. In albino rabbits rapid hair growth seems to occur in raised hyperæmic areas in which the pink colour suggests dilatation or abundance of skin vessels; no such areas have been noted on depilated guinea pigs. Hair growth on the rabbit may be artificially modified by agents that induce localized hyperæmia. It appears likely that in the rabbit both rapid growth and natural pigmentation of the hair shaft are correlated with local increased blood supply to the hair follicles. W.

10—ECONOMICS

Silk: Economic Future in the United States. I. Teplitz. *Rayon Textile Monthly*, 1945, **26**, 180-181. The disadvantages of silk in competition with rayon are (1) fluctuating price and manipulations of financial interests, (2) bad marketing, and (3) limited scope for technical improvements. In 1938 the United States consumed 51 million lb. of silk, about 80 per cent. being converted into ladies' hosiery. In 1944 the United States produced 555 million lb. of continuous filament rayon and 168 million lb. of rayon staple, and nylon production was equivalent to another 18 million lb. of hosiery yarn. To compete successfully with fine, high-tenacity and nylon hosiery yarns, silk would need to be not more than 85 cents to 1 dollar per lb., whereas in 1941 it was 3 dollars. To improve the competitive power of silk the author suggests that (1) a guaranteed fixed price is necessary, and (2) the production of silk must be modernised, and raw silk put up in more convenient packages and in a range of deniers, say 50, 75, 100, 150, etc. C.

Textile Wholesale Prices, April, 1945. *Bd. Trade J.*, 1945, **151**, 222. The index numbers for April are Cotton 160·6, Wool 184·1, Other textiles 138·6, All articles 167·7 (1930 = 100). C.

11—INDUSTRIAL WELFARE, INDUSTRIAL PSYCHOLOGY AND EDUCATION

Byssinosis: Absence in Mississippi Cotton Industry. W. L. Ritter and M. A. Nussbaum. *J. Ind. Hyg. Toxicol,* 1945, **27**, 47-51 (through *Chem. Abstr.*, 1945, **39**, 1993[9]). Byssinosis does not exist as a clinical entity among employees exposed to Upland cotton in the cotton industry in Mississippi. C.

Human Body: Reactions to Atmospheric Conditions. D. Brunt. *Nature*, 1945, **155**, 559-564. A discussion of bodily reactions to heat and cold, limits of heat-stroke conditions, acclimatization, effect of increased ventilation, classification of climates, the ideal climate, and the development of the weather-proof house in England. C.

American Quartermaster Corps Research Organization. G. F. Doriot. *J. Applied Physics*, 1945, **16**, 235-243. A report is given of the organization and work of the Research and Development Branch of the Military Planning Division of the Office of the U.S. Quartermaster-General. Some of the principal developments in the study of clothing, textiles, food, shelter and equipment are mentioned. These include the use of pile for arctic inner garments; the establishment of the principle that layers of clothing give better protection against the cold than one bulky, heavy garment; production of mosquito-proof tropical garments and a suit for protection against body lice; the use of nylon in parachutes, mountain ropes, jungle hammocks, tents, etc.; the development of new laundering methods to retain water repellency in clothing; the manufacture of a light-weight unimpregnated cloth which is water- and wind-proof by virtue of its construction alone; and a treatment of canvas duck that will make it resistant to fire, water, mildew and weathering. C.

Scientific Research: Development in India. *Nature*, 1945, **155**, 525-529, 532-535. (1) The history of scientific activity in India is reviewed and comments are made on the report made by Professor A. V. Hill after his tour of Indian centres of science, medicine and technology in 1943-44. The report stresses the need for great expansion in scientific, medical and industrial research and proposes the establishment of a Central Organization for Scientific Research with medical, agricultural, industrial, surveys and natural resources, engineering, and war research boards. The need for improved educational facilities, and the desirability of establishing a co-ordinating organization for Indian non-official scientific bodies are discussed. (2) A summary is given of Professor Hill's report which includes sections on scientific liaison and an Indian scientific office in London, scientific liaison with the United States, research training of young Indians in the United Kingdom, a research background in medical education, an All-India medical centre, medical research, vital statistics and population, agricultural research, surveys and natural resources, industrial research under the Government, scientific research in industry, technology, meteorological research, scientific instruments and equipment, post-war disposal of Government stock, research for fighting services, a central organization for scientific research, a central register of scientific and industrial personnel, pay and status of scientific workers in Government service, scientific societies in India, scientific research in Indian universities, and private benefactions in science. C.

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