paper technology

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No 2

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PAPER TECHNOLOGY

Journal of the Technical Section
British Paper and Board Makers' Association

INCORPORATING TECHNICAL BULLETIN AND
PROCEEDINGS OF THE TECHNICAL SECTION *

April 1960 Vol. 1 No. 2

CONTENTS

Proceedings papers

*IMPORTANT NOTICE ON PAGES **127** & **128** *

Bulletin

Secretary and Editor – Francis M. Bolam

Assistant Editor – W. J. Abercrombie

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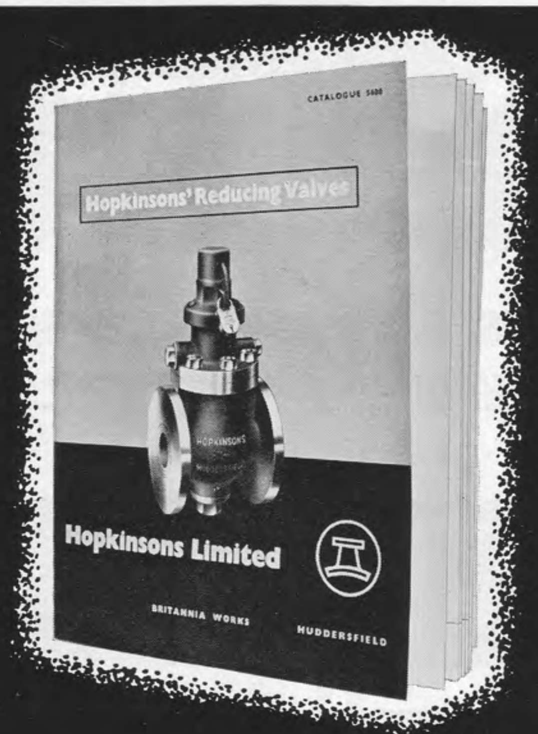
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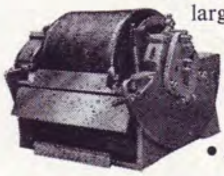

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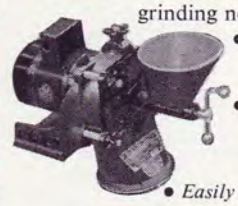

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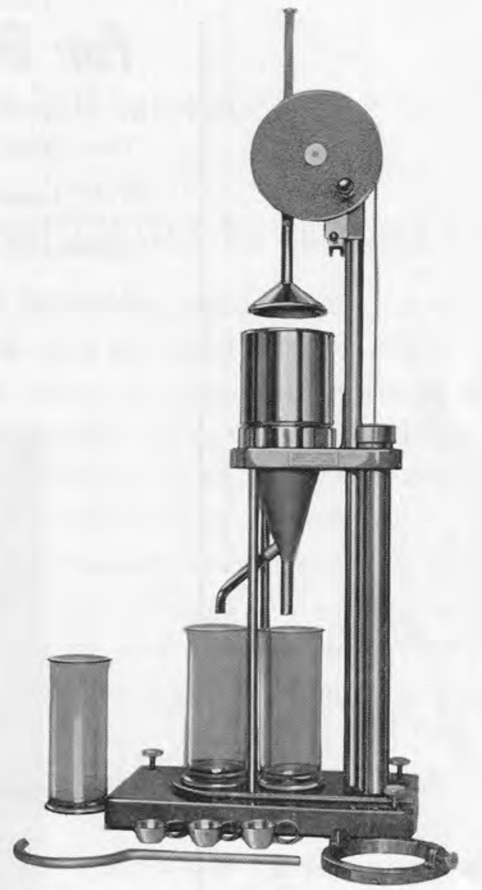
No. 850



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NEWS PAGE

Technical Section membership

DURING January and February 1960, the changes in membership were as shown—

Newly enrolled

London Division—
T. C. Bang.—*Associate*
H. J. Britain—*Associate*
B. M. Campbell—*Full*
G. R. Cooper—*Associate*
A. P. Dydensborg—*Associate*
K. B. Fissenden—*Junior*
W. Fray—*Full*
R. A. German—*Full*
D. J. H. Gow—*Full*
W. P. Hamill—*Full*
R. T. Heathcote—*Full*
A. A. Ives—*Full*
R. A. Jardine—*Junior*
K. J. Jarrett—*Associate*
G. M. Johnston—*Associate*
H. G. Johnston—*Full*
P. E. Jones—*Full*
F. H. Maddox—*Associate*
E. P. Noble—*Associate*
A. Parker—*Junior*
J. R. Parker—*Full*
E. W. Peacock—*Associate*
A. L. Penfold—*Junior*
E. A. Price—*Full*
R. Smith—*Junior*
T. M. Stephens—*Full*
D. H. S. Swain—*Junior*
G. W. P. Swenson—*Associate*
C. Ward—*Junior*
W. G. Willoughby—*Associate*
K. Wilson—*Full*
L. A. Wilson—*Full*

Scottish Division
A. R. Brown—*Full*
J. A. S. Cables—*Full*
J. C. Gurney—*Associate*
M. J. Hartwell—*Full*
W. B. Hay—*Full*
E. W. D. Jardine—*Full*
R. F. Kitson—*Junior*
I. R. Napier—*Junior*
T. J. Stein—*Full*
H. A. B. Wilson—*Full**

Northern Division—
J. Adcock—*Associate*
M. J. R. Baker—*Junior*
J. Barrell—*Associate*
R. Booth—*Junior*
G. Chapman—*Junior*
P. M. Corbould—*Associate*
J. Critchley—*Associate*
F. H. Fletcher—*Full*
R. P. Forrest—*Associate*
T. B. Gilleard—*Full*
E. Gillibrand—*Associate*
I. Greenwood—*Associate*
J. M. Holt—*Junior*
T. Jennings—*Associate*
E. G. Miles—*Associate*
H. G. Ogden—*Associate*
M. A. Privett—*Associate*
J. R. Rodriguez—*Associate*
D. Sewell—*Junior*
D. J. H. Temperley—*Full*

Western Division—
M. C. W. Brayley—*Associate*
A. R. Claridge—*Junior*
A. Evans—*Full*
A. E. Glew—*Full*
J. Hacking—*Associate*
M. G. Jones—*Full*
N. J. King—*Junior*
S. D. Orr—*Junior*
T. S. R. Parkin—*Full*
A. M. Pirie—*Associate*
D. Rees—*Junior*
K. M. Stables—*Full*
R. Turner—*Associate*

Overseas Associate—
N. J. Beckman
E. Langins
J. de Vries

* Reinstated

Resignations and withdrawals

London Division—
H. W. Adams—*Full*
T. E. Barth—*Associate*
B. H. Benger—*Junior*
J. Brown—*Associate*
J. H. Cornish—*Full*
E. A. Dawe—*Associate*
A. E. Drummond—*Full*
G. J. W. Earl—*Junior*
M. W. Goodyer—*Full*
W. E. Grossett—*Full*
H. A. Harding—*Full*
P. N. Harvey—*Associate*
J. B. Herbert—*Associate*
R. Homewood—*Full*
C. R. Latham—*Full*
J. Lawton—*Full*
A. F. Leach—*Full*
H. N. McLean—*Associate*
H. D. MacMurray—*Associate*
G. R. Manser—*Full*
M. Marshall—*Full*
M. A. Massey—*Full*
R. A. Montgomery—*Full*
C. A. Morgan—*Junior*
T. Muir—*Associate*
A. E. Nicholas-Gibbs—*Associate*
D. B. Orr—*Associate*
N. Peart—*Associate*
C. Spice—*Full*
E. B. Steel—*Full*

Northern Division—
J. M. P. Adam—*Full*
J. Baggallay—*Associate*
E. Batty—*Associate*
J. S. H. Bradley—*Associate*
T. F. Brown—*Full*
R. Carter—*Full*
J. S. Clouston—*Full*
H. Crosdale—*Associate*
E. Dean—*Full*
F. W. Grimshaw—*Associate*
J. L. Humphreys—*Full*
D. W. Leggott—*Full*
J. P. Lord—*Associate*
H. Minshall—*Associate*
H. Redfern—*Associate*
J. Taylor—*Full*
H. A. Thomas—*Full*
R. Tomlinson—*Full*
G. F. Ward—*Associate*

Scottish Division—
R. Howarth—*Associate*
G. M. Irvine—*Associate*
D. E. Kirkcaldy—*Full*
R. Leighton—*Full*
J. W. McConville—*Junior*
A. K. Macdonald—*Full*
W. M. Murdoch—*Junior*
C. Peebles—*Full*
D. J. A. Simmonds—*Full*
A. A. Traill—*Associate*

Western Division—
R. E. W. Bennett—*Full*
W. B. Burnett—*Associate*
A. Carpenter—*Full*
J. Chalmers—*Full*
L. W. Davis—*Full*
A. H. Gerrish—*Full*
A. H. Hillier—*Full*
C. A. Kellow—*Full*
J. W. Morgan—*Full*
R. F. Mullett—*Full*
B. R. Northmore—*Full*
C. A. Piercy—*Associate*
S. D. Ross—*Full*
C. P. Rowe—*Full*
E. A. Taylor—*Associate*

Overseas Associate—
G. Burkhard
L. K. Burnett
R. R. Crawford
M. Dardenne
H. Hanaya
Dr. G. I. Hoover†
S. Kagalwala
A. E. Lee†
Dr. J. Marchlewska-Szrajer
S. S. Mehta
G. B. Nicholson
Shree Gopal Paper Mills Ltd.
J. M. J. van Stiphout

† Deceased

Divisional elections

RESULTS of the postal ballot for the election of one third of the numbers serving on the Divisional committees are as follows for the three years 1960–63—

London Division
F. W. Hayward
G. F. Glover
S. V. Sergeant
N. C. Underwood

Northern Division
F. A. Craig
Dr. M. N. Strachan
P. A. Bolsover
C. G. Lawrence

Scottish Division
T. Clapperton
W. A. Gilmour
G. Wallace Adam
W. J. Verden Anderson

Western Division
R. A. Traill
J. J. Kelly
E. S. Brazington
P. Sadler

At the Annual General Meetings of the Divisions, the following officers were elected for the coming year—

London Division

Chairman—Mr. G. Thompson
Hon. Secretary—Mr. F. W. Hayward

Northern Division

Chairman—Mr. P. A. Duxbury
Hon. Secretary—Dr. V. G. Morgan

Scottish Division

Chairman—Mr. C. G. Wallace
Hon. Secretary—Mr. N. P. Brown

Western Division

Chairman—Mr. L. A. Lawrence
Hon. Secretary—Mr. R. B. Kitchen

Statistical methods

FINLAND is the host country for the fourth symposium to be sponsored by EUCEPA. This international meeting will be held in Helsinki for the three days 16th–18th May 1960.

The outline programme is as follows—

Analysis of substance variations in a papermachine—**H. E. Alve** (*Norway*)

Particle counting by photometry—**O. Andersson** (*Sweden*)

Results from an investigation into the dispersion in certain testings of paper—**Centre Technique de l'Industrie des Papiers, Cartons et Celluloses** (*France*)

Experimental design philosophy in the pulp and paper mill—**C. A. Bicking** (*U.S.A.*)

Quality control on a papermachine—**N. Blomqvist and S. Pettersson** (*Sweden*)

Statistical evaluation of the production of a kraft papermachine before and after the replacement of the head box—**G. Botto-Micca** (*Italy*)

The use of statistical methods for printability testing of coated papers—**H. Braunegg** (*Germany*)

Quality control on a supercutter—**F. C. Butcher** (*U.K.*)

Investigation into a method of purchasing wood by weight: determination of dryness in a consignment of roundwood—**Miss M. M. Darribère and J. P. Mauge** (*France*)

Statistical utilisation of basis weight measures: comparison between several machines: investigation into systematical variations—**Miss M. M. Darribère** (*France*)

Designs for quadratic regression analysis—**G. Elfving** (*Finland*)

Comparison of hydrocyclones—**L. Eriksson** (*Finland*)

The application of quality control techniques in the finishing end—**I. F. Hendry** (*U.K.*)

Examples of the practical use of response surface techniques and evolutionary operation—**I. F. Hendry** (*U.K.*)

Statistical analysis of production processes—**O. Lokki** (*Finland*)

Methods used and results obtained by modern statistical measurements of various paper characteristics—**W. Masing and W. Volk** (*Germany*)

Experimental errors in the determination of some physical paper properties—**A. Menasce** (*Italy*)

An example of incorrect use of the *t* test in comparative investigations—**F. W. Meyn** (*Norway*)

Statistical analysis of a pulp evaluation method—**P. G. Moore, D. I. Smith and D. A. H. Thomas** (*U.K.*)

Studies on dry content of wet chemical pulp by using statistical methods—**I. Palenius** (*Finland*)

Factors affecting paper and board varnishing results investigated in a mill trial using a youden square design—**F. Sundman** (*Finland*)

Reflections on the use of statistical methods—**A. F. Tout** (*U.K.*)

Evolutionary operation—**A. F. Tout** (*U.K.*)

An investigation into strength loss during the manufacture of sulphite pulp—**A. B. Truman** (*U.K.*)

The use of linear programming in paper converting industries—**W. Vollmer** (*Germany*)

Panel discussion—

On organising questions—**C. A. Bicking** (*U.S.A.*), **D. Macaulay** (*U.S.A.*), **W. Masing** (*Germany*) **and A. F. Tout** (*U.K.*)

There will be two visits to mills, a reception and dinner are the social functions arranged for participants and there is also to be a ladies' programme. Registrations must be received in Finland by *15th April 1960*. Copies of programme leaflet and registration form can be obtained from the Technical Section offices at St. Winifred's, Kenley, Surrey.

Papers on straw

LAST June, the second symposium sponsored by EUCEPA was held at Noordwijk aan Zee, Holland, when the topic was the utilisation of strawpulp. The official report (in English) of this successful and well-attended meeting is published in *Papierwereld*, 1959, **14** (4), 428. This reports as well on the European TAPPI meeting held immediately afterwards, also on strawpulping.

It was decided by the Dutch committee that organised the symposium not to publish the collected papers and discussions as a book. Discussions were therefore unrecorded. The papers presented are being published in three journals as an alternative way of making them generally available. The editors of these journals have agreed to share the papers and so avoid duplicate publication of any of them.

To date, the following papers (in English except for one) have appeared in print—

Brightness reversal of pulp and paper—H. Goldhoorn
Papierwereld, 1959, **14** (2), 367

Submicroscopic structure of straw fibres—P. A. Roelofsen
Papierwereld, 1959, **14** (3), 403

The relationship between the properties of straw and strawpulp (in Dutch)—F. M. Muller
Papierwereld, 1959 **14** (4), 419

The neutral sulphite pulping of straw: Further fundamental studies and practical results—G. Vamos and P. Lengyel
Papierwereld, 1959/60, **14** (5), 447

Continuous pulping of straw—high and low pressure—C. B. Tabb
Tech. Bull., 1959, **36** (6), 157

Recent results with continuous pulping of agricultural fibres—J. Atchison
Paper Tech., 1960, **1** (1), 55

The two papers to be published by the *World's Paper Trade Review* are—

Rice straw and rye straw for papermaking pulp—
T. Höpner

A bleached straw unit in a papermill—
J. P. Vidal and H. Benier

PAPER TECHNOLOGY will complete the series. Its third contribution by G. Centola and D. Borruso, 'Some remarks on the relationship between chemical composition and properties of strawpulps', appears in this issue (page 157) and the remaining issues for 1960 will conclude the list—

Chlorination by gaseous chlorine in strawpulp production—U. Poggianti and G. Moltedo

Interrelationships between degree of swelling and strength properties of strawpulps and their mixtures with woodpulps— G. Jayme and H. Kruger

Strawpulp non-fibrous fraction—influence on some pulp and paper properties— D. Borruso

Portable psychrometer

FROM the United States comes news of a portable thermistor psychrometer that measures in a few seconds the moisture content of air, using wet and dry thermistor beads. The instrument has three scales for measuring humidity at temperatures 10–176°F and it is stated that accuracy is within 0.5 per cent. and that the instrument can be read to ¼°F. The wet and dry temperature readings are made by pressing trigger buttons, the operation taking less than 10 sec. and relative humidity is then read from a psychromatic chart or slide rule.

New films

ADHESION AND BREAKS AT THE WET END

Wiggins Teape Group Research Organisation, Butlers Court, Beaconsfield, Bucks.

(A copy of this film can also be borrowed from the Technical Section library)

16 mm. Colour, black and white 9½ min. Silent Hire free

Content—1. Apparatus for the measurement of adhesion; *2.* Measurement of adhesion in the laboratory; *3.* Simulation of breaks in the laboratory; *4.* How do breaks start?; *5.* How do breaks spread?

GATEWAY TO THE FUTURE

Wiggins Teape & Co. Ltd., Sales Promotion Dept., Gateway House, Watling Street, London, E.C.4

16 mm. and 35 mm. Colour 25 min. Sound Hire free

Content—Showing the organisation, technical advances and training in up-to-date paper technique used in the Wiggins Teape Group. The presentation is novel and adds to the interest of the film.

FRICTION

Technical & Scientific Films Ltd., 18 Hanway Street, London, W.1

Hire from Educational Foundation Film Library, Brooklands House, Weybridge, Surrey

16 mm. Black and white 20 min. Sound Hire 15s.

Content—The film demonstrates the basic laws of friction; firstly, that friction is independent of surface area and, secondly, that it is proportional to load. These laws are explained by diagrams, models and photomicrography, demonstrating the area of real contact between surfaces, showing the formation and shearing of small welds at contact points and the ploughing of a relatively soft surface by irregularities on a harder surface. The effect of molecular surface layers in reducing friction and the increase in temperature of sliding contacts are both shown. The principles of fluid and of boundary lubrication are also demonstrated and the chemical action of long-chain fatty acids as boundary lubricants is explained.

PRINCIPLES OF ULTRASONICS

Data Film Productions Ltd., 21 Soho Square, London, W.1

Hire from Educational Foundation Film Library, Brooklands House, Weybridge, Surrey

16 mm. Black and white 15 min. Sound Hire 10s. 6d.

Content—The film opens with a demonstration of the relation and range of sonic and ultrasonic waves. This is followed by a section showing how ultrasonic waves are detected and the various types of wave generator that can be used to propagate them: loudspeaker, magnetostrictor and crystal transducer. The remaining sections deal with the properties of ultrasonic waves and the uses to which they can be put. These sections are sub-titled *Rectilinear propagation*, *Energy* and *Cavitation*, the last illustrating both damaging and useful effects. The film ends with a summary of the points made and with a reminder that the field of ultrasonics is one where there are still discoveries to be made.

(*continued on page 173*)

for your reading

Attention is drawn below to a number of papers of interest to be found in recent journals available from the Technical Section library.

Pressurised screening of groundwood pulp with the Bird centriscreen

T. N. McLenaghan, I. Clark-Pounder and S. Salomon

Pulp and Paper Mag. Can., 1959, **60** (8), T238

The Magnefite process—a comparative study

M. D. Robinson and D. W. Harris

Pulp & Paper Mag. Can., 1959, **60** (8), T243

The fundamentals of curl in paper

P. Glynn, H. W. H. Jones and W. Gallay

Pulp & Paper Mag. Can., 1959, **60** (10), T316

New future for flat-belt drives

O. R. Witworth and G. R. Bruck

Paper Trade J., 1959, **143** (39), 24

Fibre activator process

C. W. Heckroth

Paper Mill News, 1959, **82** (48), 8

The fibre activator process is concerned with the conditioning of cellulose and other fibres with a specific chemical followed by the addition of one of the large number of suitable additives. The whole process takes place in the wet state and the chemical change supplements the hydrogen bonding and results in the formation of a film-like layer round each fibre. The retention of additives is claimed to be complete and uniform.

Vibration as a measure of liquid density and pulp stock consistency

G. J. Thiessen and I. R. Dagg

Pulp & Paper Mag. Can., 1959, **60** (9), T263

The vibrations resulting from an unbalanced rotor may be used as a sensitive measure of the density of a liquid. The accurate determination of volume, which is usually necessary in density measurements, may be eliminated with this method. A continuous flow instrument is applicable only to homogeneous fluids, but an intermittent flow model may be possible for pulp measurements.

Temperature within the grinding zone—part 1

F. Luhde

Pulp & Paper Mag. Can., 1959, **60** (9), T269

Spruce and balsam bark as a source of fibre products

F. Bender

Pulp & Paper Mag. Can., 1959, **60** (9), T275

Interrelation of ink and paper

A. C. Zettlemoyer and J. M. Fetsko

Pulp & Paper Mag. Can., 1959, **60** (9), T279

Production of high-yield sulphite for newsprint from West coast woods

D. L. Steward and H. F. Crotogino

Pulp & Paper Mag. Can., 1959, **60** (9), T284

Felt running size—its effect on board finish and production

D. McConaughy

Paper Ind., 1959, **41** (8), 550

Boiler water treatment

P. Hamer

Proc. Soc. Wat. Treatm. Exam., 1958, **7**, 44

The author discusses some methods for preventing corrosion by steam, including the use of neutralising and filming amines; for preventing entrainment of salts; for preventing corrosion within the boiler, including chemical de-aeration with sodium sulphite or hydrazine. A method of controlling carbonate softening of the water in the boiler to yield a free-flowing sludge and thus keep the heating surfaces clean is indicated. The general principles of boiler feedwater treatment are listed.

The volumetric determination of chloride in paper and water by a polarisation end-point procedure

D. Price and F. R. Coe

Analyst, 1959, **84**, 62

A volumetric method using a polarisation end-point procedure is described for determining small amounts of chloride in aqueous solution. The necessary electrical apparatus is simple in construction and operation. The sensitivity of the end-point is improved by the presence of free acid, particularly acetic acid. The method used to examine water samples requires a 100 ml. sample, to which is added 10 ml. glacial acetic acid before titration with 0.01N silver nitrate. Results are tabulated for samples of boiler water, river water, condensate and tap water; the amperometric method was satisfactory in most cases, but some samples failed to yield the characteristic titration curve and the turbidity due to colloidal silver chloride was slow to appear. This behaviour may be due to the presence of organic matter in the water sample; further investigations are necessary before the procedure can be extended to the routine examination of all water samples irrespective of their origin and composition.

(*continued on page 121*)

Page 117 – was New Films list

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, **14** (2), 367

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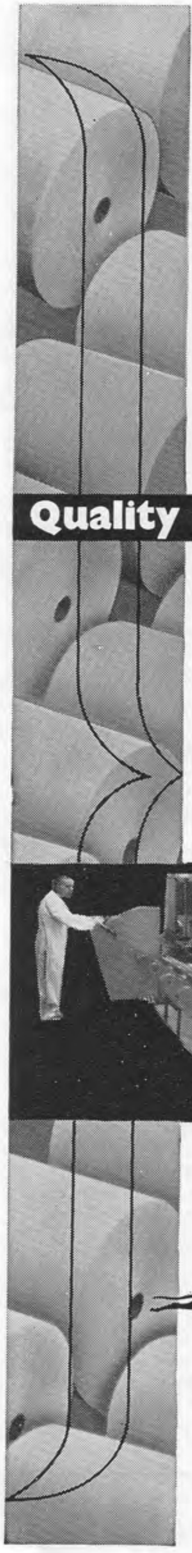

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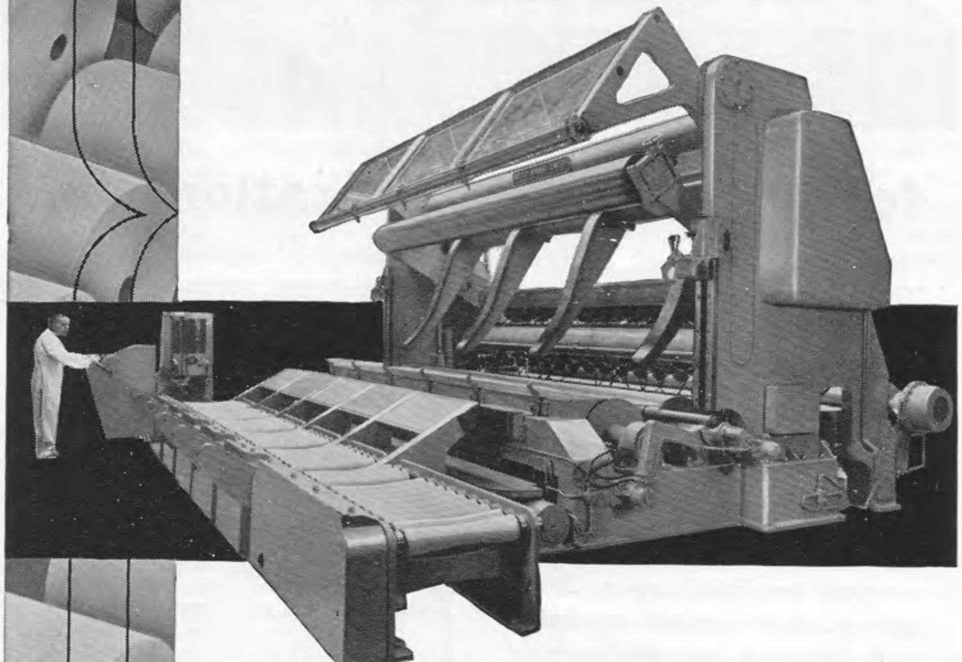

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Some recent developments in sulphite pulp making

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(For your reading continued from page 118)

The distribution of oxidant consumption in bleaching

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L. W. Zabel
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J. E. Stone and H. V. Green
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Development of high purity dissolving woodpulp for tyre cord production

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The flow properties of paper pulp stock

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W. L. Ingmanson, B. D. Andrews and R. C. Johnson
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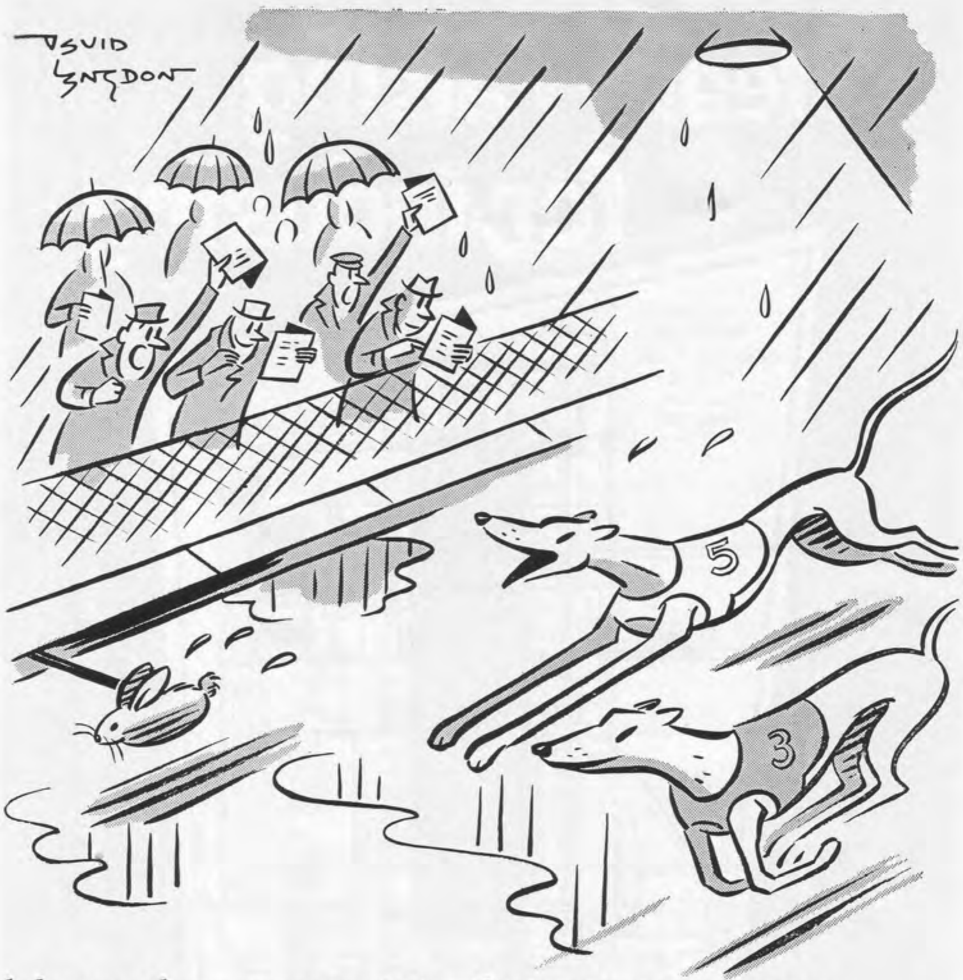
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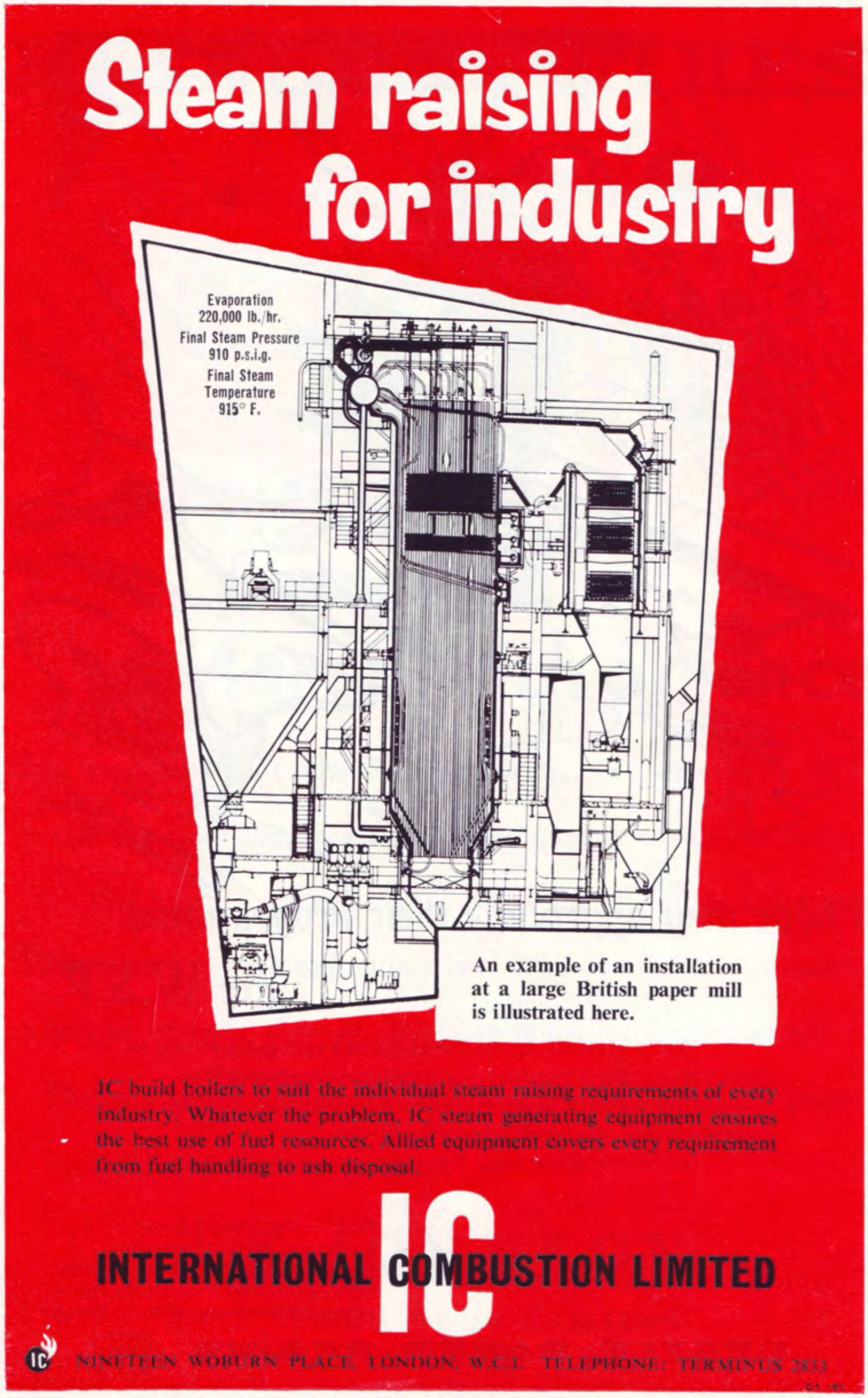
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● The Journal combines and replaces the Technical Section's previous two publications, *Proceedings* and *Technical Bulletin*.

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(see over)

● This journal is constituted from the same material that appeared formerly in *Proceedings* and *Technical Bulletin*, the two distinct sections being retained in each issue for those members who wish to file or bind them separately.

● With this in mind, additional page numbering of the *Proceedings* section has been provided on the top outer corner of the relevant pages. These page numbers are prefaced by the letter T and will commence from T1 with each volume.

● Sequential page numbering for the journal as a whole commences at page 1 with each volume and runs through the the whole of each year's issues.

● Six issues of PAPER TECHNOLOGY will be published each year—

No. 1 in February	No. 4 in August
No. 2 in April	No. 5 in October
No. 3 in June	No. 6 in December

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● The register of members will in future be made up on 30th September each year for publication in the December issue. Accuracy in the register details will be assured by members notifying the Secretary of any changes of position, address, etc. as soon as these occur.

Evolutionary operation

LAST October, the Statistics Committee ran a very successful all-day meeting devoted to evolutionary operation. The lecturer was Mr. G. A. Coutie of the Dyestuffs Division of Imperial Chemical Industries Ltd., who opened with a general talk on how to discover the best conditions under which to operate a process, then followed with a description of the relatively newly conceived method of running a plant so as continuously to improve its operation, a technique called *evolutionary operation*. Below is a synopsis of this talk and a summary of the very lively discussion that followed it.

❖ METHODS for improving the efficiency of industrial processes may broadly be classified into three groups, involving—

1. Theoretical considerations.
2. Empirical studies in the laboratory.
3. Empirical studies on the plant scale.

The complexity of many modern processes is such that in practice attention has to be directed mainly towards empirical methods. The amount of effort that can be devoted by specialist groups in an industrial organisation to laboratory-scale process development is necessarily limited by the manpower available and often represents only a small fraction of the effort they would really like to make. The method of *evolutionary operation* is a device whereby, with very little extra effort, a production plant itself may produce, not only the desired product, but also information on how the efficiency of the process may be improved. So far, applications of this technique have been made primarily in the chemical industry, but the methods are quite general and could equally well be applied to suitable processes in the paper industry.

It is customary for a production process to be operated according to a fixed set of conditions, but, although considerable care may be taken in the initial choice of these, they will seldom result in the location of the ultimate plant optimum. As a result of experimental campaigns on the plant scale, new ideas and chance discoveries, improvement in the efficiency of the process usually continues over many years and the object of evolutionary operation is to speed up this process. In this method of operation, the plant is not run according to a fixed set of conditions. Instead, systematic, small modifications following a carefully planned and continuously repeated cycle are made.

Because the modifications are small, in order that the smooth running of the plant may not be upset, their effect will probably not be detected in individual cycles; but, as the results of successive cycles are averaged, evidence on the effect of the modifications is gradually built up. Eventually, it is possible to see in what way the method of operation of the plant should be adjusted in order to obtain greater efficiency; this improvement is then incorporated by making the appropriate change and further cycles are started about the newly found conditions. The procedure should be thought of as a new method of plant operation, rather than a piece of short-term experimental work, since, whenever a change is made back to the customary 'static' method of operation, information about possible improvements to the process is being forfeited.

In practice, it has been found that it is best to vary two or three variables at a time when operating in this way, since this allows an easy visual assessment of the situation at any time to be made. For example, if the temperature of reaction and the concentration of one of the reactants are to be varied in a chemical process, each at two levels, there are four possible ways of operating the process—(*a*) lower temperature with lower concentration, (*b*) higher temperature with lower concentration, (*c*) lower temperature with higher concentration and (*d*) higher temperature with higher concentration. A cycle consists of operating the process for a certain time at each set of conditions and recording the observed responses—for example, yield, strength, colour at each set. The average response for each set of conditions at the end of each cycle may be recorded at the corners of a square for easy visual assessment; at the end of each cycle, a simple statistical analysis is carried out to determine whether the average effect on a response of modifying either variable can be detected as real when it is compared with the inherent variability of the plant. This calculation is quickly carried out on a standard worksheet prepared specially for the purpose.

At the end of each cycle, one of several types of decision may be taken. The possibilities are—

1. To carry on for another cycle with the same levels of the same variables.
2. To extend the range over which the variables have been tried, if little effect has been observed.
3. To make a change in the standard operating conditions and to restart modifications from the new point, if a real improvement has been detected.
4. To choose one or more new variables and to start a new phase of the operation.

Evolutionary operation has been applied over the past five years in six of the factories operated by the Dyestuffs Division and some thirty processes are currently operating in this way. Almost by definition, it will be rare for large percentage increases in efficiency to be gained for processes that have been in operation for many years, yet substantial increases have been made on some processes in just these circumstances. For fairly large-scale processes, however, an improvement of only 1 per cent. in efficiency may lead to substantial annual savings.

The factors that have entered most frequently into our programmes have been (not surprisingly) temperature, time and concentration; the most common responses are yield, purity or, when possible, a composite cost function that takes into account raw material values, operating costs and yield. The method has been applied with equal success to both batch and continuous processes. One application has been to a batch process for a dyestuff intermediate, in which, during a period of four years, operating conditions have been changed each week, thirteen different variables have been studied and a yield increase of over 10 per cent. has been achieved.

A second example concerns a continuous catalytic process, in which modifications have been studied over a period of 2 years to variables between and within catalyst runs, in which the 1 per cent. increase in efficiency that has been achieved represents considerable savings because of the volume and value of production.

Experience has shown that, in a chemical works involving many different processes, it is rarely advisable, when introducing evolutionary operation, to expect an already overburdened plant superintendent to cope on his own with even the small amount of extra planning and analysis that are necessary. It has been found worthwhile and completely satisfactory to train a chemist in simple statistical techniques and to make it his full-time (or part-time, if necessary) task to collaborate with plant superintendents in the design and interpretation of evolutionary operation, also to maintain liaison with the statisticians so that more advanced techniques may be used when necessary. One of the main objectives to be borne in mind is that evolutionary operation should be simple in design and simple to analyse. If this is so, it will cause the minimum upset to the running of the plant and will be accepted as an integral part of production.

❖ DURING the discussion that followed this talk, it was evident that there was a great deal of interest in the possibility of applying evolutionary operation to papermaking and in learning how to set about doing so. Some of those present considered that the large number of uncontrolled and uncontrollable factors in papermaking would prevent the use of evolutionary operation, but Mr. Coutie emphasised again that a limited number of factors should be studied in each phase and that the factors that were not controlled would then merely inflate the estimated experimental error. The application of evolutionary operation to more limited field such as stock preparation or paper coating was generally considered to be somewhat easier. Mr. Coutie considered that it should be possible in papermaking to apply the technique to optimise on control rather than on yield, but many more measurements would then be required.

More detailed discussions of the difficulties that might be experienced in applying evolutionary operation to the papermaking process then ensued and Mr. Coutie agreed that interactions might cause difficulties and also pointed out that those factors easy to control might well not be the important ones. Some of the audience feared that the product might go outside specification, because of the deliberate alteration of conditions: Mr. Coutie re-affirmed that the changes in levels of factors should be small and within the normal range of variation, so the product should be no worse than usual.

While answering more general questions about evolutionary operation, Mr. Coutie stated that the rate and volume of testing is not increased, as the plant will provide information for the asking. The relationship of quality control to evolutionary operation was discussed and Mr. Coutie said that, whilst quality is held constant by quality control, it is improved by evolutionary operation; in addition, evolutionary operation may show why a plant goes off control.

Concerning the arrangement of the experimental conditions, Mr. Coutie confirmed that a triangle or a tetrahedron could be used instead of a square or a cube and added that, though the use of a triangle or a tetrahedron does have certain merits (as one can move towards optimum conditions more quickly), it is probably easier (especially for the layman) to visualise a cube than a tetrahedron. Of methods for eliminating unimportant variables, he considered that a highly fractionated factorial design was more preferable than the random balance technique.

In reply to another question, he said that the problem of two peaks in a response surface does not arise in practice and that, although it is not possible to assume that the displacement of the contour surface from laboratory scale to plant conditions could be regarded as constant for similar conditions, it should be possible to establish such a relationship for a very restricted range of conditions.

Mechanical machine drives

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Technical Representative, Bertrams Ltd.

GIVEN AT A MEETING OF SCOTTISH DIVISION: CARLTON HOTEL, EDINBURGH
ON 2nd DECEMBER 1959, Mr. C. G. WALLACE IN THE CHAIR

Synopsis

This paper briefly surveys the historial development of mechanical drives. It shows that, with improved materials and design, the modern mechanical drive is well able to hold its place in competition with electric sectional drives. Approximate capital cost comparisons are given.

Historical review

IN making a comparison of machine drives, a brief review of their development will perhaps not be out of place.

The most common type of mechanical drive today is that usually known as the Marshall drive, which first came into use about 80 years ago and, so far, in its basic arrangement has outlasted all other types. The basic arrangement makes use of a rightangle bevel or worm gear unit to drive each machine section, the gear units being belt or V-rope driven from a lineshaft arranged parallel to the machine, the lineshaft in turn receiving its motion from a prime mover.

About the turn of the century, various types of rope and cone pulley drives were commonly used to drive the machine, the ropes and belts running parallel to the machine, so making access to the back of the machine difficult and restricted.

In the first decade of this century, there appeared the Milne vari-vee rope drive, which used cotton rope and a variable pitch diameter rope pulley at each machine section for draw control. About the same time, White's clutchless drive appeared. This drive used cotton ropes and cone pulleys to transmit power to the various sections, one cone pulley at each section being movable to start and stop the section by tightening or slackening the belt.

Both these drives were primarily designed for fine papers running up to about 400 ft./min. maximum and were still in vogue after World War I. For higher speeds, various combinations of rope pulleys, cone pulleys and friction clutches were used for speeds up to about 750 ft./min. and were the most common type of drive for fast-running machines until the sectional electric drive became established in the mid-1920s.

During this period, the Marshall drive had progressed little, apart from the introduction of machine-cut bevel gears (which were still noisy) and their enclosure in simple gear cases. Worm gears were seldom used, owing to their inefficient design. Friction clutches remained much as before. A clutchless type of section unit was introduced a few years before World War I, using a loose pulley next to the gear unit cone pulley in place of a clutch. Despite the restriction of access to the back of the machine, the section-to-section drive was generally preferred to the Marshall type, which before World War II was considered unsuitable for speeds in excess of 500 ft./min.

Today, although a few of all the foregoing drives are still running, the large majority of machines either have a mechanical sectional or electric sectional drive and Marshall drives are in operation on machines up to 200 in. wide and as fast as 1 500–1 600 ft./min. That mechanical drives of this type can now be successfully used for such powers and speeds is due to improvements in design and materials over the past 25 years. These improvements are worth at least a brief look.

Modern design and materials

In each section drive, the rightangle gear unit is the most important item, being usually either a spiral bevel gear or worm gear type, the latter being more common for ratios of 4:1 and over. For both types, especially for worm gears, improved materials, better tooth-form design, precision cutting and finishing of the teeth, greater rigidity in the gear cases, attention to the dissipation of heat, ball and roller bearings to maintain accurate alignment and better lubricants have all combined to give compact powerful gear units of high efficiency, occupying considerably less space than before.

The clutch is an obviously important part and the introduction of bonded asbestos friction materials has resulted in smaller and more powerful clutches capable

T32 of very high speeds. Pneumatic operation is now commonplace, piston-operated disc type or a flexible tube rim type both being popular, the control valves at the front of the machine permitting inching and starting without snatch.

Beltshifters with ball-bearing roller belt guides to reduce wear on belt edges are now standard practice. Electric operation of the beltshifters from the front of the machine is quite common. Ball and roller bearings are now in common use at all points throughout the drive.

Hitherto, these drives have been designed to suit belts made from natural materials. Due to centrifugal force, the maximum efficiency of these belts is attained between 4 000 ft./min. and 5 000 ft./min., according to the type of belt used. For wide, fast-running machines, this belt speed limitation has necessitated heavy, wide belts, which do not conform easily to the tapered pulley, with resultant fall in efficiency and increased maintenance costs.

In recent years, synthetic belts have been developed, which, properly applied, solve these difficulties. These belts have a nylon centre faced with chrome leather that is specially treated to give a friction grip 25–40 per cent. more than ordinary materials, the driving pull being taken by the nylon. In current practice, synthetic belts are being run at speeds up to 8 000–10 000 ft./min. and they are suitable for much higher speeds.

For safety reasons, pulleys are seldom run much in excess of 5 000 ft./min. for cast iron and 8 000 ft./min. for cast steel. To take full advantage of these belts, it would appear at present that ductile cast iron or cast steel alloys offer the best means. As a replacement for ordinary belting on existing drives, however, the belt width can be reduced by about a third. These belts are also suitable for short centres and pulley ratios as high as 9:1.

As an alternative to taper cone belt pulleys, the vari-vee principle of the old Milne rope drive is also used today with modern V-ropes and variable pitch diameter pulleys. Introduced shortly before World War II, the V-ropes give a short centre compact drive, with the lineshaft arranged directly over or under the section units or at floor level.

It is difficult to give figures for the accuracy of draw control maintained between sections, this being mainly affected by the accuracy and taper of the cone pulleys, the belt width, tension and accuracy of making the belt joint. The mounting of the clutched cone pulley on ball bearings and the use of narrow width belts, particularly the nylon belts, reduces cyclic draw variation within acceptable limits for most machines.

To reduce cyclic variations in draw control on high speed machines, differential drives have been developed in which the section units are coupled together by the lineshaft, there being no belt or V-rope drives other than that from the prime mover. A few drives of this type were built about 30 years ago, but did not meet with general acceptance.

Recently, however, a differential drive has been developed in which each section unit has, in addition to the main bevel gears, epicyclic gearing operated by electric and hydraulic motors for draw control, these motors being used also to inch or reverse the section, even when the lineshaft is stopped.

A number of special purpose additions may be made to the ordinary Marshall section units such as pneumatic brakes and electric motor barring drives for heavy cylinder sections and for calender reversing drives, these additions being interlocked to ensure correct use. Today, the variable speed electric motor is almost universally used to drive the lineshaft by V-ropes or belt. A few machines are still driven by high speed steam engines that exhaust to the drying cylinders.

Particularly since the last war, increased machine speeds, extra plant to maintain or to improve quality at these speeds and the greater use of labour-saving equipment have combined to increase the power required to make paper. At the same time, other improvements have reduced the process steam required such that it is very difficult—if not impossible—to balance the steam required for power generation with that required for process work. This has led, particularly in the U.S.A., to the use of small, high pressure steam turbines directly geared and coupled to the lineshaft, the exhaust steam being used in the drying cylinders. In Britain, this trend has been met by buying the extra power required off the national grid system.

Cost comparisons

Comparing modern mechanical drives with the electric sectional type the three main points are—

1. Initial cost.
2. Maintenance.
3. Transmission efficiency.

The Marshall drive with taper cone belt pulleys is the cheapest in first cost and easiest to maintain.

The vari-vee type of drive is somewhat higher in first cost and maintenance, but can be used for higher powers than the flat belt drive.

The differential drive is capable of the highest speeds and power requirements, but no data is available at the moment of costs.

While the total cost naturally increases with the size and speed of the machine, the cost per installed horsepower falls with increasing size and speed.

Approximate present-day costs for a taper cone pulley drive, excluding the prime mover, will vary from £68 per h.p. at 500 ft./min. to £46 per h.p. at 1 000 ft./min. and down to £35 at 1 500 ft./min.

The cost per h.p. of the prime mover will vary with the type, being as low as £21 for shunt controlled d.c. motor, about £24 with mercury arc rectifier up to about £40 with Ward Leonard motor generator set. A steam turbine will cost about £30 per h.p.

Electric sectional drives are more costly and, depending on the application, may be as much as 50 per cent. higher on slow and medium speed machines to 15 per cent. more on high speed drives relative to the combined cost of a mechanical drive and its prime mover.

The efficiency of a modern mechanical drive can be as high as 95 per cent. though usually taken as 90 per cent. for estimating purposes. That of the prime movers will vary with the type. High speed steam engines have efficiencies about 90 per cent.; Ward Leonard drives about 80 per cent., whereas steam turbines are about 85 per cent. efficient.

The simplicity and accessibility of a Marshall drive commends itself and makes for easy maintenance. With routine greasing and checking of oil levels, it will run for years without renewals of any kind apart from replacements of belts and clutch linings every few years.

As has been shown, mechanical drives have made big advances during the past 25 years, especially in their application to wide, fast running machines. With improved materials and production techniques, there is no reason that they should not eventually be used for even higher speeds.

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Electronic multigenerator sectional drives

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GIVEN AT A MEETING OF SCOTTISH DIVISION: CARLTON HOTEL, EDINBURGH ON 2nd DECEMBER 1959, Mr. C. G. WALLACE IN THE CHAIR

Synopsis

The paper outlines the system of the electronically controlled multigenerator sectional drive and describes the operation of the electronic regulators. The performance of the drive is discussed in terms of long-term accuracy and transient response. Finally, the advantages of the electronic drive over other types are considered.

Introduction

THE electronically controlled sectional drive was the latest arrival in the field of papermachine drives. Its advent was conditioned as much by the great strides made during the war in the science of electronics and the theory of servo-control as by the pressing need to achieve higher accuracies and faster rates of response necessary for the higher speeds of modern papermachines.

It was only six years ago that a paper(1) read before this Division described the first electronically controlled multigenerator d.c. sectional drive to be installed in Great Britain. Since then, a great deal of experience has been gained, considerable advances have been made and the system has proved itself in many notable installations to be capable of the highest performance demanded by papermachines of all types from tissue to board.

Requirements of the papermachine drive

FIRSTLY, the fundamental requirements of any papermachine drive—

1. Power input at a number of points, each corresponding to one section of the machine, with provision for independent starting, stopping, crawling, inching, possibly reversing, also smooth acceleration up to papermaking speed.
2. Close control of draw between sections to an accuracy of about 0.1 per cent. of top speed.
3. Fast response so that any incipient speed change is corrected before it can build up and break the sheet.
4. Constancy of general machine speed for substance control within a range of 10:1 or more, depending on the type of papers to be made.
5. Absolute reliability with the minimum of maintenance.

The electronic multigenerator sectional drive

THE system of the multigenerator sectional drive is outlined in Fig. 1(*b*); each section of the papermachine is driven by a d.c. motor supplied from its own generator. The motors run at fixed field strength and their speeds are controlled by varying their armature voltage by means of the section speed regulators *SR* which excite the generator fields.

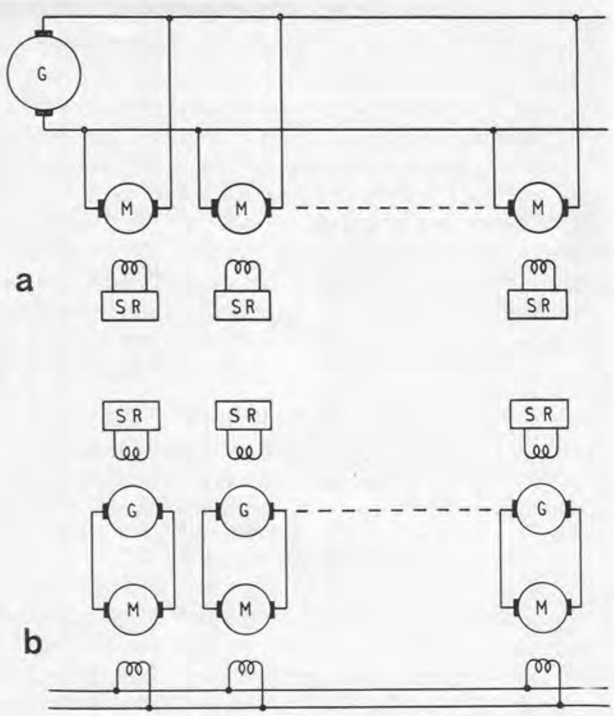


Fig. 1—Multigenerator sectional drives

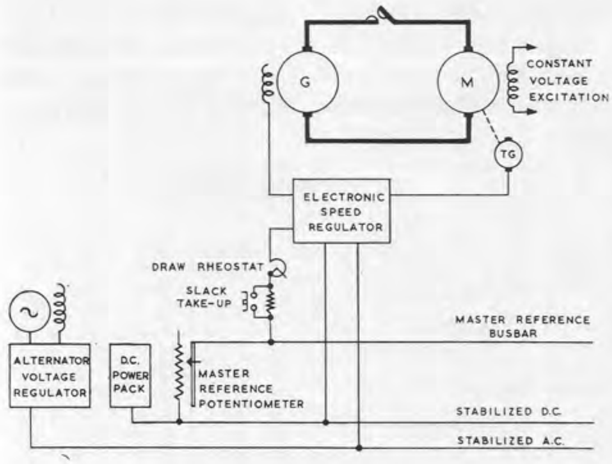


Fig. 2—Schematic circuit of electronic drive

Fig. 1(*a*) shows for comparison the single generator scheme in which the general speed level is set by generator voltage and individual section regulation is done by motor shunt field control.

Fig. 2 shows in rather more detail the chief components of one section of an electronic multigenerator sectional drive. The reference for general machine speed is taken from a master reference potentiometer that feeds a busbar to all sections. The master potentiometer is supplied from a d.c. power pack that produces a voltage stabilised to 0.1 per cent. accuracy. The master reference voltage is modified at every section by a draw rheostat and a fixed resistor, which may be shorted by a push-button to effect a temporary speed change for taking up slack. The modified section reference voltage is then compared in the electronic regulator with a feedback voltage proportional to section speed produced by a d.c. tachogenerator *TG* coupled to the section motor. The small difference between the reference and feedback voltages is greatly amplified in the electronic amplifier, whose output stage feeds the generator field.

An alternator with its own electronic voltage regulator supplies stabilised a.c. to every section for the power amplifiers supplying the generator fields and also for the valve filaments to minimise variations of cathode emission.

The section speed regulator

FIG. 3 shows the electronic speed regulator for one section, slightly simplified for clarity: *PM* is the master potentiometer supplying the reference to all sections; *TG* is the feedback tachogenerator coupled to the section motor *M*. The maximum reference voltage *eR* is 150 V. negative with respect to the earth line and the maximum tachogenerator voltage is, say, 150 V. positive. These two voltages in series (that is, 300 V.) appear across resistors *Ra* and *Rb* in series.

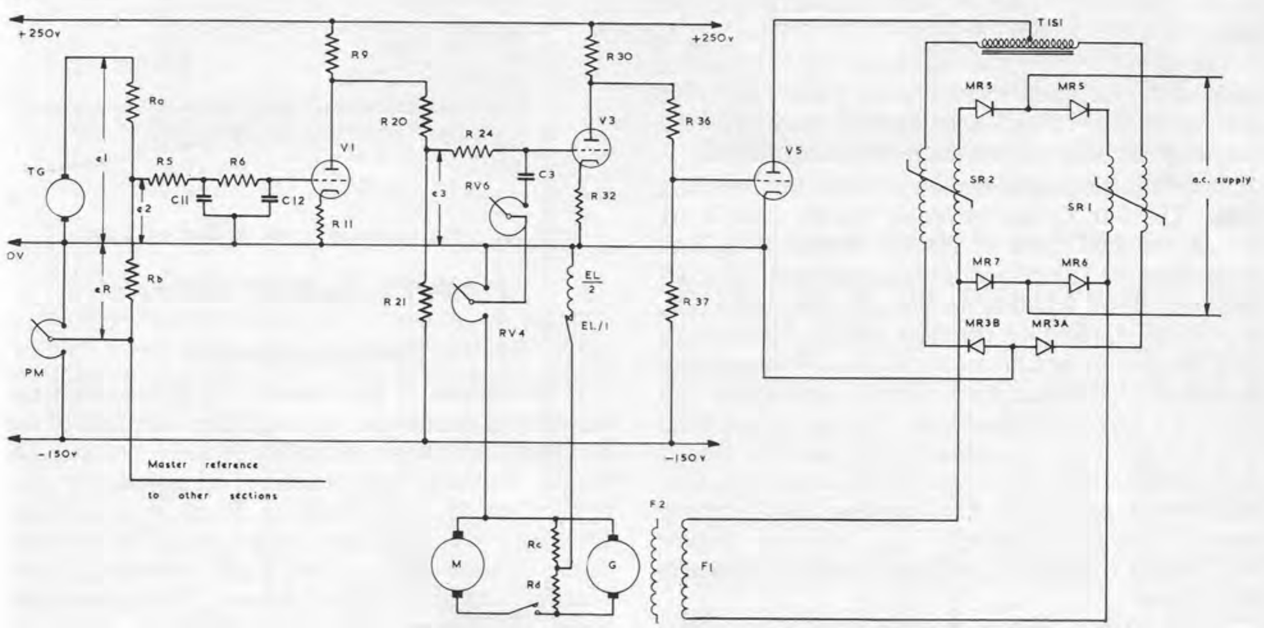


Fig. 3—Section speed regulator circuit

T36 (The draw and slack take-up resistances are included in *Rb*.) Now, if resistances *Ra* and *Rb* are equal and the tachogenerator voltage *e1* is the same as the reference voltage *eR*, then *e2* must be zero and the grid of valve *V1* must be at earth potential. The function of resistor *R6* and condensers *C11* and *C12* is to smooth out tachogenerator voltage ripple.

Consider now what happens if an increase of load causes the section motor to drop in speed. Tacho voltage *e1* decreases and *e2* becomes negative. The grid of valve *V1* therefore goes negative with respect to its cathode and the valve passes less current. The voltage drop in anode resistor *R9* therefore becomes less and the anode voltage of *V1* rises. Because of the amplification by the valve, this voltage change is approximately 20 times greater than the change in *e2* occurring at its grid.

The first amplifier stage output voltage is applied to resistors *R20* and *R21* and a voltage *e3* is tapped off and applied to the grid of the second amplifier valve *V3*. Fig. 4 shows the characteristic of the first stage. The rise in first stage output voltage previously described for a drop in speed now causes the grid of valve *V3* to go positive with respect to its cathode and the valve therefore passes more current. The increase of valve current increases the voltage drop in *R30* and the second stage output voltage thus drops. The second stage amplification is also about 20, so that the total first and second stage amplifications, together with about 50 per cent. attenuation in *R20* and *R21* is $(20 \times 20)/2 = 200$.

The second stage output, like the first, is resistance coupled to the third stage control valve *V5*, which determines the current in the control winding of the magnetic amplifier output stage of the regulator.

The magnetic amplifier used is of the flux resetting type. The flux in one saturable reactor core is set during one half cycle of the a.c. supply to a level determined by the current flowing through valve *V5* and the control winding; in the following half cycle, the output winding on the same reactor conducts as long as the core is saturated and thus presents a low impedance, but blocks when the core unsaturates and presents a very high impedance. The part of the cycle over which voltage is applied to the generator field is thus determined by the current in the control winding. Rectifiers in series with each winding block reverse current when that winding is idle. A second reactor with similar windings repeats the process in alternate half cycles.

The important feature of this type of magnetic amplifier is its very fast response time, which is inherently less than one half cycle or 0.01 sec. at 50 c/s.

Fig. 5 and 6 illustrate the electronic pre-amplifier panels for two sections of the papermachine and behind them the magnetic amplifier output stages.

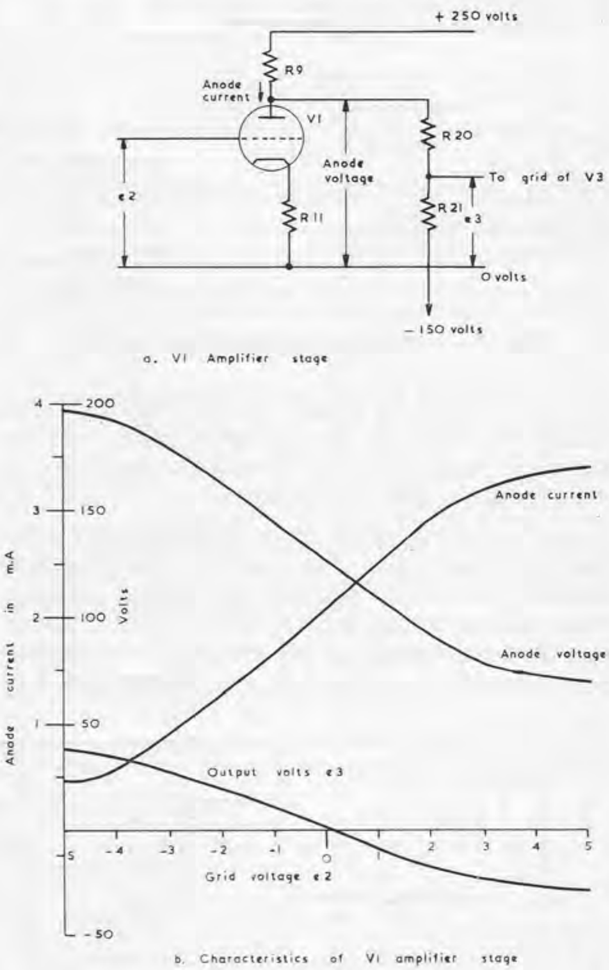


Fig. 4—Valve amplifier characteristics

The tachogenerator

IT is inherent in any closed loop system that the accuracy of control can be no greater than that of the feedback element—in this case, the tachogenerator. A special machine was therefore developed for this application to have excellent long term stability, linearity over a wide speed range, negligible temperature variation and a low ripple content. These features were achieved by the use of Alcomax magnet poles, silver graphite brushes running on a monel metal commutator and skewed slots.

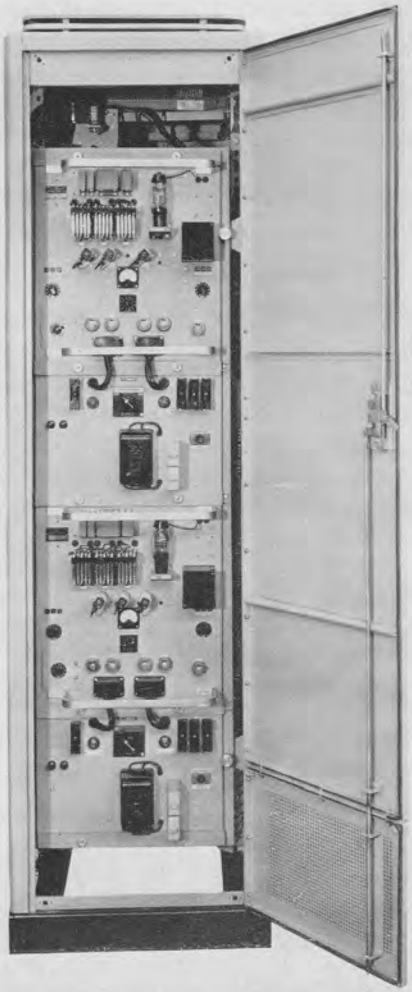


Fig. 5—Section speed regulator pre-amplifiers

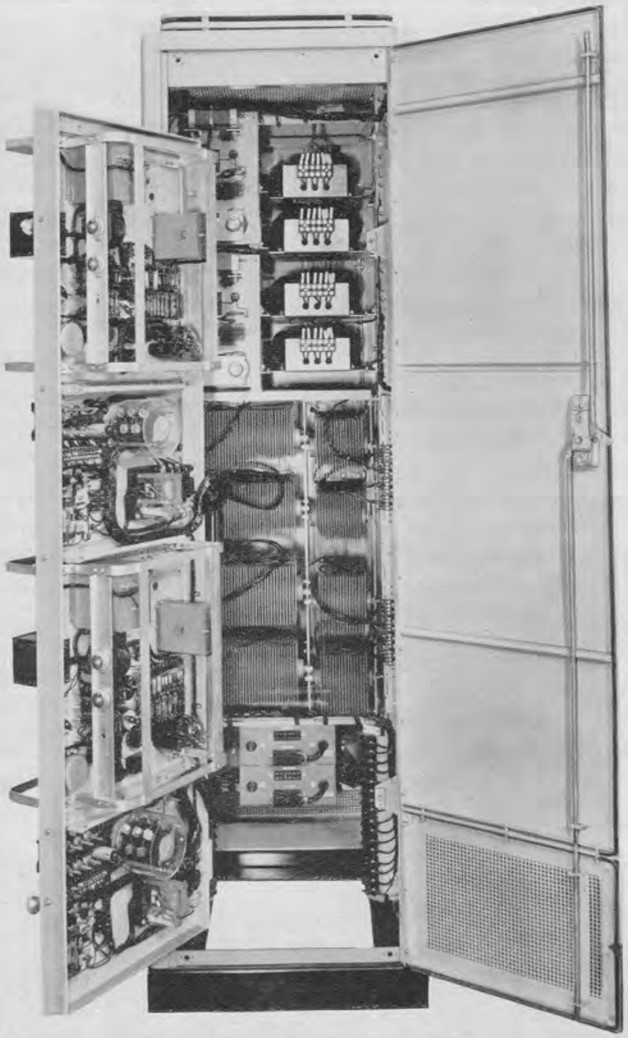


Fig. 6—Electronic speed regulator magnetic amplifiers

Performance of the drive

HAVING looked briefly at the system of the electronically controlled multigenerator sectional drive, we may now consider how it meets the requirements of the papermaker.

The use of a separate generator for each section of the machine gives complete flexibility of operation, because all functions of crawling, inching, reversing and acceleration are carried out by the section regulator acting on the individual generator field quite independently of all other sections. Crawl speed can be individually adjusted to suit the requirements of each section. The breakaway torque for starting difficult sections such as drying cylinders on sleeve bearings is limited only by the peak capacity of the motors and generators and is independent of the crawl voltage. Acceleration up to running speed is perfectly smooth, being controlled by the charging up of a condenser and is free from the surges associated with contactor resistance starting, which can put undesirable stresses on wires and felts. Furthermore, the rate of acceleration can be individually selected for each section merely by turning a small knob.

With the multigenerator scheme, a sudden change of load caused, for instance, by starting or stopping a heavy section, produces no disturbance in the other sections, because the shock is carried by the section generator, whereas, in the single generator scheme, T38 there will be a transient voltage change on the busbars and, with the mechanical drive, there will be a speed disturbance on the line shaft.

The steady state accuracy between sections of the electronic sectional drive is ± 0.1 per cent. of top speed over long periods in spite of load changes from zero to full load, supply voltage variations of ± 15 per cent. and temperature changes of 20°C. Normal load changes account for only about 0.01 per cent. change in speed. The accuracy of speed of the machine as a whole against the same range of variables is 0.2 per cent.

Steady state accuracy alone, however, is not sufficient to prevent paper breaks, unless the speed of response of the regulator is fast enough to correct errors before they build up beyond the tolerable limit. Because of the high gain and negligible delay of the electronic amplifier, it is possible to apply heavy forcing to overcome the inductance of the generator field and the inertia of the section to bring about the required correction in the minimum time.

Fig. 7 shows actual recordings of response to sudden changes of speed reference taken on two sections of a large newsprint machine with an electronic drive designed for 2 300 ft./min. Fig. 7(*b*) is of a 550 h.p. calender section and Fig. 7 (*a*) a 550 h.p. dryer section. The upper traces show section speed to an expanded scale and the lower traces show the motor current during the speed change.

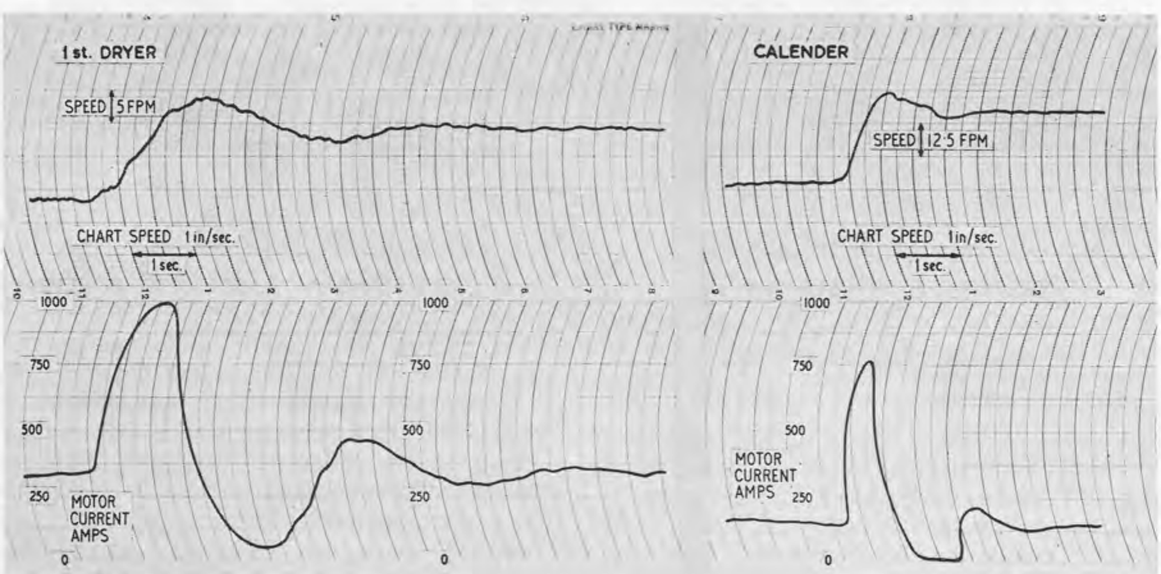
It is important to note that, when speed is controlled on the individual section generator field, the same high speed of response is obtained throughout the speed range however wide; this must be compared with control on the motor shunt field, which becomes progressively less effective as the armature voltage is reduced.

Maintenance

THE electronic speed regulator is entirely static and has no moving parts to wear out or require oiling or greasing. Routine preventive maintenance is limited to replacement of a few valves about once in two years.

In the unlikely event of trouble in the electronic circuits, the complete amplifier is removed and replaced by a spare so that the section can start up again without delay. The fault can then be located and cured at leisure. Fault finding is simplified by test facilities built into the electronic panels and can be carried out by any electrician who can assimilate the elementary principles of electronics.

The contactor control gear associated with the multigenerator electronic drive is remarkably simple,



(*a*) (*b*)

Fig. 7—Speed regulator response recordings

being limited to a line contactor, isolator and the usual protective devices. This is because all operations such as crawling, reversing and acceleration are performed by the electronic regulator.

Summary

THE advantages of the electronically controlled multigenerator sectional drive may be summarised as follows—

1. Clean layout of the back side of the machine, the drive equipment being limited to motor, gear box and tachogenerator.
2. High steady state accuracy and fast, non-oscillatory response, leading to fewer breaks and a more closely controlled and consistent finished product.
3. The same fast response is obtained throughout the speed range.
4. Complete flexibility of operation, because every section has its own generator.
5. Draw adjustment from any convenient position; a scale on the rheostat indicates the draw to the papermaker.
6. Draw range can be as wide as required for creping or other purposes.
7. Complete absence of belts and pulleys, which require maintenance and are a potential source of speed error.
8. Economy of holding spares, since individual generators are relatively small and standardised in two or three frame sizes. Motors are standard compound machines with no special characteristics and are of the minimum frame size for their h.p. rating, because they run at fixed field.
9. The section motor ammeter shows a direct measure of load torque and thus gives early indication of any machine fault such as a stiff bearing or a maladjusted vacuum box.

Conclusion

THE greater productivity demanded by present day competition must mean higher machine speeds, closer control of the finished product, less broke and less downtime. In all these factors, the machine drive plays a decisive part. At about 500 ft./min., driving powers are generally great enough to warrant a sectional drive and, at speeds above this, the performance of the drive becomes increasingly critical and the advantages of electronic control pay greater dividends.

Acknowledgements

In conclusion, the author would thank the Chief Engineer of the Motor and Control Gear Division, A.E.I. Ltd. for permission to read this paper.

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T40

Sectional electric interlocked papermachine drives

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Harland Drives Limited

GIVEN AT A MEETING OF SCOTTISH DIVISION: CARLTON HOTEL, EDINBURGH ON 2nd DECEMBER 1959, MR. C. G. WALLACE IN THE CHAIR

Synopsis

The differential type of sectional electric drive usually comprises a separate driving motor for each machine section, all section motors being supplied from a single main generator with the automatic regulators operating in the field circuits of the controlled motors. The system provides position control of the drive motors and is completely positive in operation. Following a disturbance within a section, the regulator will correct the speed in the form of a damped oscillation about the correct speed, the final speed error being zero.

Sectional drive control

THE Harland drive was the first successful sectional electric drive offered commercially. In view of the various interests represented on this panel, it is obviously my duty to expound the virtues of the differential type of sectional electric drive as applied to papermaking machines. In so doing, it is necessary to draw certain comparisons, but comparisons need not always be odious and, indeed, may serve to stimulate discussion. The first point to make is that the type of drive applied to any particular machine can be decided only after a very full examination of all the factors involved. The most important of these factors is the material being processed and the requirements of the process itself. For instance, even with papermachines, the process requirements of tissue papers vary considerably from those of, say, newsprint. Various forms of control are open to the drive designer (such as velocity, tension, position) and, as already stated, the final selection depends on many factors. In general, however, for papermachines, it will be the contention that position control provides the most complete answer.

Let us first deal with the virtues of the sectional drive itself as distinct from various foims of mechanical drive. The sectional drive offers fingertip control of each section of the papermachine quite independent of any other section and, furthermore, allows the input power to each section to be metered separately. This latter point is of great interest, as a proper system of logging the power inputs can form the basis of a sound preventive maintenance programme. All forms of sectional drives also eliminate power clutches and this feature was, in fact, one of the major reasons for the introduction and success of the sectional electric drive. Our present discussion, however, will confine itself to the differential type of sectional electric drive.

The drive system

SUCH a drive would consist of a plurality of section motors, all supplied from one main generator and each controlled section equipped with a differential regulator, the heart of which is a differential gear unit that acts as the error detecting device. It should be borne in mind that the regulating system must perform two functions—the detection of the error and the final correction of the error. The differential itself has three shafts—two input and one output. One input shaft is driven by the master speed motor and all regulators associated with the complete drive are coupled together and driven by the same master motor. The design of this master speed motor is generally similar to the sectional drive motors it is controlling. The second input of the differential is driven by the controlled section itself through a synchronous link, the final input being through a pair of cone pulleys with belt drive to provide draw control. The output shaft of the differential moves at a speed proportional to the difference in speed between the two input shafts and is used to operate a rheostat working in the shunt field of the controlled motor.

Such a system provides position control and is completely positive in operation. No speed error, however small, can persist without correction. The regulator, in fact, measures the angular displacement of the section motor relative to the master speed motor and, since all sections are compared to the same master speed motor, this means that each section is held in angular position relative to the adjacent sections. This is in fundamental opposition to another system in which the section speed is first converted, by a tachometer, to a voltage, this voltage being compared to a standard reference and the difference (or error) amplified before being returned to the section as a correction. Such a system is non-positive and provides velocity control. It is non-positive, because random variations in the tachometer can give rise to random signals when no speed error has taken place, also because it is difficult to ensure that the tachometer tracks properly over the speed range and will give a truly proportional voltage/speed characteristic.

Regulator action

FOLLOWING a speed error, the differential regulator forces a correction on to the system in the form of a damped oscillation about the preset speed; the system finally returns to the exact preset speed and the resulting error is one of position only. This, again, is in opposition to the rival system that will make a correction only while the speed is wrong and make no attempt to make up the loss or gain in length of sheet that has occurred during the speed error. It has been asked if this latter point is necessary: I submit that it is. Take, for example, the case when the papermaker has set a loop between the first and second presses. If the second press overspeeds, this loop will be drawn tighter. Under position control, the loop will return very nearly to the preset condition following regulator action; under velocity control, the loop will be permanently tightened. The drive, I submit, should maintain the conditions imposed on the machine by the papermaker and position control achieves this end more accurately than does velocity control.

It has often been argued that field control of d.c. motors is difficult over a wide speed range. This is not so, provided certain fundamental rules of electrical engineering are obeyed and the section motors are designed with the correct characteristics. This does not mean special machines—only machines having certain characteristics to ensure stable operation. It can be quite easily shown that a d.c. motor operating on reduced armature voltage has a torque output curve in the form of a parabola with the maximum torque output occurring when the I.R. drop is equal to half the applied voltage. Beyond this point, the torque reduces and the motor becomes unstable under automatic control. It simply remains, therefore, to design the section motor with a load regulation at minimum running voltage that does not approach the maximum on the torque parabola. This method of design has a distinct advantage, since it usually results in a motor having a nameplate rating well below its maximum output. This results in a cooler running machine, with reduced maintenance and offers also advantages in speed of response.

It can be shown mathematically that the speed of response of a d.c. machine under differential control is a function of

$$E^2/KR + 1/P$$

where E = Applied voltage,
K = Papermachine section inertia,
R = Motor armature circuit resistance,
P = Motor field time constant.

In other words, the speed of response is inversely proportional to the armature circuit resistance. The larger motor will have a lower armature resistance, hence a faster speed of response. At the same time, this formula clearly shows the reason for using one large d.c. generator to supply all the section motors rather than an individual generator for each section. The armature resistance includes the generator resistance (as this is part of the total circuit around which restoring power must be forced) and the large generator will obviously have a much smaller armature resistance than the individual generator, which would be for all practical purposes the same frame size as the motor it is supplying. The single generator, therefore, inherently leads to a faster system response.

To assist further in speed of response, first derivative control can be added easily to the position control system and can be used to maximum advantage, as it is obtained directly from the output movement of the differential gear. This first derivative is in fact a velocity signal such that the combined signal contains the elements of both the speed of response of the velocity system, together with the final accuracy of the position system.

The use of a direct current master motor with mechanical regulators has sometimes been compared unfavourably with electronic or magnetic amplifiers working with a stabilised voltage reference unit. In point of fact, the mechanical system has at least one important advantage—the master system possesses inertia. This inertia is carefully calculated such that the speed of response of the master section falls between the response speeds of the heaviest and the lightest sections of the drive.

T42 Consider the effect of a disturbance on the a.c. mains that would affect the voltage output of the main generator or generators. Before this voltage change can be corrected, the effect will be felt by the machine sections to differing degrees, dependent on the individual section inertias. Thus, regulator action, with respect to the master, will be called for. The stabilised master reference would not be affected by the a.c. supply change such that the relative error of each section will be a maximum with respect to the master, calling for violent regulator action on the lighter sections and resulting in intersection speed variations where heavy and light sections are adjacent, say, last dryer and calender. The mechanical regulator system, however, possessing inertia, will itself respond to the change in generator voltage to a degree lying between the heavy and light sections. Section regulator action is limited therefore to the difference between the master and the sections. The master system acts in fact as a buffer between the a.c. supply and the papermachine drive, which allows each section regulator to be designed for maximum speed of response such that it is best able to deal with errors arising within the section itself.

Conclusion

So much for the theory in application of the differential regulator. It is a relatively simple concept and incorporates only well-known and well understood components of robust construction. There are many cases of complete drives shipped overseas that have been erected and commissioned by the mill staff working from instruction manuals only, without any further assistance from the supplier. Maintenance is easily accomplished by normal mill staff engineers.

The modern differential regulator incorporates a differential of the nut and screw type, providing a linear output movement that is designed to operate a carbon pile type of resistance for stepless speed control. Derivative control is obtained from a simple oil dashpot directly from the output movement of the differential gear.

Sectional electric drives that incorporate differential regulators have been applied to papermachines with top production speeds as low as 240 ft./min. and as high as 2 200 ft./min. Designs are now available for the largest modern newsprint machines with designed speeds in excess of 3 000 ft./min. General machine speed ranges of greater than 10:1 have been successfully achieved.

Demands of modern printing production on papermaking

K. G. PAYNE

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GIVEN AT A MEETING OF SCOTTISH DIVISION: GEORGE HOTEL, GLASGOW ON 27th JANUARY 1960, MR. C. G. WALLACE IN THE CHAIR

Synopsis

The printing requirements are for bright, stable, printable, clean and uniform paper supplied in the full number of complete sheets to the ream count.

Printing has three interconnected functions of feeding the paper into printing position, printing and then delivering the printed sheets. Principal troubles encountered are—dry paper, variation in size on mill cut sheets, paper off-square preventing good feeding, variation in surface, inadequate surface bonding, variations in acidity, moisture content in relation to static, bad sorting. All of these affect production seriously and the effect on modern high-speed automatic printing is proportionately greater than on slow running handfed machines when much of the faulty paper could be extruded as the sheets were fed in one by one.

Printing demands of paper

THERE is only one demand—a sheet that is bright, ink receptive, stable, clean and uniform. The quality should be such as to give maximum efficiency in terms of printed sheets per pound sterling, repeatedly and with certainty.

That, I regret to say, is the only answer I can produce to your invitation to address you on this subject and the rest of the paper is concerned with the expression of personal opinions about converting paper into print, principally problems that limit printing production.

No printer can understand why paper cannot be constant and the correct thickness, consistent in printability, the correct size and square. We do not understand why we cannot reconcile the number of copies produced by web printing with the mill yardage specification—that is, if the mill will specify its reel yardage and if the yardage bears even remote resemblance to its specification. The substance variation of 5 per cent. either way permits a variation in outturn and wastage in unbalanced signatures that is hardly credible in this day and age.

We do not understand why mills should consistently turn out paper in which finish and colour should vary as much as it does from the top side to the wire side. We know, of course, that one side rests on a wire mesh, through which the water drains away to leave a paper web, but it does not seem sufficiently understood in the paper trade that paper is a raw material that is later converted into a usable product and that it is of paramount importance that both sides should present similar appearance and finish, unless a one-sided paper is required for a special purpose. I suppose that twin-wire papers are really the answer and I am glad to see the popularity of such papers increasing. Unless I am mistaken, even the humble bathroom accessory is now twin-wire!

We do understand that the craft of printing is developing into a precision craft. Nowadays, progressive firms are going to great length to establish precision methods and materials, with the object of putting to machine plates or formes that do not require adjustment of inaccuracies before printing may proceed.

The type we cast is produced on machines made to accuracy standards of one ten thousandth of an inch and the product is accurate to about a quarter of a thou. Alignment of face is now made almost exact by comparison against set standards under high magnification epidiascopes. Blocks are mounted on metal and made up to predetermined height accurate to half a thou and the whole is assembled to a similar degree of accuracy, with the sole object of cutting down the proportion of machine standing time to running time.

It is not long ago since the maximum printing speed of most machines almost matched the net output. The position is now changed: running speeds have doubled. Flatbed machines will now print at 4 000 copies per hr.

T44 and sheet-fed rotaries at 6 000 per hr. They *will* print at those speeds, but only too often they do not, because of the poor materials presented to them. It is normal to find potential production cut by half and I wonder why on earth the printer invests in extremely expensive plant to step up his production, when the raw material supplied to him is such that almost the entire benefit of higher running speeds is lost.

In printing, we have three interconnected functions —firstly, feeding the paper into printing position, then printing it and, finally, getting it from the printing cylinder to the delivery pile. I shall comment on various troubles we have in connection with these functions.

Dimensions

WHENEVER there are discussions on the dimensional stability of paper, I notice reference to tight edges and big centres. I have come across this in wartime when printing maps in the field, but, even in those conditions, it was never a major problem. The real problem to me seems to be that paper delivered to letterpress printing factories is dry and that it absorbs avidly all the moisture it can get, with consequent loss of register and with development of edge wave.

About a year ago, I visited a printing works to see a magnificent German 4-colour, sheet-fed litho rotary machine. It was running along quite nicely at about 6 000 copies per hr., though with a fair number of checks. In the feeder was a pile of paper about 6 ft. high and the top reams had a wave measuring not more than 1 in. from crest to valley. That was sufficient to bring down the production from an expected net of 5 000 from a running speed of 7 000 plus to an actual net of 3 000 from a running speed of 6 000. My friend had very hard words to say about the paper. What interested me was that, only a week earlier on a two-colour letterpress machine, with a feeder pile of half the size, the measured depth of wave was nearly 5 in. and the net output was something like 750 per hr., owing to the bad separation and bad reception at the lays of such sheets. I do not suggest that we continued to print at such an uneconomic rate—the demonstration was for a mill to point the fact that moisture content, even for letterpress papers, should be kept up to 7 or 8 per cent. to avoid or minimise dimensional changes, especially in relation to edge wave.

In machine-made paper, there is always an orientation with the long axis of the fibres in the machine-direction, which causes the paper to change dimension more in the cross-direction than in the grain direction. If a dry paper is exposed to medium relative humidity, it takes up moisture and reaches equilibrium faster than a wet paper gives up moisture in the same conditions and the equilibrium value of the moisture content will not be the same in the two cases. Desorption will stop at a point when the paper contains more moisture than it would have acquired by absorption and can be about 1 per cent. This hysteresis effect is related to the moisture content of the paper and to the ambient atmospheric humidity and can be of considerable value to the printer. Before paper is fit for printing, it must be properly conditioned to give maximum stability. It should be preconditioned to 1 per cent. higher moisture content than the equilibrium content for the machineroom humidity. There is a side effect to this plea for high moisture content affecting the printer. In manufacture, it is inevitable that static will be developed and by far the best way to remove this is to raise the moisture content of the paper. There is another side effect affecting the papermaker—increased moisture content enables him to sell extra water at a pretty good rate of a shilling or more per lb.!

In speaking of dimensions, I have considered changes due to the nature of paper, but there are other dimensional difficulties that are mechanical: I refer to mill cutting. The custom of the trade allows for ½ per cent. variation, not exceeding ¼ in. This is all very well, if the variation is permitted only above the nominal sheet size. When the variation falls below that, the printer (particularly the bookprinter) is in real trouble. Take a 40 in. × 60 in. sheet that varies only by ¼ in. The sheet is slit at machine so that one half is correct size: the other varies from 29¾ in. to 30 in. The signatures with variations of this nature are well undersize and, unfortunately, cannot be spotted until the forwarding stage of binding, when it is necessary to examine all copies, retrim them and eventually produce a sub-standard book.

Sheets are very often cut off square and there follows considerable variation in register and havoc at the folding machine. Variation at the lay is doubled for each fold parallel to the lay edge and can easily throw the last fold off register by a quarter inch.

Surface

IF the coating of an art paper does not adhere properly to its body stock or if the surface fibres are inadequately bonded, the printer has trouble that not only destroys the quality of the work being produced, but pulls down the production of work to an extent that makes the purchase of expensive high speed machinery a farce. The defects arising during printing are well known to every printer and are perhaps directly responsible for the epidemic outbreaks of loss of hair, ulcers and intemperance in the printing trade.

The tacky inks used may pull away pieces of coating or large clumps of fibre. The immediate effect is that the half-tone being printed has a fine white crater that almost inevitably appears in the middle of the densest areas—this is a pick! What happens to the material picked is far more jolly. One might hope that, being loose enough to be winkled off the paper coating, it would disappear via the ink table to the duct. Instead, it finds its way to the printing plate and sits there accepting ink from the forme rollers and presenting its impression to the subsequent sheets. Since it stands slightly higher than the general level of the forme, the part of the plate surrounding the pick cannot be inked and the pick shows on the finished print as a small black dot surrounded by a white halo. The Americans call this a hickey, but in this country the great Australian adjective is attached to the pick.

The loose material from the paper can mix with the ink and fill in the spaces between the dots on the half-tone plate. This does not matter so much on the solids or three quarter tones, but shows up extremely badly on light background.

The printer can try to overcome a weak paper by reducing his ink, of course, but then runs into other problems, notably that of powdering, whereby the vehicle of the ink sinks into the paper leaving the pigment lying on the surface of the paper comparatively unbound and free to rub, giving an effect remarkably similar to set-off. In really bad cases of powdering, the pigment can be wiped off the paper to leave behind an impression that is little more than a mild staining.

Ink reduction is no real answer to the problem. There is a straight alternative of either carrying on regardless of quality to the certain displeasure of the customer and consequences arising therefrom or to do the best one can in very difficult circumstances. This best takes many forms—opening the ream package as if it contained gold dust, brushing the top, bottom and sides of reams, then hanging in a paper maturing machine and turning on the air blast to maximum or, if these fail, to run the paper through a printing machine blank with the cylinder brush set tight to remove as much dust or as many picks as possible. These measures are palliatives and it is invariably found that even after all this the machine must be stopped frequently to wipe the picks from the blocks and to wash down the forme rollers.

It is not only badly coated art papers that give the printer a headache: there are uncoated papers with badly bonded fibres, especially antique woves and the diabolical bulky featherweight antique wove. Look at a machine bed after running only a few reams through the machine and one sees the steel completely masked by a dense covering of paper fibre. What one does not see readily is the mass of fibre that is absorbed by the ink felted on the rollers and the scavenging action that carries the fibres back to the ink duct. After a couple of hours, the ink put freshly into the duct is like black porridge and it prints just about as well as porridge would. The counters of the letters fill up and the machineman has to stop and scrub out the forme every two or three hundred impressions.

This scrubbing out may sound all very well, but (quite apart from reducing output to a quarter of what it should be) it has a bad effect on quality. From starting clean, quality deteriorates with the accumulation of fibre to its nadir. The impressions following wash-up are clean and sharp and, when one comes to read the complete book, even the layman will be offended by the juxtaposition of grey and black pages.

The best answer I have come across to these problems is to fit a vacuum sheet cleaner to the machine cylinder. As the sheet of paper to be printed is carried to its impression line, the fine brushes on the cleaner detach the loose fibres from the surface and the vacuum trunking carries them and any other dust to a container. There is a famous Scottish printing firm that has these sheet cleaners fitted to a battery of machines. The object was to improve quality and not only was that object achieved, but production was considerably increased and economies in ink consumption effected.

This vacuum cleaning has its danger, I believe. There is a story told about a printer who vacuum-cleaned a particularly dirty bulky featherweight. The book was required for urgent publication and the cases were made up correctly to a dummy text. When the cleaned sheets were folded, gathered and sewn, the embarassment became plain—the book fell short of its proper thickness by $\frac{1}{8}$ in.!

Surface sizing has done much to alleviate the problem of fluffing and the printability of the sheet has been greatly improved thereby; however, there is still the bogey of cutter dust—edge dust to the printers. Why cannot precautions be carried out in the mill? Every time a reel runs through slitters to the sheeters, paper dust is created and it is not beyond the ingenuity of engineers to fit vacuum-cleaning heads on the various webs.

T46 We print with a stiff paint consisting of a pigment ground into a vehicle of oils and varnishes. This ink is metered from a duct to a series of rollers whose purpose is to break up the ink into a fine film on the ink table or drum from whence it is picked up by a set of inking rollers and applied to the printing surface and transferred by impression to the paper. Drying of the inking is effected by absorption into the paper fairly quickly (so providing a 'set' that enables the sheets to be stacked) and by oxidation drying, which is slower, but results in the final hard-bonding of ink to paper. If it were not for the addition of drying agents, oxidation would be a very slow process. As it is, the process of drying is seriously affected by moisture, governed by the ambient relative humidity and the acidity of the paper. These two factors, relative humidity and acidity must be considered together.

The drying time on a neutral paper is doubled, if the ambient relative humidity is increased from 65 per cent. to 75 per cent.; but, if the paper is acid—say, below pH 5—the drying time is multiplied to ten times for a comparable change of relative humidity. Although acidity is only likely to bother the printer when the atmosphere has greater than 65–70 per cent. R.H., there are very many occasions in this climate when we have such conditions and then the printer is in a vulnerable position. Let the paper then be acid and the ink will set, but not dry on regular lines of paper used in conjunction with inks developed for the paper at its normal acidity. The really difficult part comes in that the printer does not know the print will not dry until it is too late. In making paper, the chemist knows what variations in acidity are present. Suiely, the answer should be to label distinctively all papers with a pH value of 5 or less. Then the printer could (especially, as nowadays there is no dearth of humidity meters) anticipate trouble and use an ink compounded to dry even under the adverse conditions of humidity and acidity.

Delivery

SECOND only to the papermachine in its capacity as a static generator comes the printing machine: what it lacks in quantity, it makes up for in quality. Dry paper is an excellent medium for acquiring and retaining electric charges. Paper acquires a negative charge by friction against metals, felt, rubber or textiles. These materials exist in plenty on the feeding mechanism and cylinder of a printing machine. Added to this, there is a development of charge by the action of pressure: this is generally positive in charge and is more important than friction charges.

If charged paper is brought near a neutral or oppositely charged surface such as delivery tapes, it will stick and be difficult to drop from the mechanism neatly into its proper position on the pile. That is not too bad, if only one source of static is present—usually, in such cases, the charge is negative and the pile is loose with sheet edges tending to curl upwards and to be caught by the succeeding sheet. If the charges arise from two sources—frictional and impressional—then we have the same difficulty in getting the sheet to drop and, when it does, it sticks to wherever it drops and will not jog into an even pile.

The effects of static are, of course, not confined to sheet-fed machinery and, when one enters the field of high speed, web-fed rotaries, it is interesting to note the very special attention paid to overcoming production losses arising from this source. In America, the Curtis Publishing Co. has batteries of colour Cottrell perfectors printing two colours one side of the web with quick drying inks and four colours on the other side, wet with oil oxidation inks, at a speed of 290 ft./min. The machine rooms have water sprays in the roof, because it is found that paper with a huge moisture content prints better than dry paper. In addition, the machines are fitted with anti-static electric discharge units, without which satisfactory delivery of the printed sheets is impossible. In this country, there are book printing rotaries on which the web is led from the reels through a steam bath to the impression cylinders.

Static charges develop in dry paper. In moist paper with a content of about 7–8 per cent., any charge will leak away pretty quickly and so far the control of static lies in the papermaker's hands. Make us paper that is in equilibrium in a 65 per cent. R.H. atmosphere and there will be little or no trouble with static. If we can start off with a high moisture content paper, we can take care of most of the problems arising from static on the printing machines by using discharge neutralisers and atomiser humidifiers.

Demand and supply

THERE seems to be some notion that paper is a commodity that is disposable by weight. There is a convention established (presumably by the mill) that paper is charged by tonnage: that may all be very well for what goes into the beaters, but what the printer buys is a quantity of sheets of paper on which he may print and sell the product to the consumer. Oddly enough, the consumer will not pay for sheets that have holes in the middle, for torn sheets, half sheets or even corners of sheets masquerading as full sheets. Why then should the printer be subjected to supplies that he cannot pass on to his customer?

I have heard it said that the printer of today is not the craftsman he was yesterday; that fifty years ago he knew how to print and did not complain to the extent that he does now. The simple fact is that machines were fed by hand in those days. The layer-on had manual and visual control of the sheets laid into the machine and could exclude the bad sheets as they occurred. Nowadays, with automatic feed, it is all too possible for an imperfect sheet to be accepted and taken into the cylinder. Only too often, a crush-up results, with damage to forme and entailing repairs costly in platemaking and in machine standing time. Only too often, the sheet goes through with a partial miss on the cylinder and a dozen following sheets are spoiled by set-off from the miss.

It is no answer to tell us to return the inspection tags. These have to be extruded before stacking the feeder and are fairly useless when it comes to having a sheet round the inking rollers or a crush-up. We need our men at the delivery end of the machine to ensure that we have done our part properly, not attending the feeder to ensure that the papermaker has attended to his obligations.

Explanations given by the paper trade to account for bad overhauling include—

> "The standard of sorting depends on the state of trade. In times when paper is short, the papermakers do tend to send out paper of rather lower quality than they would at other times; no doubt you are then glad to get it."

> "All the employees in the mill are on an incentive bonus and the more paper they can rush through, particularly on night shift or in the evening, the better they like it, the more money they can earn."

> "Now that incentive bonuses are the thing, we must face facts. We all know that a certain amount of lumping goes on whenever the overlooker's back is turned."

Now what can one make of that? We lose heavily by bad sorting, starting with losses in the machine room and administrative costs in complaining to paper manufacturers and merchants. We do this at a time when we are struggling to be competitive by installing high speed machines at high capital cost, by installing precision methods and by adopting procedures that will avoid waste of time. When *we* install incentive schemes, we cannot go to our customers and say, "Our chaps want to earn extra money, so they are putting your work through regardless of quality or of what you need. We're sorry about it, of course, but we ourselves are doing very nicely out of it, thank you and we've got a whale of a good balance sheet this year." *We* cannot do it and we don't believe that *you* should.

I return then, gentlemen, to my original demand of modern printing production on papermakers. I require paper that is bright, stable, printable, clean and uniform. The quality should be such as to give maximum efficiency in terms of printed sheets per pound sterling, repeatedly and with certainty and there should be 500 full sheets in the ream of 500.

discussion

MR. R. S. HESKETH: Do printers find that they get better results from large makings? If so, why cannot the printers get together to standardise sizes and substances so that the papermaker would have a better chance to run his machines with consistent quality?

MR. K. G. PAYNE: Naturally, large makings are normally more consistent than a number of makings amounting to the same tonnage. Printers are conscious of the need for standardisation—not only of paper, but of machinery—and relating the two. We strongly recommend the increased usage of ISO sizes, but it is only fair to say that our customers are resistant to using sizes they don't know. It would be helpful if both paper and print trades jointly pursued publicity to develop the use of these ISO sizes and of g./sq. m. for substance.

MR. HESKETH: Why is it that printers who had been complaining about bulky antique wove paper for many years still continue to purchase very substantial tonnages of it? I cannot accept that the printers' customers insist upon this quality, as the customer and the printer are in many cases the one. It seems unfair to criticise the profits of the papermaker, at the same time declaring that bulky antique wove is produced to persuade children that they are getting more for their money than they actually are.

MR. PAYNE: The number of printer-publishers is very few and, even in this small minority, it is the publisher who insists on the bulk. As a printer, I think that it is a mistake to use a paper that is a nightmare to papermakers and printers alike and that, in the final product, inevitably results in sacrifice of quality to quantity in the shape of bulk.

The supplementary comment confuses the criticism of papermakers' profits, which was that some of these profits might be applied to ensuring supply of the correct quantity of full, usable sheets in the reams delivered and not to include part sheets or damaged sheets in the count.

MR. A. A. LAIDLAW: On the shortcomings of bulky antique woves and featherweights in particular, does the printer have the specification of the paper for a particular job or is it specified by his customer?

I am thinking now of the many occasions when I have seen a wrongly specified paper—usually a matt art or a bulky antique wove, used for a subject that requires clarity and precision in reproduction—and have found that the paper is blamed by the printer when these objectives cannot be obtained on the paper supplied.

MR. PAYNE: In general, the customer, if he be a publisher or an advertising agent, will specify or supply paper. The questioner is right on his point about wrong specifications. I think it is not so much that printers blame papermakers as regret that they sell such papers without warning the buyer that the materials are not suitable for good quality printing.

MR. LAIDLAW: Most papermakers and coaters are very well informed about the effects of pH value and relative humidity on ink drying time. Many printers specify the pH value and tolerances they require. Control of pH on machine-finished papers is always carried out and seldom varies by more than 0.1–0.2. The control of pH on coated papers, particularly machine-coated papers, is sometimes more difficult to achieve while conforming with other features of a full specification, but a good compromise is usually possible.

Is it not up to the printer again to see that the paper he has to use is suited to the job for which he is going to use it?

MR. PAYNE: Agreed—the catch is that when using standard papers there is no indication of pH value and, short of testing every making or delivery received, the printer does not know when to add extra driers to the ink until it is too late. Although pH *seldom* varies by more than 0.1–0.2, it *occasionally* varies by many times that amount and it is on these occasions that the printer faces heavy consequential loss. Specification of pH value on the ream label would alert any printer who was well informed on the effects of pH and relative humidity on ink drying time.

MR. R. M. THOMSON: I propose that Mr. Payne should give his paper to the printing machine makers. The modern printing machine is now made to very fine limits—indeed I have seen a printing machine with 17 sets of micrometer-controlled rolls that might be very suitable to print metallic or plastic foils. Paper-machines have many rubber rolls, so why not print with rubber rolls instead of micrometers?

MR. PAYNE: We don't *print* with micrometers, but we do use them for accurate determination of thickness of printing plates whether they be metal, plastic or rubber. All of these materials are used for printing nowadays and, generally speaking, the more accurate the plate, the better the quality of printed result—especially when using rubber, which will not only print foils, but will print the finest and most delicate of type matter or line when handled properly on machines built, as they are nowadays, for the purpose.

MR. T. CLAPPERTON: Mr. Payne has told us that, amongst its many faults, paper can show hickies (from particles of fluff or coating) in the finished print. Would he not agree that this upset can also be very readily caused by the printer himself, when he splits perfectly good art paper with a blunt guillotine knife that has been functioning in the print shop as a general purpose cutter and used for cutting all types of wrappers and strawboards, as well as paper?

MR. PAYNE: Yes, I agree entirely. Too many printers do not regard a sharp knife as an economy and thereby build up a heap of hickies and consequent production losses for themselves. I agree also with the implication that printers should have special guillotines set aside for cutting white paper, but this can only be done when the volume of work in the various types of cutting makes it possible to specialise. The practical answer is to keep the guillotine clean (wiping over carefully before splitting art paper) and to use a sharp knife.

Marsh prize winning essay for 1959

The use of glass as a papermaking fibre

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Synopsis

Glass fibre naturally has advantages of stability and strength over cellulose fibres and has for many years been recognised in the textile industry. Problems of the use of the fibre in paper have been investigated and methods developed for the production of papers containing amounts of glass up to 100 per cent. Earlier work was limited to high-cost speciality papers, but developments in this field have brought about the possibility of the inclusion of small percentages of glass fibre in papers and boards produced in large quantities. Advantages gained are of increased machine speeds, yardage and caliper, besides the important gains in dimensional stability.

Introduction

IT is now more than twenty years since the conception of the use of glass fibre as a papermaking material was first put forward. At that time, little enthusiasm welcomed the idea and only in the last ten years has serious research been carried on towards producing special grades of paper using glass fibres. During the last year, acceptance of the fibre as a papermaking material has taken place in this country and the commercial production of paper from glass has started as evidenced by the general availability of such products as borosilicate glass fibre filter paper. At present, such production is limited and demand for glass fibre for papermaking is limited and prices are high. From experience in the United States, however, it is most probable that, as the volume of production increases, so prices will fall. In this way, papers incorporating the fibre would become less expensive to produce and would emerge as serious competitors to other papers in the speciality fields and even ultimately in tonnage papers and boards.

The characteristics of glass fibre that make it a most useful material in several industries are basically derived from the inorganic nature of glass. Glass fibre is not affected dimensionally or chemically by wide changes in relative humidity, temperature or chemical pollution of the surrounding atmosphere. The fibre has therefore been used widely when such considerations are important. In textiles, it has been used to give cloth that is resistant to fire, moisture, chemical pollution and shrinkage. In mixtures with both natural and artificial fibres and more recently on its own, glass fibre has been used in cloths for soft furnishings such as curtains and upholstery, for which some or all of the above-mentioned properties are of prime importance.

The special properties of the textile type of continuous drawn filaments have been used in the making of building papers. In these, the fibres are laminated between paper, thus giving the paper resistance to wide variations in atmospheric conditions met with in the building uses. This paper may be used as heat or sound insulation or as a filling material without fear of deterioration by atmospheric humidity, temperature or pollution. The fibres have been included in laminated boards for similar purposes with the same advantages over more normal grades.

A further property of the fibre is its very high tensile strength. This gives to paper and board laminates using it an improvement in both tensile and impact strengths. An application of this is the lamination of the fibre into paper tapes to give high strength packaging tapes at relatively low cost.

History of glass fibre in papermaking

THE same properties that make the fibre of value as a textile are used in its papermaking applications and the early work was mainly carried out to produce durable papers compared with normal writing and printing paper. For several years, the research on glass fibre paper was limited to a glassmaking firm in the United States; after the war, work involving pilot plants in other laboratories, notably at the National Bureau of Standards, was commenced. At this time, the raw fibre was expensive and its only possible uses were in high-priced speciality papers.

T52 The raw material of glass fibre has been made from several types of glass including aluminium silicate, kaolin, quartz, silicate and borosilicate. The fibres are manufactured by the two main processes of *drawing* and *blowing*. Drawing is a similar process to that used in the production of artificial textile yarns. Glass in the form of marbles is remelted and drawn in filaments through fine nozzles of the requisite size and then wound on to reels. From these, the filaments are rewound into balls with a large number of roving ends: from these balls, the fibre may be chopped to any required length. The filament diameter is controlled by the nozzle size and is generally 3, 5, 7 or 9 microns for papermaking fibres. The second process (blowing) forces hot gas down on a molten stream of glass blowing it into fine filaments. Fibres from this process are of varying lengths between a fraction of an inch and one inch. Diameters here are controlled by pressure, temperature and speed and vary 0.5–3 microns.

Initially, the blown fibres with these variations in dimensions were the more attractive for papermaking purposes and it was fibres of this type with which the early work was done. The papers used glass for all their fibrous content, combining it with fillers such as Teflon and silicon when they could be used and were needed, as in electrical and other papers. For filter papers, no binder was required and glass was the only component. Glass by its very nature is not affected by water and cannot fibrillate. Thus, when used as a papermaking fibre, it must depend on some other action than hydration and fibrillation bonding to form it into a sheet. It was found early on that a method of producing bonding was to lower the pH of the stock before formation on the wire. The acidity causes a layer of glass to gelatinise on each fibre and this creates a bond when the sheet is formed and dried. The action occurs below pH 4 and was found to have the greatest effect at pH 2.9. At this high level of acidity, paper of high strength is produced, as the bonding is good and the sheet has tensile strength approaching that of the glass fibres themselves. An additional action of this acid state is to disperse fibre flocs in the preparation. This is most important as glass fibres are very brittle and any form of beating process will fracture them. Beaters in this process are therefore used merely as agitators that, with the acid, disperse the fibres in the stuff.

The papers made on pilot plants at the National Bureau of Standards and in laboratories of both glass and paper manufacturers in the United States during the early 1950s were mostly of the 100 per cent. blown fibre type. Among papers using these were high quality filters for gas masks. Here, a big advantage was that, as well as being very efficient at the removal of particles from gases, the size of these particles could be selected far more closely by using fibres of controlled diameters in the manufacture. From these papers have been developed a range of filters now commercially available that have special advantages over normal papers, although more expensive. There is no binder in the sheet, so errors in filtering cannot occur from impurities in the paper. The fibres can be of sub-micron diameter and, at 0·5 micron, will give retention of 0·1 micron particles. Besides, the filters are heat resistant up to 520°c, do not clog and are more rapid than other papers used in similar filtrations. Filters are now available giving higher retention at much faster speeds than was previously possible. They are used extensively when such factors are important as with polymers, syrups, resins, fertilisers and metals.

The printing and writing papers produced used binders and, although they could not be calendered, as this would fracture the fibres making the sheet very weak, the quality of work on them was good. The reason for this is that the even distribution of fibre size and of filler gives a soft, even surface that does not need to be so highly smoothed as a normal cellulose-based paper to obtain high printing or writing quality. These papers were used for maps and legal documents, for which durability to ageing and wear, especially folding, were more important than price.

Blown fibre stock was also found to have a wide potential usage in the paper laminates field. H. Ardleter(1) and Horton and Waugh(2) have given details of these uses and the advantages to be gained in using these fibres. The kraft papers used for resin impregnation are compared with and without a 10 per cent. glass fibre additive for strength properties. Gains are shown with the addition on papers and their laminates in impact, compression, fold and tear results; a reduction of almost 50 per cent. in shrinkage in the cross-direction also occurred. The papers when used as electrical papers for capacitor and insulator purposes are shown to have good properties at high humidities and temperatures, which is a distinct advantage over normal kraft papers.

Methods for using drawn fibres of 5, 7 and 9 micron diameter for the manufacture of these papers were developed and paper was made from these fibres in 1956. These produced a more open sheet at lower cost, with high resin penetration possible when compared with the blown glass product. These properties of openness and resin impregnation are important in some grades of laminates. In certain cases, it has been possible to add the resin in the papermaking process and so eliminate a stage from the manufacture of the laminates. The types of laminate produced cover those that are heat and chemical resistant, flame retardant, dimensionally stable, also for decorative uses, as well as the electrical ones mentioned above.

Before this production of paper from drawn fibres in 1956, these cheaper fibres had only limited use in paper. High acidity as a bonding method is more suited to blown fibres with their more random dimensions and has limitations in its use also because of corrosion and the adverse effect of pH on ink drying; however, the development by the glass manufacturers of a sizing agent for use with glass fibre in papermaking made possible the use of these drawn fibres, without high acidity and its disadvantages. This size is applied in the fibre manufacturing process to the filaments drawn from the tank holding the molten glass before the preliminary winding takes place. The size is compounded so that it will initially bind the two hundred fine continuous filaments into one strand, which can then be handled by the winders and rewinders. The size has further properties, such that on being added to paper stuff the chopped strands will disperse into individual fibres and will finally give a bonding in the sheet on drying. Sizes of this sort have been developed to result in a good cellulose-to-glass bonding in mixed furnishes, as well as glass-to-glass bonding in all-glass furnishes. The availability of such a size has made possible the use of the cheaper drawn fibres of large diameter as a papermaking material. An early use was to incorporate the fibre in asbestos papers for both insulation and filtration purposes to obtain added strength while maintaining the special heatproof and high retention properties.

Recent work and applications in tonnage paper

FROM all the work on glass fibre as a papermaking material, a long list of properties given to papers using them has evolved. The most important of these are as follows—

1. Dimensional stability—A property deriving from the facts that the fibre itself can absorb only very small amounts of moisture of under 0.3 per cent. and any bonding taking place is not dependent on water. Thus, the bonding will be unaffected by the presence of water in the final sheet. This refers of course to 100 per cent. glass papers and the effect will be modified in mixtures of glass and other fibres.

2. Higher tear, tensile and impact strengths, which are the result of high tensile strength of the fibre itself. The stretch properties are low, the fibres having a maximum of 3 per cent. stretch at rupture and, with little 'give' in the bonding, this results in low stretch in the final sheet compared with other papers.

3. Resistance to all forms of change in the ambient conditions in which the paper exists. Temperature and chemical pollution, as well as humidity variations will have little effect on the properties.

4. Low density, resulting in a high caliper and bulk in the final paper, also freer stock with increased drainage and drying rates and high permeability.

5. High wet strength, enabling easier working on the wet end of the papermachine.

The properties important in speciality papers such as controlled and rapid filtration, good electrical properties (insulation and capacitance) and high resin absorbency caused by the bulk have been mentioned earlier. These general properties, together with the use of the longer, cheaper fibres, suggested the addition of glass fibre to tonnage papers and boards for three main reasons. In printing papers, the dimensional stability is of great importance for multi-colour work, as well as to reduce troubles by the paper curling and warping when stored in unconditioned atmospheres. In addition, the freeness of the stock allows greater drainage and drying rates, leading to increased speeds and lower power consumption. Furthermore, the high wet strength would allow the paper to withstand higher tensions at the wet end of the machine, which would in turn allow an increase in the speed.

For these reasons, work has been carried out on pilot plants in America to find whether the use of glass fibre in printing papers is feasible and whether there are any great advantages in doing so.

It has long been known that the hysteresis effects from changes in moisture content in paper were related to the stretch properties of the sheet. These in turn have been related to shrinkage on the papermachine during the drying process. Thus, if some way of preventing this shrinkage is applied to the machine, then low stretch and good dimensional stability will result. The addition of glass fibre to the furnish in small amounts does this by supplying rigid material, around which the paper web is made. This material inhibits shrinkage of the sheet as it dries, so preventing marked stretch and dimensional variation in the final sheet.

On the Fourdrinier machine, the shrinkage takes place mainly in the cross-direction, as the machine-direction is under tension. This shrinkage can occur far more freely at the deckle edge of the web, as the middle is under restriction from the paper surrounding it. There is therefore a distinct profile of cross-direction shrinkage across the web, which is shown by the stretch profile in the same direction. The initial experiments[3] used 5 per cent. of 9 micron drawn fibre in kraft and sulphite pulp furnishes and noted any changes in the cross-direction shrinkage profile. Marks, measured distances apart, were made on the web at the presses, their separations at the reel were observed and, from the differences in these measurements, the shrinkage was calculated. A 5 per cent. addition of the large diameter fibre was found to even out the profile to give less than 15 per cent. edge-to-middle variation, also to reduce the shrinkage generally to half its original value. On a 54 lb. offset paper, for example, edge shrinkage in the cross-direction dropped from 7 per cent. to 3.3 per cent.

The dimensional expansions in the cross-direction with increases in humidity were then found for sheets containing 5 per cent. and 10 per cent. of glass fibre. Results showed the expected drop in expansion with the addition of glass, the reduction being to about half the original value with expansions of the order of 1 per cent. for 5 per cent. addition of glass fibre and reduction to a quarter of the original value at 10 per cent. It was further found that 5 micron fibre was more effective then 5.5. micron glass wool in the same proportions.

Tests on the machine-direction properties showed little change in shrinkage and hygroexpansivity on addition of glass furnish as might be expected from the state of tension existing in this direction during the drying process. Effectively, the addition of glass in small quantities to the furnish of a printing paper can thus reduce the difference in hygroexpansivity between machine- and cross-direction to make an almost 'square' sheet with good dimensional stability.

The advantages of increased drainage rate have been noted on machines, both pilot and commercial, when the dry line has moved appreciably nearer the slice on different papers with the addition of small quantities of glass fibre. The increased drying rate has also been shown by taking moisture content values in the dryer sections of pilot machines.

The high caliper of papers and boards containing a small percentage of glass fibre could make the use of the fibre an economic proposition in papers and boards sold to a caliper specification and in which non-curl and dimensional stability are important factors.

The more recent pilot plant work has not yet been extended to commercial production. Limited trials on commercial machines have shown similar advantages to those forecast in the laboratories and both these types of experimentation serve to show that, at the small percentage additions (which are all that could be tolerated for economic reasons in tonnage papers), there are gains in yardage and caliper and speed of production, as well as improvements in dimensional stability.

Summary

GENERALLY, the future of glass fibre in papermaking seems assured, as it is already being used in commercial production, particularly in the United States, of speciality papers that include filters, electrical papers, special grade laminating papers, flongs, printing and writing papers such as those for legal documents and maps.

The properties that make the fibre suitable for these products—its stability, strength and rigidity—also make it a possible agent for increasing quantity and quality in tonnage papers and boards by giving high tensile strength and bulk with better dimensional stability.

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G. Centola and D. Borruso

Some remarks on the relationship between chemical composition and properties of strawpulps

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GIVEN AT THE SECOND EUCEPA SYMPOSIUM HELD AT NOORDWIJK, HOLLAND IN JUNE 1959

Summary

Many pulps, mainly those obtained from annual plants, are constituted of more or less complex mixtures of fibrous and non-fibrous elements, which show different forms, physico-chemical properties and chemical composition.

Many investigations have been carried out to evaluate the relationship between chemical composition and properties of strawpulps, but the influence the mixture components can have on the pulp properties has apparently been overlooked.

The possibility of establishing some relationship between chemical constitution and paper properties of pulps of this type is discussed on the basis of a comparative study of pulps from straw and other annual plants and their fibrous fractions.

Introduction

THE tests made in order to establish the relationship between the morphological, chemical and structural characteristics of pulps and their papermaking properties have not so far brought results that can be accepted unreservedly, owing both to the considerable complexity of the problem and to the imperfect and incomplete knowledge of the phenomena that occur during beating.

The problem can be simplified by reducing the number of variable factors involved, that is, by searching for the relationship that may exist between the paper properties and the chemical composition of a definite type of pulp, thus presumably eliminating the influences both of the morphological and of the submicroscopic structures.

The various authors who have so far studied this problem and carried out detailed and very interesting researches have confirmed an experimental fact that is from a practical viewpoint well known—that is, in a general way, a pulp may be beaten faster and develop greater strength if its content of hemicelluloses (wood pentosans and polysaccharides) is higher. The results of the experiments so far made do not allow, however, a reliable relationship to be deduced, even approximately, between hemicellulose or pentosan contents and paper properties.

It is almost certain that the progressive removal of these substances from the fibres brings about some noticeable variations of the structure. It is demonstrated in fact that fibres become inert to beating action on swelling in alkaline solutions at concentrations almost as strong as those capable of causing mercerisation. The concentration at which the fibre starts to become inert to beating may vary from one pulp to another, according to its lattice order and to the critical concentration at which the native lattice (cellulose I) is transformed into the lattice of mercerised cellulose (cellulose II).

McKenzie and Higgins[1] treated cotton linters, purified eucalyptus pulp and bleached kraft pulp with caustic soda solutions of various concentrations. They observed that in all pulps examined the papermaking properties (beating rate, tensile strength and extensibility) changed according to the alkali concentration and the nature and size of the changes were approximately the same in all cases.

We can thus say, considering that the amount of hemicelluloses present is very different in the three materials (0.6 per cent. linters; 1 per cent. eucalyptus cellulose; 7.1 per cent. bleached kraft), that the variations brought about with the treatment are due more to the fine structure variations than to the hemicellulose contents.

Ten years ago,[2] we arrived at the same conclusions in a similar study, which was also mentioned at the Cambridge symposium of 1957, 'Fundamentals of papermaking fibres'.[3] We deemed we could state that the relationship between the chemical composition of fibre and papermaking properties could not be established, owing to the fact that it represents a medium value that may vary considerably with the chemical composition of the layers of the fibre undergoing the beating process; also because the chemical composition may be of secondary importance in comparison with structural characteristics and especially with the structural characteristics of the outer layers of the fibre. These structural characteristics may be greatly modified both during the cooking and the bleaching processes and during treatments for hemicellulose removal.

It is, in fact, well known that the annual plant pulps are formed of a very complex mixture of particles (sclerenchyma fibres, parenchyma cells, large pith cells, hair and epidermal cells, etc.), which are individually endowed with very different properties and also possess a chemical composition variable within certain limits. The papermaking properties, besides depending upon the raw material considered as a whole, also depend very largely upon the percentage of all these constituents forming the mixture.

This statement is amply proved in the comparison between the chemical composition and the beating behaviour of three pulps of annual plants (straw, *Thypha*, esparto), produced by the monosulphite process and then beaten as whole pulps and as fibres after removal of the non-fibrous fractions.

TABLE 1 — COOKING CONDITIONS AND YIELDS

Plant material	*Chemicals used (percentage on the oven-dry material)*	*Conditions (liquor to wood ratio, temperature and time of cook)*	*Pulp yield (unbleached), per cent.*	*Residual lignin (unbleached), per cent.*	*Pulp yield (bleached), per cent.*
Wheat straw (lignin 18.5 per cent.) ..	Na_2SO_3/10 Na_2CO_3/4	1 : 5.5 150°—155°c (3 hr.)	50	3.3	47.0
Thypha angustifolia (lignin 19 per cent.) ..	Na_2SO_3/14 Na_2CO_3/4	1 : 7 160°—165°c (3 hr.)	70	12.8	57.0
Esparto (lignin 19 per cent.) ..	Na_2SO_3/14 Na_2CO_3/4	1 : 7 160°—165°c (3 hr.)	48	6.5	44.0

The results obtained by Jörgensen[4] after a detailed examination of the relationship between chemical composition and papermaking properties of spruce and birch pulps obtained with different cooking processes are, in this regard, very significant.

Not less significant is the fact that the introduction of some substantive azo-dyes[5] or of some small amounts of substitute groups (methylation, carboxymethylation, hydroxyethylation)[6–8] in the fibres brings about very noticeable variations in the papermaking properties of the pulps, independently of the percentage of hemicellulose. When from the study of linter or wood cellulose we pass to the study of pulps of annual plants in general and of straw in particular, the problem becomes more complex and, consequently, the conclusions regarding the eventual and possible relationship between chemical constitution and papermaking properties are even more uncertain.

Experimental part

1. Raw materials

Italian wheat straw, cleaned and dusted.
Italian *Thypha angustifolia.*
North African esparto.

2. Cooking conditions

Two kilograms of material were treated in a 15 litre electrically heated rotary digester with monosulphite liquor, buffered with sodium carbonate. After cooking, the material was screened, then bleached in the ordinary way with chlorine water, alkaline extraction and, finally, with sodium hypochlorite at pH 11. The hypochlorite treatment was stopped when the pulp reached a brightness of about 80 per cent. This was done in order to limit the oxidation phenomena that take place with a strong bleaching process (Table 1).

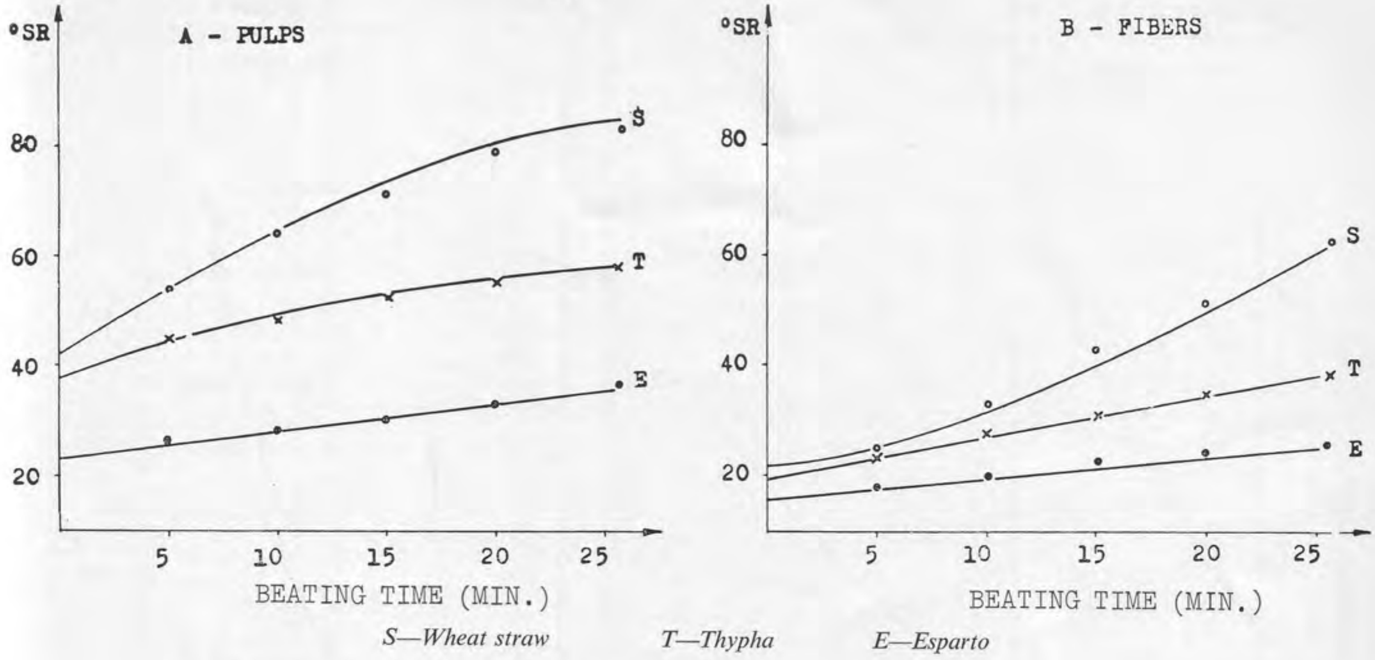


Fig. 1—Beating degree (°S.R.) versus beating time for pulps (A) and for fibrous fractions (B)

3. Fibre classification

The Bauer-McNett classifier having 30, 50 and 250 mesh wires was used. The water was maintained at a flow of 1.5 litres/min. The duration of each classification was that required for 60 litres of water to flow through. Each 10 g. (oven-dry) sample was divided as follows—

(*a*) Long fibres (on 30 mesh); (*b*) short fibres (on 50 mesh); (*c*) non-fibrous particles mixed with very short fibrous elements (on 250 mesh) plus material in the 60 litres of outflow water.

Under such conditions, this method not only allowed a study of fibre length distribution, but also of the removal of the non-fibrous particles from the fibrous fraction before beating.

We consider fibrous those fractions that do not pass through the wires of 30 and 50 mesh.

4. Beating

The beating was effected in a Jokro mill. For each pulp and for its corresponding fibrous fraction, beating periods were those corresponding to 750, 1 500, 2 250, 3 000 and 4 000 revolutions.

In the accompanying graphs, each curve representing the results shows six values obtained for identical beating times (Fig. 1—2).

5. Freeness

The measure of the beating degree was obtained with the Schopper-Riegler tester. Furthermore, the drainage factor was measured with the Ivarsson and Johansson apparatus.[9–10]

6. Handsheets preparation

After beating, sheets of 80 g./sq. m. were prepared on the Rapid-Köthen sheetmachine, according to the German standard specifications. The sheets were submitted to physico-mechanical tests after conditioning for 48 hr. at 20°C and 65 per cent. R.H.

7. Physico-mechanical tests

The laboratory handsheets from the different pulp samples before and after beating were tested for the following characteristics—breaking length (m.); tearing strength (g.); folding endurance (number of double folds); density (g./c.c.); air resistance (sec./100 c.c.); opacity (TAPPI); scattering power (from TAPPI opacity and reflectivity).[11]

8. Chemical analysis

The following data were determined on the pulp and on its fibrous and non-fibrous fraction—insoluble

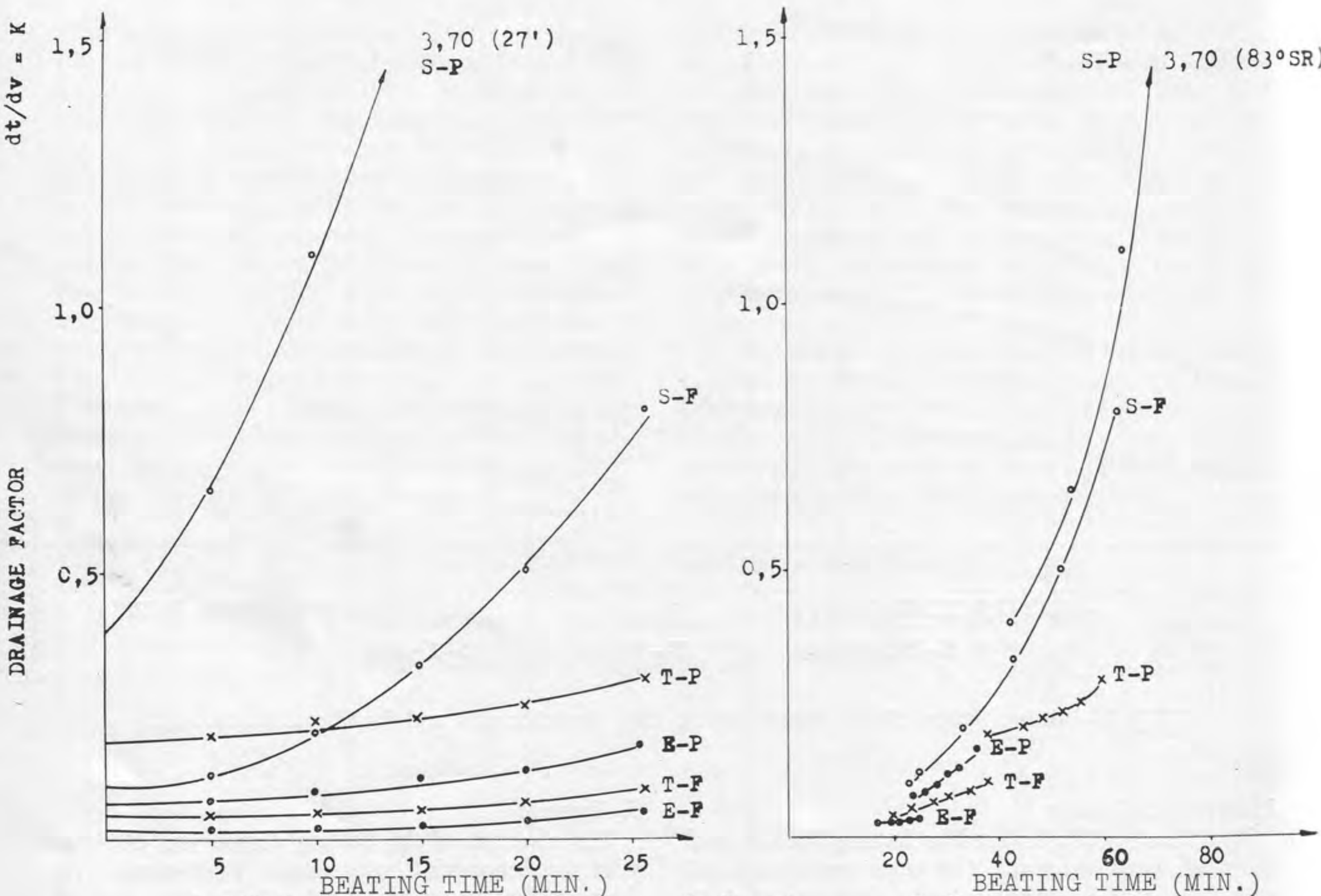


Fig. 2—Drainage factor versus beating time and relationship between beating degree (°S.R.) and drainage factor

in 18 per cent. sodium hydroxide (Merkblatt IV/29, Proc. B); pentosan and alkali-resistant pentosan (Merkblatt 9); percentage of ash; residual lignin by colorimetric determination of the brown colour at 4 200 Å of the hydrolysed pulp in 76 per cent. sulphuric acid, assuming that the lignin content of the pulp is proportional to the brown colour of its sulphuric acid solution.[12]

9. X-ray diffraction

For the investigation, a General Electric X-ray diffractometer (XRD-3) was used. This instrument is equipped with a goniometer having a movable Geiger counter device, which is connected through an amplifier to an electronic recorder. Approximately monochromatic Cu-K_α radiation was used, the incident X-ray beam from a copper target tube being filtered through a nickel foil of suitable thickness. The intensities shown in the diffraction patterns were recorded on the logarithmic scale. The analyses were made by reflection on flat surface samples.

10. Ultra-violet microscopy

After embedding the plant material in butyl methacrylate, 4 micron thick sections were prepared with a Jung microtome. The specimens were examined in the visible light and then photographed at a wavelength of 2 750 Å.[13]

Discussion of results

As an effect of the removal of the non-fibrous fractions, the beating rate decreases and the freeness increases in all the examined pulps. This effect is at a maximum (Fig. 1 and Fig. 2) for the strawpulp, in which no variations of any importance are noticed in the chemical composition (Table 2—with the exception of the ash content) between fibrous and non-fibrous fraction. It is at a minimum in the esparto

TABLE 2 — FIBROUS COMPOSITION AND CHEMICAL CHARACTERISTICS OF THE PULPS EXAMINED

Characteristic	*Straw*	*Esparto*	*Thypha angustifolia*
Fibrous composition			
Long fibres	45	62	38
Short fibres	22	22	30
Non-fibrous particles	33	16	32
Insoluble in 18 per cent. caustic soda			
Pulp	73.0	88.2	82.0
Fibres	75.6	92.4	88.0
Non-fibrous particles	70.5	80.2	76.0
*Pentosans**			
Pulp	33.0	25.5	20.4
Fibres	33.0	20.2	20.8
Non-fibrous particles	30.9	30.4	18.8
Pentosan content of fraction insoluble in 18 per cent. caustic soda			
Pulp	5.5	15.5	10.0
Fibres	7.8	14.3	10.8
Non-fibrous particles	5.0	17.4	5.8
Ash			
Pulp	7.6	0.85	4.3
Fibres	7.2	0.60	1.2
Non-fibrous particles	9.5	1.60	9.5
Residual lignin (colorimetric determination—percentage transmittance)			
Fibres	60	46	25
Non-fibrous particles	26	20	10
Linters	80	80	80

* Calculated on ash-free and moisture-free material

pulp, however, in which such differences of composition are greater.

The beating behaviour of the *Thypha*, which, like straw, contains a high percentage of non-fibrous fractions with a chemical composition very similar to that of the fibrous fraction, is more like that of the esparto than that of the straw. By plotting the drainage characteristics against the freeness (°S.R.), we observe how, at the same stock wetness, different drainage values amongst the various pulps and their

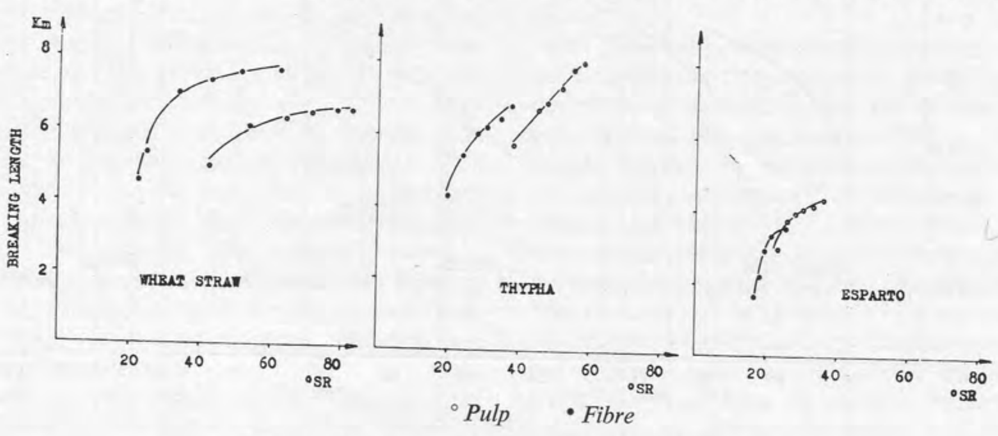
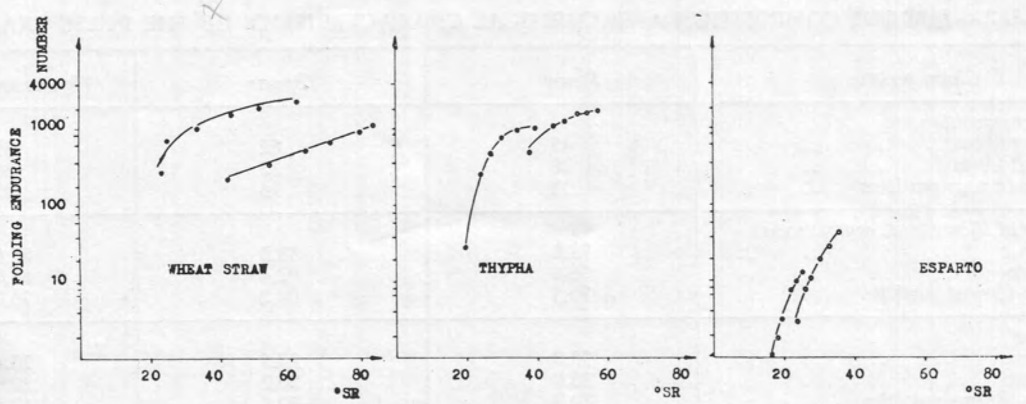
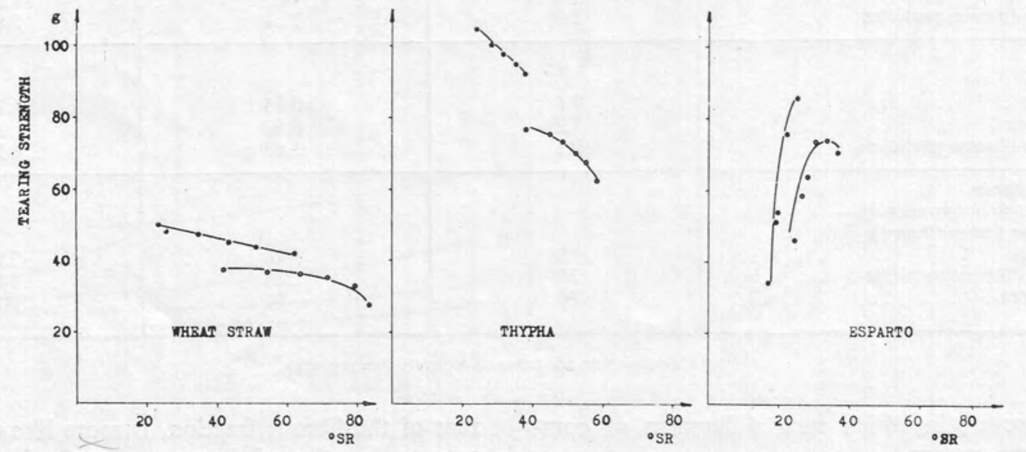


Fig. 3—Breaking length versus beating degree



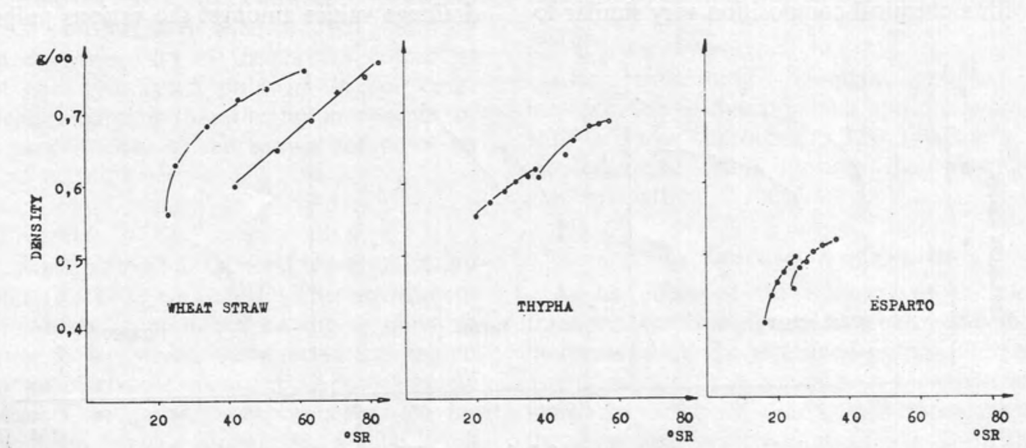
° *Pulp* • *Fibre*

Fig. 4—Folding endurance versus beating degree



° *Pulp* • *Fibre*

Fig. 5—Tearing strength versus beating degree



° *Pulp* • *Fibre*

Fig. 6—Density versus beating degree

TABLE 3 — SOME MECHANICAL PROPERTIES OF THE PULPS AND THEIR FIBROUS FRACTIONS

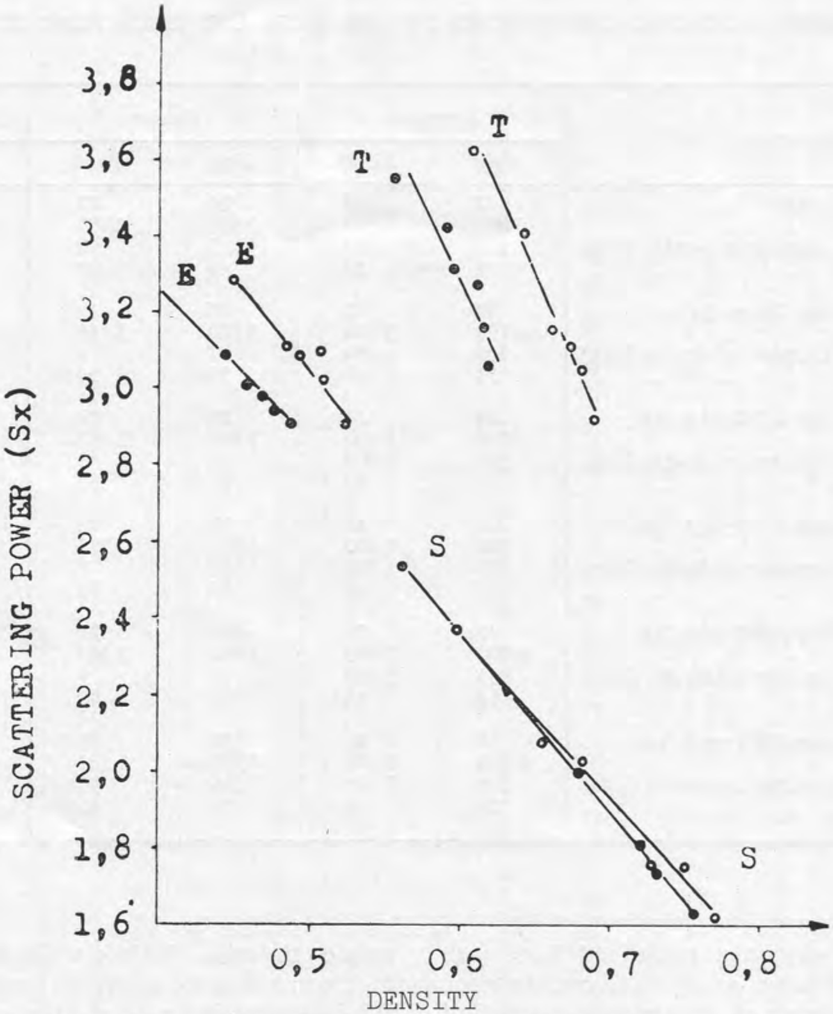
Properties	*Strawpulp*		*Esparto*		*Thypha angustifolia*	
	Pulp	*Fibres*	*Pulp*	*Fibres*	*Pulp*	*Fibres*
Freeness (unbeaten), °S.R.	42	23	24	17	38	20
Breaking length, m.	5 000	4 500	2 940	1 690	5 760	4 330
Folding endurance (number of double folds)	250	350	3	0	527	34
Tearing strength, g.	38	50	46	34	77	85
Freeness (beaten, Jokro 750 rev.), °S.R.	54	25	26	19	45	24
Breaking length, m.	6 100	5 300	3 800	2 180	6 700	5 400
Folding endurance (number of double folds)	360	750	7	1	1 000	340
Tearing strength, g.	38	47	59	54	76	105
Freeness (beaten, Jokro 1 500 rev.), °S.R.	64	34	28	20	48	28
Breaking length, m.	6 300	7 000	3 940	2 890	6 700	6 050
Folding endurance (number of double folds)	500	1 000	12	3	1 100	450
Tearing strength, g.	37	47	63	58	73	100
Freeness (beaten, Jokro 2 250 rev.), °S.R.	71	43	30	22	52	31
Breaking length, m.	6 500	7 300	4 080	3 275	7 300	6 100
Folding endurance (number of double folds)	670	1 700	21	7	1 500	950
Tearing strength, g.	36	45	75	76	70	98
Freeness (beaten, Jokro 3 000 rev.), °S.R.	79	51	33	24	55	35
Breaking length, m.	6 600	7 600	4 080	3 300	7 900	6 300
Folding endurance (number of double folds)	800	2 000	27	9	1 550	800
Tearing strength, g.	33	44	74	86	68	97
Freeness (beaten, Jokro 4 000 rev.), °S.R.	83	62	36	25	58	38
Breaking length, m.	6 500	7 600	4 350	3 550	8 000	6 800
Folding endurance (number of double folds)	1 200	2 200	46	14	1 650	900
Tearing strength, g.	26	42	71	83	92	92

fibrous fractions may take place and how such differences become larger as the °S.R. reading rises.

In the development of the physico-mechanical properties of the sheets (Fig. 3, 4 and 5 and Tables 3 and 4), it is to be observed that for the strawpulp the presence of non-fibrous fractions acts unfavourably on the breaking length, folding endurance and tearing strength, while for the esparto and the *Thypha* the presence of non-fibrous fractions acts unfavourably on the tearing strength, but helps to increase the breaking length and the folding endurance. This different behaviour may be accounted for by the fact that, if one considers the density of the sheets obtained for the same beating time, the strawpulp shows a definite increase in the density of the fibrous fraction handsheets in comparison with those prepared from the whole pulp. In the other pulps, however, we observe the reverse (Fig. 6).

In the optical characteristics also (Fig. 7), we observe definite differences between the pulps of *Thypha* and esparto on the one hand and the strawpulp on the other. Besides, while the scattering power is determined in the strawpulp by the fibrous fraction, it is influenced in the *Thypha* and esparto pulps by the non-fibrous fractions. These results are in accordance with the physico-mechanical characteristics indicated above.

All these observations seem to indicate that, while the non-fibrous elements are of great importance in determining the beating rate, the physico-mechanical properties of the sheets may, at the same Schopper-Riegler freeness, be influenced either by the fibrous or the non-fibrous fractions. In all cases, however, it is almost impossible to establish the relationship between the behaviour of the mixture components of the pulps investigated and their chemical composition. More details will be submitted in the paper presented by Borruso at this meeting. There is no doubt that the morphological characteristics more than the chemical ones have a greater influence on the behaviour of the whole pulps and their fibrous fractions.



S—Wheat straw *T—Thypha* *E—Esparto* ° *Pulp* • *Fibre*

Fig. 7—Scattering power versus density

It is well known that the parenchyma cells of straw-pulp show very large internal cavities during the beating process and tend to split easily or to collapse into thin sheets. Furthermore, the bast cells of the straw, in which the lumen may occupy as much as one third of the width of the fibre and in which the lignin is mainly concentrated in the middle lamella, tend to collapse in the softening action of the beater (internal fibrillation),[14] thus giving a translucent and dense sheet.

In esparto, the fibres are thick-walled, so that the lumen is nearly closed. These fibres retain on drying a round cross-section and a sinuous, springy form. Ultra-violet microscopy shows that a considerable number of fibres are lignified not only in the middle lamella, but also in the cell walls that run up to the lumen.

It is probable that the physical and chemical linkage existing between lignin and polysaccharides in the cell walls remains even after extraction. Thus, the pulp becomes difficult to beat and its sheet has a low density and a high scattering power. It is also possible to observe, with the microscope, some great differences between the non-fibrous fraction of straw and esparto. In fact, the esparto non-fibrous fractions are mostly formed by very small tooth- or pear-shaped hair cells, whereas the straw contains a considerable amount of large and flat pith cells.

The *Thypha* fibres also are thick-walled and the lignin is distributed over the entire cross-section.

What has been said for esparto also applies to this fibrous material. The higher rate of beating and the different physico-mechanical characteristics observed between *Thypha* and esparto pulps are to be ascribed in part to the higher percentage of non-fibrous elements in the *Thypha* and to the presence amongst these elements of a certain quantity of parenchyma cells similar to those found in straw.

Besides the differences in morphological structure, the differences of fine structure are to be taken into consideration. Such fine structural differences may be due, to a certain extent, to a different distribution of the chemical constituents throughout the cell wall.

In Fig. 8—10, the X-ray diffraction patterns of the whole pulps, of the fibrous and non-fibrous fractions of the straw, esparto and *Thypha* pulps are shown. It is possible to observe that the fibrous fractions always show a larger percentage amount of crystalline material than do the non-fibrous particles and, therefore, of the whole pulps. Esparto shows the highest

Fig. 8—Diffractogram of fibrous fraction

lattice order, *Thypha* follows, then straw.

Chemical analysis shows that the esparto pulp has a higher content of alkali-resistant pentosans than have the other two pulps and its percentage of pentosans is intermediate between straw and *Thypha* pulps. It is interesting to note that the percentage of alkali-resistant pentosans is much higher both for the esparto and the *Thypha* pulps and that in the plant tissue the lignin is fairly uniformly distributed over the whole fibre cross-section so as to be incorporated in the cellulose network. This very close linkage in the plant material between lignin and carbohydrates has been considered[15] as the principal cause of the difficulty of swelling and mercerisation of the *Thypha* fibre compared with other fibres having the same lignin contents.

It is very probable that, even after the cooking and bleaching processes, the skeleton of encrustant substances present in the cellulose network may not be altogethei destroyed and that the swelling and the

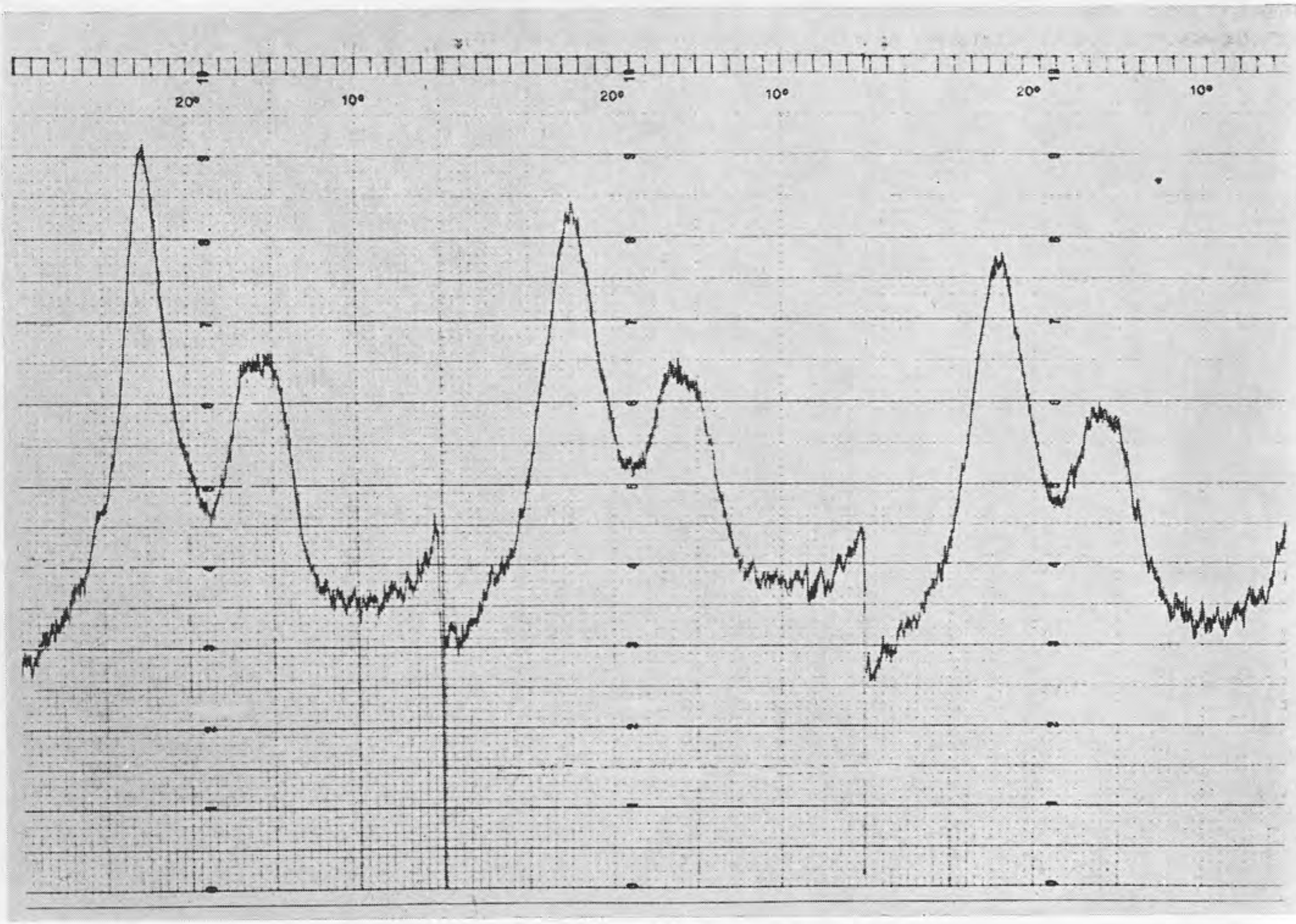


Fig. 9—Diffractogram of pulps

internal fibrillation difficulties remain also in the finished pulps as a result of a probable linkage between polysaccharides and lignin.

Conclusions

The percentage of the fibrous and non-fibrous elements in the mixture, more than the chemical composition of the pulp as a whole, have a prevailing influence on the pulp's reaction during beating and on the properties of the sheets, as has often been proved, particularly with strawpulp. This is proved by the researches carried out, representing the first attempts to interpret the papermaking properties of pulps from annual plants, considering the heterogeneous constitution of the fibrous and non-fibrous elements.

The usual chemical analysis can hardly lead us to reliable conclusions in evaluating the papermaking

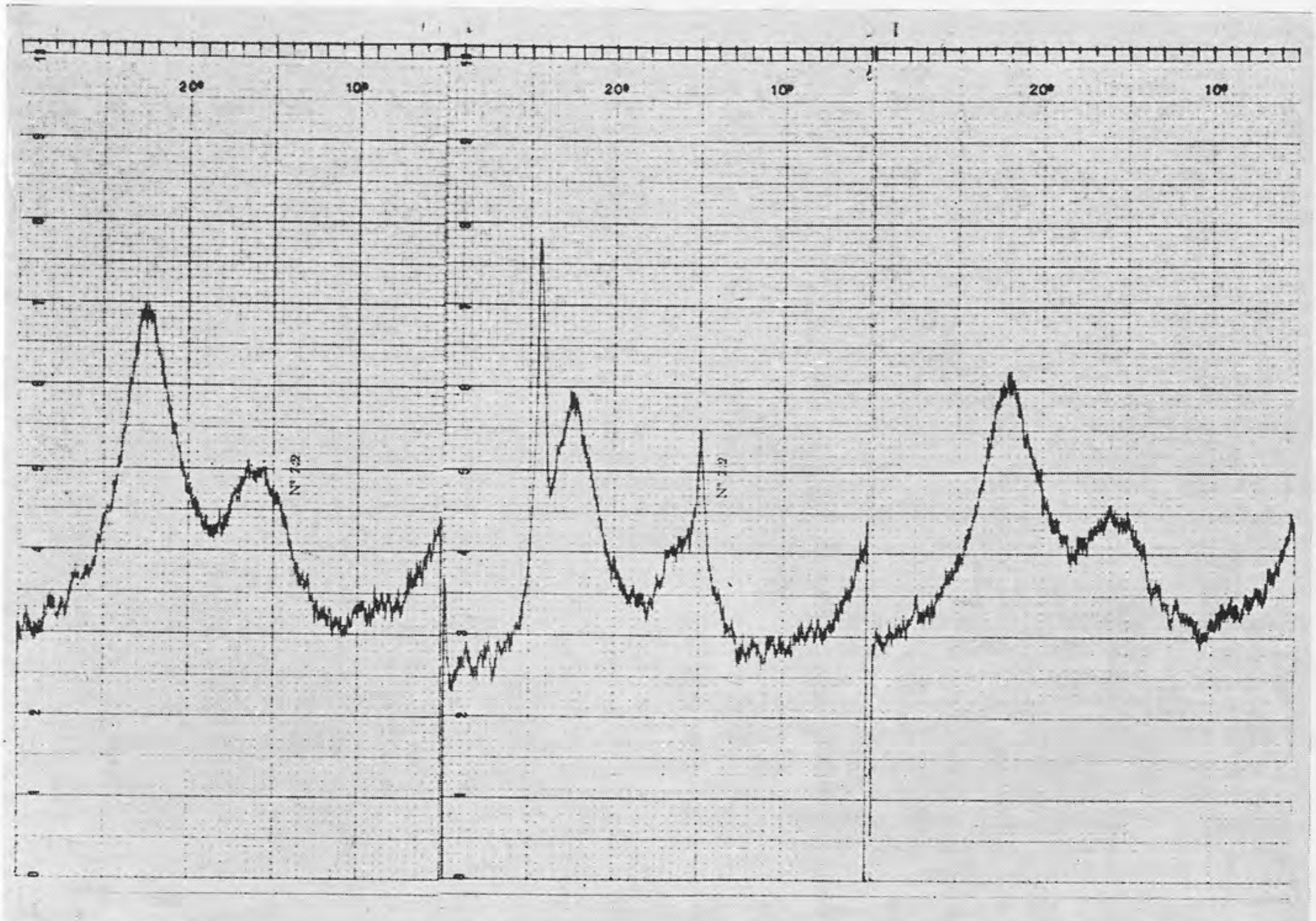


Fig. 10—Diffractogram of non-fibrous fraction

TABLE 4 — SOME PHYSICAL PROPERTIES OF THE PULPS AND THEIR FIBROUS FRACTIONS

Properties	*Strawpulp*		*Esparto*		*Thypha angustifolia*	
	Pulp	*Fibres*	*Pulp*	*Fibres*	*Pulp*	*Fibres*
Freeness (unbeaten), °S.R.	42	23	24	17	38	20
Air resistance, sec./100 c.c.	185	38	0	0	19	2
Density, g./c.c.	0.600	0.560	0.452	0.400	0.610	0.550
Opacity (TAPPI)	81	81.5	86.5	85.3	89.4	89.7
Scattering power, SX*	2.37	2.53	3.29	3.28	3.62	3.53
Freeness (beaten, Jokro 750 rev.), °S.R.	54	25	26	19	45	24
Air resistance, sec./100 c.c.	440	45	1	0.4	30	3
Density, g./c.c.	0.654	0.630	0.485	0.442	0.640	0.588
Opacity (TAPPI)	78.2	78.4	85.5	84	88.6	89.2
Scattering power, SX*	2.09	2.21	3.09	3.09	3.40	3.42
Freeness (beaten, Jokro 1 500 rev.), °S.R.	64	34	28	20	48	28
Air resistance, sec./100 c.c.	700	60	1	0.4	38	4
Density, g./c.c.	0.682	0.680	0.485	0.455	0.660	0.592
Opacity (TAPPI)	78	76	85.5	83.7	87.2	88
Scattering power, SX*	2.04	1.99	3.10	2.98	3.13	3.30
Freeness (beaten, Jokro 2 250 rev.), °S.R.	71	43	30	22	52	31
Air resistance, sec./100 c.c.	1 900	140	1	0.6	50	4
Density, g./c.c.	0.730	0.720	0.510	0.473	0.680	0.610
Opacity (TAPPI)	74	75.5	85.6	84	87.1	87.8
Scattering power, SX*	1.74	1.82	3.12	3.00	3.11	3.27
Freeness (beaten, Jokro 3 000 rev.), °S.R.	79	51	33	24	55	35
Air resistance, sec./100 c.c.	2 800	200	2	0.6	46	4
Density, g./c.c.	0.750	0.730	0.510	0.478	0.677	0.607
Opacity (TAPPI)	74.5	72.5	85.0	83.6	86.6	87
Scattering power, SX*	1.77	1.73	3.00	2.94	3.05	3.15
Freeness (beaten, Jokro 4 000 rev.), °S.R.	83	62	36	25	58	38
Air resistance, sec./100 c.c.	8 000	750	2	0.8	65	5
Density, g./c.c.	0.770	0.760	0.518	0.493	0.683	0.614
Opacity (TAPPI)	73.8	70.8	85.0	83.2	85.7	87.3
Scattering power, SX*	1.60	1.63	2.87	2.90	2.90	3.05

* From TAPPI opacity and reflectivity (80 g./sq. m. sheet)

properties, unless it be based on a study of the distribution of the possible linkages between the chemical constituents of the pulp. This is due to the morphological differences observed under the microscope on the fibrous and non-fibrous elements of the various pulps, which also show different degrees of crystallinity and a different combination and distribution of the chemical constituents in the cell wall.

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Book review

Industrial gums: Polysaccharides and their derivatives— Roy L. Whistler
(*Academic Press, London, 1959, 766 pp., £8 18s. 6d.*)

THIS substantial American handbook comprises thirty chapters, each a self-contained review of a gum or small group of closely related gums, written by an experienced specialist who has worked with the products described. These chapters are preceded by an introductory one by the senior editor—*Factors influencing gum costs and applications*. In the preface, Dr. Whistler sets out his aims: "It is, therefore, a collection of practical information on industrial gums, prepared in such a way that it may be useful to research workers, chemical engineers, technical sales personnel . . . who wish to learn more about gums." Having emphasised that as many as possible of the chapters have been written by persons with an industrial background, the editor continues "It is also hoped that the chapters have been so organised that potential gum users can make a rational selection of the gum best suited for their particular product or application."

How far are these aims realised? Is the practical information offered sufficiently detailed and precise to be of much value to the research worker, especially one engaged in the paper industry; to the chemist serving as a kind of scientific handyman in a papermill; or to the practical craftsman papermaker with limited formal education in chemistry and physics looking for independent guidance to help him sort the wheat from the chaff amongst the many claims made for proprietary products now offered to the paper industry? Is a rationale of gum usage really presented?

The introductory chapter makes a promising start towards answering the last question. The wise reader seeking guidance on the background to the availability, economics and future prospects for various gums before making a decision with a long term commitment would do well to spare the few moments necessary to read this short chapter; it contains notes contrasting gums derived from limited, near haphazard, sources with those commercial products more securely founded in origin and readily expandable in output as demand grows. The later part of this chapter very briefly highlights one or two general features of the physical and organic chemistry of gums that are in the background of their industrial applications; this part of the chapter is written in terms straightforward enough for the graduate chemist, but, perhaps inevitably, plunges too deeply into the modern concepts of these sciences to be fully appreciated by the non-graduate practical man.

The chapters thereafter are reviews, each written by a separate author, covering one gum only—with one or two unimportant exceptions. These chapters are written with the industrial chemist in mind and contain summaries of the occurrence, extraction, purification and chemical and physical properties of the gum concerned together with notes on its applications. Apart from the sections on applications, the chemist will find these notes interesting and useful reviews. On the whole, these sections are well written and up-to-date, although there is inevitably some unevenness in subject treatment between one author and another.

The notes upon the applications in each chapter read all too much like condensed versions of gum manufacturers' literature. Because of limitations of space (and perhaps some times because details are hazy), the information given upon a particular application is scanty and seldom particularly satisfactory, except as a starting off point for experiments. The reader who is a papermaker will have to be patient with very brief and generalised paragraphs indeed upon the important applications of certain gums in his own field.

Unfortunately, a book compiled in this manner, each gum treated by a separate specialist, suffers from a serious drawback: this book is no critical survey, it does not take typical types of industrial application for gums such as solution thickening, film formation, etc. and discuss these particular problems in relation to the whole range of gums available. It therefore offers no guidance upon the merits or faults of a particular gum compared with the others available and mentioned in the index as being potentially suitable for a given purpose. For example, the reader will find no help towards choosing between starch, sodium alginate and cellulose derivatives—or mixtures of some of these—for the surface sizing of paper; reference to the index entry for this subject, followed by consultation of the relevant sections under the heading 'Applications' in each chapter upon a gum gives no more guidance than separate consultation of manufacturers' literature. The reader is presented with no rational basis for choosing between the various claims for usefulness in surface sizing made for all the gums mentioned in the index. A reader with chemical training and little practical experience of various gums would find the notes upon chemical and physical properties of the substances helpful as a starting basis, but resort would have to be made to experiment before a choice could be made.

The writing of a thoroughly critical survey of this latter kind would call for exceptional qualifications of knowledge and industrial experience from the author or group of authors. In the absence of such qualified authorship, this book is probably the best that can be expected as a reference work. For the paper industry, it should be useful to the chemist in the group research laboratory or the laboratory of a research association and for the mill chemist in a large papermill. It will be of little more value to the non-chemical reader in the paper industry than a collection of manufacturers' literature.

The book is well printed and the proof reading has obviously been carried out with great care. The bibliographies are useful and up-to-date. The nomenclature used is of recent American origin and the reader may find the new variations upon old familiar names slightly annoying until he becomes used to them.

CHAPTERS 2–8 (192 pages) deal with various seaweed gums; of these, algin (sodium alginate) is the only one of practical importance to the papermaker, but this is not to say that the other chapters are lacking in interest.

CHAPTER 4 is contributed by a member of the staff of the principal American alginate producer and the contents betray this background. Even without the advantage of a seaweed raw material that can be harvested mechanically and processed without preliminary drying, the British industry is larger and more competitive—even in the U.S.A.—than the reader may be led to imagine.

More details upon size press and coating recipes would have been interesting in the notes on applications of algin in the paper industry, but as requirements vary so much these are best settled by a practical trial in co-operation with the manufacturers.

Alginates are more important in the paper converting industry than the reader might surmise—for control of penetration of synthetic polymer dispersions, and for varnish hold-out and uniformity. The amine alginates (insoluble in water, but soluble in alcohols), pioneered in Britain, are not mentioned; these are also of interest to the converter.

C. T. Blood

CHAPTERS 9–21 (324 pages) are concerned with guar and locust bean gums and the like. The information here is certainly authoritative, particularly on the chemical side. It is well to mention that one or two statements need qualification or amendment. Thus, on page 362 (third section), the period when frost damage could occur to the locust bean crop ought to be extended to include March.

On the following page (fifth section), the figure of 8 per cent. for kernels in the locust bean must be varied with climatic conditions, local rainfall and the hotter, drier countries (parts of Spain and North Africa), the pods are rather wizened and the pips relatively larger, giving yields of sometimes over 10 per cent.; in a wet season in Cyprus, the yields are down to 7 per cent.

The mesh sizes given on page 364 are put forward somewhat dogmatically; in the U.K., production is certainly not limited to one mesh only for technical grades.

Disagreement must be registered with the information on the colour of high grade gums. It is not just a matter of visual effect, as reflectometers are used and a reading of about 28 is considered to indicate whiteness, though it does not give the speck content of a high grade.

Exploitation of locust bean kernels certainly dates back further than the quarter century stated: more than half a century is nearer the mark.

The applications in the paper industry for these products are not always correctly indicated. Two particular instances are concerned with locust bean gum. It is called a beater additive, but could better be described as a wet end additive: unless the gum is in modified form (unusual in paper usage), it should be 'cooked' and added as a (hot) solution, preferably at the head box or mixing chest. Earlier, it is stated that guar is more suitable for paper applications than is locust bean gum; British experience is that, weight for weight—providing the user goes to the trouble of 'cooking' the locust (guar needs no cooking)—better all-round results will be obtained with the locust gum. It is admitted, however, that the red-brown husk of the locust bean means that only high grade locust gum can be used for white papers.

Guar is listed for improving filler retention, but this seems doubtful. There is a new type of titanium dioxide being produced in U.S.A., however, for which retention is said to be increased in conjunction with guar gum.

A. V. Turner

(*continued on page 173*)

(News page continued from page 117)

Paper museum

FOR some time now, the Technical Section has been interested in setting up a national paper museum and it appointed the Museum Committee in 1957 to further this project. Plans have made excellent progress. Premises at St. Mary Cray, Kent have been made available at a nominal rent and the paper industry and allied interests were appealed to in December 1959 for funds to run the museum. This appeal has met with ready response and over £1 000 has been received in donations for this year: some of these will continue for the next 7 or 10 years on a covenant basis, so allowing income tax on the gifts to be claimed for the fund.

The fund has been recognised as having charitable purposes and is not liable therefore to taxation. The trustees appointed as its administrators are Mr. Hugh Balston, Mr. Rémy Green and Mr. Philip Prior.

What repairs, alterations, heating and lighting installations have to be made to make the premises suitable for establishing the museum have recently been agreed on by the Museum Committee and the management of British Vegetable Parchment (Delcroix) Ltd. Provision has also been made for cleaning and supervision.

When this preliminary work is complete, the museum items already promised will be called in. Since the appeal for funds was made, additional exhibits have been forthcoming. The interest shown in every quarter is most encouraging.

Individuals and firms at home and abroad that have not yet done so may like to donate either money to the Museum Trust Fund or items to exhibit in the museum. Write to the Technical Section Secretary, St. Winifred's, Welcomes Road, Kenley, Surrey.

Package printing

AMONG forthcoming conferences is one organised by the Institute of Packaging on the theme *Package buying and print*. This will be held at The Grand Hotel, Eastbourne for the three days 23rd–25th May 1960.

The conference chairman is Mr. C. C. Hazelwood, Chairman of the Institute and the thirteen papers to be presented will deal with—

1. The significance of printing in packaging.
2. How to apply modern printing techniques.
3. What the package buyer needs to know about print.
4. Newest trends and developments in printing methods.

Registration fee is 5 gn. Leaflet with programme and registration (and hotel booking) form may be obtained from Secretary, Institute of Packaging, 50 Poland Street, London, W.1.

Proceedings indexes

MEMBERS who have been wanting indexes to *Proceedings* will be pleased to know these are now on sale—see page 196.

Visit to Canada

FOR latest details, see page 177.

Book review *(continued from page 170)*

THE last ten chapters (224 pages) of the book deal with cellulose derivatives and starches and they make a signal contribution to the literature on this very wide and complex subject. Much valuable information is recorded dealing with the history, development, preparation, manufacture and properties of these types of products, thus providing a ready source of concise and factual information in a manner not previously so readily available either to the user or student handling these substances.

Under the sub-titles 'Uses', information about both accepted and recommended uses is clearly described. It is felt that these sections could have been expanded with advantage, giving more information on the many applications, but it is realised that this might have upset the balance of the book. The information provided, while not being detailed to a marked extent provides a sound basis upon which experimentation for practical applications may be conducted.

To those people engaged directly in the paper and converting industries, the chapters under review will prove most acceptable. Particular interest should be shown in the chapters dealing with starch amylose, starch amylopectin and starch ethers, since these products, which are relatively new, are now in regular commercial production and their properties are being exploited widely in these fields.

The chapter dealing with the subject of dextrins treats this most complex commodity in a most lucid and informative manner. Those people engaged in the preparation and application of vegetable-based gums and glues will find this section invaluable.

The entire book is excellently produced, well up to the high standard of the Academic Press, is well indexed and contains copious references to the literature. It should find a ready place on the book-shelves of all the scientific and technical personnel engaged in the papermaking and paper converting industries and should prove an invaluable reference book.

W. H. Boardman

SUMMARIES from foreign journals

Translations in English of the originals of these summaries are available only on order at standard rates—details may be obtained on application to the Secretary

*

THE following are freely abridged versions of the original papers available in the original language through the Technical Section Library—

The control of draw on papermachines

G. Kessler

Wochbl. Papierfabr., 1959, **87** (11/12), 498–505

THE function of a papermachine is to extract water from the stuff delivered to the wire and to convert it into a reel of paper of uniform basis weight and moisture content. A large number of variables must be kept constant to achieve this aim, among them two that are determined by the papermachine drive—the tension or extension in the sheet between sections. Unfortunately, in most cases, the direct measurement of these quantities is not possible.

To maintain a constant slack loop of paper that has reached a high degree of strength (as is necessary on a coating machine), direct measurement of the loop is essential, for example, by photoelectric means, but, on the papermachine, the sheet has sufficient give to tolerate speed changes of the order of 0.1 per cent. Therefore, maintenance of constant speed can result in successful papermachine operation, even though disturbing effects such as changes in shrinkage or transient load changes will be felt throughout all sections following the point of disturbance.

A block diagram is derived that shows not only the operation of individual section regulators, but also the interaction between sections by way of the sheet.

Many different types of papermachine drive are described, all using various forms of electrical, mechanical or electro-mechanical differential, in which the reference speed for each section is compared with the actual speed of the section, any difference causing a correction to wipe out the error.

These systems include some with speed integral control; integral and proportional control; integral, proportional and differential control; and proportional control only. The latter is the only type of system not requiring a variable ratio transmission such as belt and cone pulleys for speed adjustments and permitting the ideal of control by tensiometer—a device that directly measures sheet tension—to be incorporated.

Finally, various arrangements of draw-adjusting gear manufactured by Brown-Boveri, A.E.G. and Siemens Schuckert are described in some detail and illustrated by photographs.

Fourdrinier wires from plastics

M. Weinfurt and M. Chromy

Papír a celulosa, 1959, **14** (1), 7–9

THE experiments reported here were concerned with the polyamide plastics, perlon and silon and the machine wires made from these synthetic fibres were found to have the following advantages—

1. A working life considerably longer than that of the conventional phosphor bronze wires.
2. The weight of a silon or perlon wire is only one tenth of the weight of the equivalent phosphor bronze wire, which greatly facilitates wire changing.
3. Wear on suction box tops is greatly reduced, as the synthetics have low friction coefficients and are so light and durable.
4. The lightness of the wire and the low friction coefficient mean that there is a considerable reduction in the power necessary to drive the wire.

The perlon filaments used in the experiments had diameters of 0.45–0.60 mm. and the wire was woven with 8–10 filaments per cm. Since it is impossible to weld polyamide plastics successfully, the wires are either woven endless or are joined with stitched seams. The stretched wires are then treated while running with infra-red radiation (at 165°c) before being put on the papermachine in order to even the tension and so avoid difficulties that were found with untreated wires as a result of their high elasticity and tendency to crease.

With combined silon/phosphor bronze wires, this heat treatment is unnecessary and the rigidity of the woven wire is supplied by the phosphor bronze wires of the weft. Wire life is about 40 per cent. longer than for a bronze wire. Care must be taken in cleaning synthetic wires and the most suitable agents to remove the given materials are—

1. Pitch—alcohol, caustic soda, xylene.
2. Grease—carbon tetrachloride, ethylene trichloride, chloroform, benzene.
3. Calcium deposits—dilute hydrochloric acid in a dilution of 1 part acid to 3 parts water.

(*continued on page 179*)

VISIT TO CANADA

TECHNICAL SECTION members have responded well to the Canadian invitation to spend three weeks in Canada visiting mills on both East and West coasts and to attend the summer meeting at Banff. Of the 36 names listed for the trip so far, seven are ladies and it is hoped that amongst the further enrolments coming forward there will be several more ladies. Three papers have been offered by members for presentation at the conference and further contributions are required to make a worthy British effort.

ANY member still thinking of joining the party is urged to let the Secretary know without delay, as block travel bookings must now be confirmed. The estimated total cost for the trip is £700—£800.

THE itinerary is briefly as follows, the mill visits arrangements still being tentative—

Friday, 26th August	Fly to Vancouver	
Monday, 29th August	Visit Powell River Mill	
Tuesday, 30th August	Visit B.C. Forest Products Mill, Crofton	Vancouver Island
Wednesday, 31st August	Visit Port Alberni Pulp and Paper Mills	
Thursday, 1st September	Visit Harmac Mill, Nanaimo	
Friday, 2nd September	Visits to Westminster Paper Co. Ltd. and Sydney Roofing & Paper Co. Ltd., Vancouver	
Saturday, 3rd September	Visit Northwestern Pulp & Power Ltd., Hinton, Alberta	
Sunday, 4th September	Jasper Park Lodge	
Monday, 5th September	Lake Louise	
Tuesday, 6th September **Wednesday, 7th September** **Thursday, 8th September** **Friday, 9th September**	Canadian Technical Section Summer meeting, Banff Springs Hotel— *Towards the more complete and efficient use of our raw materials and manpower resources*	
Saturday, 10th September	Fly to Toronto	
Sunday, 11th September	Train to Niagara	
Monday, 12th September **Tuesday, 13th September**	Visit mills in Niagara Peninsula— Alliance Paper Mills Ltd., Garden City Paper Mills Ltd., Interlake Tissue Mills Co. Ltd., Beaver Wood Fibre Co. Ltd., Brantford Roofing Co. Ltd., Ontario Paper Co. Ltd. and Provincial Paper Ltd.	
Wednesday, 14th September	Visit mills in Toronto area— Hinde & Dauch Paper Co. of Canada Ltd. and Gair Paper Products Division of Continental Can, Acme Paper Products Ltd., Dominion Cellulose Ltd. and Don Valley Paper Co. Ltd.	
Thursday, 15th September	Visit mills in Ottawa area— E. B. Eddy Co., Canadian International Paper Co.	
Friday, 16th September	Visit Howard Smith Paper Mill, Cornwall	
Saturday, 17th September	Visit Rolland Paper Co. Ltd., St. Jerome, near Montreal	
Monday, 19th September	Visit Pulp and Paper Research Institute of Canada, Pointe Claire, Montreal	

Alternative return travel arrangements

	Depart Montreal by air —
Monday, 19th September	To Prestwick, Manchester, London (BOAC) — arriving mid-morning, 20th September
Tuesday, 20th September	To London (TCA) — arriving mid-morning, 20th September
	Depart Montreal by sea —
Friday, 16th September	To Liverpool by Cunard *Saxonia*, arriving Greenock, 22nd September and Liverpool, 23rd September
Tuesday, 20th September	Canadian Pacific *Empress of England*, arriving Greenock, 26th September and Liverpool, 27th September


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(Summaries from foreign journals continued from page 174)

The wire must be thoroughly rinsed with cold water after cleaning. These wires can also be cleaned with a hot water or a jet of steam (though the temperature must not exceed 100°C) or with a brush of the same plastic.

The wires must be expected to increase in length by 3–5 per cent. during running, so it is essential to allow for this if maximum working life is to be ensured. It was found useful therefore to make the wire 3–5 per cent. too short and then to soak it in cold water for at least 12 hr. before fitting. The usual fitting procedure can be used. The wire should be stretched only when it is in motion and, after fitting, should be sprayed with water and run for 15 min. before stock is allowed to run on to it, the vacuum in the suction boxes being increased gradually. It is found that, in most cases, maximum length is attained after running for 15–25 hr.

A scroll roll on all-silon wires maintains the machine wire width and slip on the driving roll or at the vacuum boxes can be avoided by a rubber-covered surface. When the wire is out of use, it should be slackened, then retightened for reusing. Holes in the wire should be mended with the sewing wire, which should run well into the surrounding fabric.

A fine silon/bronze wire is being used experimentally for making various grades of paper.

The air content of pulp suspensions

W. Brecht and U. Kirchner
Wochbl. Papierfabr., 1959, **87** (8), 295–305

It was shown that the amount of air entrained in a pulp suspension depends on a large number of factors, but especially on a particular characteristic that can conveniently be called the *air entrainment tendency* of the pulp. This is defined as the amount of air taken up by a pulp when it is subjected to given mechanical agitation. A testing method was developed and it was found experimentally that the air content of a pulp depends mainly on surface active agents. These reduce the surface tension of the liquid and, with pulps containing air, this results in the formation of numerous small air bells. Since water containing groundwood fibre shows an extremely pronounced tendency to take up air, it is suggested that this is due to its content of surface active agents.

A sheetmachine was used in laboratory experiments to find the effect of the air content on rate of water removal and on the relationship between the wet and dry states. The drainage rate was found to decrease sharply with increasing air content; the strength properties of both wet and dry sheets were also reduced, but permeability was increased. In order to ensure that the stuff flowing on to the wire has a low air content, it is essential that all unnecessary agitation should be avoided.

What is the position with hardwood pulps?

H. J. Col
Papeterie, 1959, **81** (3),177–8

In general, hardwood pulps are of most interest in the making of printings and writings, amounts of 25–30 per cent. being fairly common and going as high as 70 per cent. in certain grades. Progress in refining methods has provided suitable means for working short fibres, in particular the non-contact type of refiner. The refining of hardwoods is completely different from that of softwoods, since a gentle treatment is sufficient to give the best of their strength properties and to ensure good formation on the wire. If these pulps are treated in beaters, it is essential that strict control be exercised on the beating conditions, but the pulps acquire their best properties when treated in high-speed conical refiners at a consistency of 4.5–5 per cent. They should be treated separately from long-fibred components, even if this involves additional production difficulties.

To these general considerations can be added the papermachine conditions especially important for printings—

Wire—the effect of the ratio stuff speed/wire speed
Suction boxes—progressive increase of vacuum
Wet presses—highly polished and non-porous
Felts—closely woven and clean; moisture content of web entering drying section 60–62 per cent.
Smoothing press
Drying section—progressive increase in temperature, but not exceeding a maximum of 100°C; polished, untarnished drying cylinders; felts kept in close contact with the sheet
Size press
Moisture content of the sheet leaving the machine—corresponding to 94–95°C

Recently, it has been found that beech, either by itself or admixed with other hardwoods such as elm and birch, can be pulped by the sulphate process and used for many grades of paper. The kraft process gives the pulp strength properties approaching those of softwood sulphite pulps.

(*continued on page 184*)

TECHNICAL SECTION LIBRARY

✚ Recent acquisition

Symposium on paper and paper products
(*American Society for Testing Materials, Philadelphia*, 1959, $2.75)

Contents — Introduction—H. A. Birdsall; Some historical developments in paper testing—W. R. Willets and F. R. Marchetti; Discussion; Testing of synthetic fibre papers—F. H. Koontz and J. K. Owens; Discussion; Non-woven fabrics and synthetic fibre papers: technology and end uses—J. T. Taylor and P. J. McLaughlin; Discussion; New developments in the internal bonding of paper—K. W. Britt and J. W. Eastes; Discussion; A new cotton paper furnish—J. A. Harpham; Clupak paper—a new type of high stretch paper—its manufacture and performance—R. J. Diaz; Discussion; Relative humidity measurements in package materials testing—B. H. Schrier and P. K. Wolper.

✚ Publications received

B.S. 3176 : 1959—Printed matter and stationery: A and B series of trimmed sizes
(*British Standards Institution, London, 1959, 4s.*)

B.S. 3137 : 1959—Bursting strength of paper
(*British Standards Institution, London*, 1959, 6*s.*)

This publication is based upon British PBMA Method PT 7/8 : 1959

B.S. 3177 : 1959—Permeability to water vapour of flexible sheet materials
(*British Standards Institution, London, 1959, 4s. 6d.*)

This publication is based upon British BPMA Method PT 19 : pm 1950

B.S. 3203:1960 Glossary of paper, stationery and allied terms
(*British Standards Institution, London, 1960, 7s. 6d.*)

APPITA Standards
(*Australian Pulp and Paper Industry Technical Association, Melbourne*)

P2 m–58	Preparation of wood samples for chemical analysis
P3 m–58	Ash content of wood and pulp
P4 m–58	Solubility of wood in boiling water
P5 m–58	Solubility of wood in boiling tenth normal sodium hydroxide
P405 m–58	Substance of paper and paperboard
P414 m–57	Conditioning of paper and paperboard for testing

Cylinder machine operating difficulties—Prepared by the Board Committee
(*Technical Section, Canadian Pulp and Paper Association, Montreal, 1959*)

Practical treatment of 30 difficulties in machine operation (22 pages)

One hundred and fifty years of papermaking by hand—J. Barcham Green

[Copies donated by Mr. J. Barcham Green and The Paper Publications Society, Hilversum]

Installation of the 'High-capacity wet separator' in stock preparation systems—F. Heese
(*Akademische Druck- u. Verlagsanstalt, Graz, Austria*)

Various applications for the 'High-capacity wet separator' patented by Prof. F. Wultsch (in German)

The papermachine drive (Der Papiermaschinenantrieb)—Prof. F. Wultsch and F. Brandlhofer
(*Güntter-Staib, Biberach-Riss, Germany, 1959*)

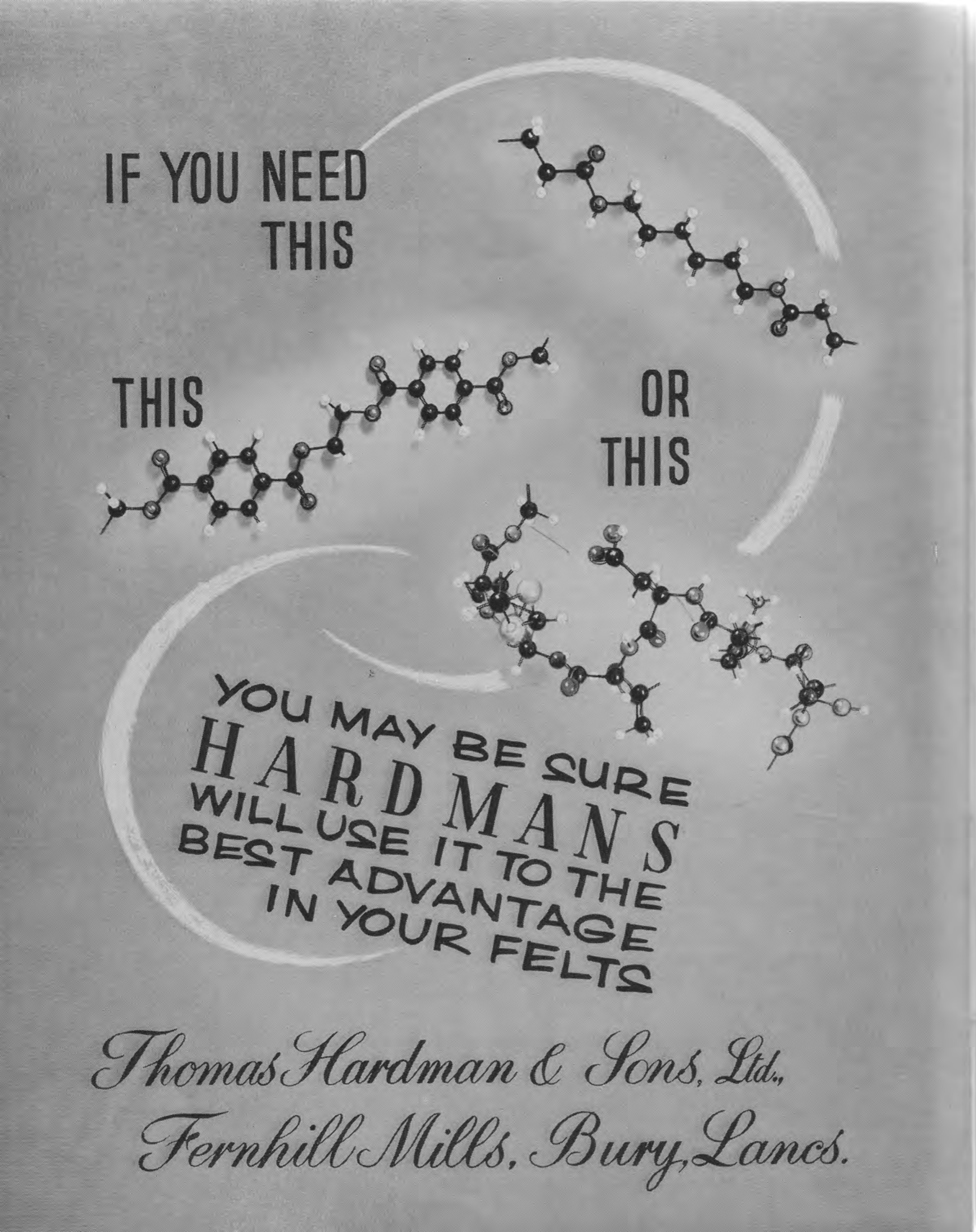
1. Non-variable drives
2. Variable drives
3. Power transmission
4. Simple mechanical drives
5. Simple electrical drives
6. Multiple drives
7. Drive control
8. Multi-motor drives for Yankee machines
9. Drives for creping machines
10. Drives for board and cylinder mould machines, for machines making greaseproof paper and for multi-wire machines
11. The economics of papermachine drives

Text (in German) 169 pages; 154 references; index

The biology of *sphaerotilus natans*—
L. Scheuring and G. Höhnl
Monograph No. 26 (in German)
(*Association of Pulp and Paper Chemists and Technologists, Darmstadt, 1956*)

Contents — 139 pages of text that reviews the literature on the subject, deals with the morphology and propagation of the bacterium *Sphaerotilus* and refers to its behaviour in sulphite pulpmill effluent: 66 literature references.

(*continued on page 183*)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Fernhill Mills, Bury, Lancs.

RUSSIAN PAPER INDUSTRY

No. 12, DECEMBER 1959

Science and technology

(Library continued from page 180)

A study of groundwood screening—
W. Brecht and K. Weishaupt

Monograph No. 28 (in German)

(*German Association of Pulp and Paper Chemists and Technologists, Darmstadt, 1959*)

After a short review of the development of screening equipment, the present position in groundwood screening is discussed and current problems are considered. The first essentials for any examination of the screening process was to decide upon the nomenclature and to develop a fractionation method that would be applicable to all grades of pulp.
Special experimental equipment was built and used in studies on the accuracy of determination and the range of variations in the stock used in practice.
The type of rotary screen in use today was investigated under a wide range of conditions. It was confirmed that there is a considerable difference in screening effect between centrifugal strainers and simple flat screens, the working principle of the rotary strainer being a compromise between the two main types and having several advantages over them.
The relationships found under process conditions make it possible for the first time to evaluate exactly screening equipment before it is used.
One characteristic of all wire type screens was that they showed preferential retention of particles whose length to breadth ratio was greater than 6:1. On the other hand, the hydrocyclone type showed preferential retention for particles with this ratio less than 6:1, which made it particularly valuable in certain applications. Modern screening installations using both wire screens and hydrocyclones reduced fibre losses and gave an improved product.

(Summaries from foreign journals continued from page 179)

The effect of shake on sheet formation and fibre orientation M. Judt

Das Papier, 1959, **13** (3/4), 46–54

In the course of this study, more than a 100 experiments were made on six different papermachines. This large amount of experimental data was then used in an attempt to obtain a clear picture of the fibre orientation in machine-made papers and the effect of shake, by using various pulps and by altering machine speeds, speed ratios (v_a/v_s) and drainage conditions. The work is preceded by a survey of 31 literature references.

The effect of machine speed

It was confirmed that the effect of wire shake on fibre orientation depends on machine speed. Since the rate of water removal at the table rolls increases with machine speed, the prime cause for the reduced effect of shake is the increased rate of water removal.

The effect of variations in the ratio v_a/v_s

The favourable directional fibre ratio at the speed ratio $v_a/v_s = 1$ is unaffected by wire shake at low machine speeds. At higher machine speeds, it is reduced from 0.56 to 0.41. When stock flows on to the machine wire with a v_a/v_s ratio different from unity, the difference in speeds causes turbulence and thus affects the formation of the web. The effect of wire shake on fibre orientation can be increased by causing a controlled turbulence as the stuff leaves the slice and runs on to the wire.

TABLE 1

Papermachine and experimental conditions		*No. of fibres counted*	*Average fibre orientation*						*Fibre cross/machine ratio*
			In machine-direction			*In cross-direction*			
			1	*2*	*3*	*4*	*5*	*6*	
PM III, Mixture II 80 g./m.², 50° S.R., wood-free Speed v_s = 141 ft./min.	Unshaken 11.5/210	2 903 2 820	38.8 31.4	13.5 13.4	9.4 10.6	20.4 22.8	8.0 11.7	9.8 11.2	0.53 0.725
PM IV., Mixture I 60 g./m.², 60° S.R., wood-free Speed v = 262½ ft./min.	Unshaken 7/560	3 533 3 937	43.7 40.5	10.6 13.4	7.9 7.6	22.1 24.3	7.3 6.0	8.4 7.2	0.51 0.60

The effect of wire shake on free stuff

Several papers were made with and without shake and at machine speeds of 66, 187, 269 and 308 ft./min. In all cases, shake had an adverse effect on the cross/machine strength ratio and the number of fibres lying in the cross-direction was reduced. Water removal was very rapid with all the pulps used and, consequently, the shake had little opportunity to affect fibre orientation, since the rate of water removal in the region of maximum shake intensity at the beginning of the table roll section is so high that shake has no influence on felting.

The effect of wire shake on wet stuff

Two different pulps were used and the resulting fibre orientations are shown in Table 1.

In all cases, the fibre ratio in the two directions was improved by shaking and more fibres were found to lie in the cross-direction. With these pulps, water removal is slow and, consequently, wire shake has a considerable effect. It is concluded that the effectiveness of the shake is closely dependent on the rate of water removal at the table rolls.

The effect of shake on water removal

The amount of water removed at the table rolls was measured under different conditions and the results are given in Table 2.

Over the first nine table rolls of this papermachine, shaking decreased water removal from a free stuff (36° S.R.) by about 5.1 per cent. Slow shaking (16.5/150) did not affect water removal at the first three rolls, but rapid shaking produced an effect on all three groups of table rolls.

With the wet stuff (50° S.R.), slow shaking increased water removal by about 0.8 per cent. and rapid shaking by about 2.6 per cent. The effect is most obvious on the first three table rolls, for over this stage a slow shake increases water removal by 4.3 per cent. and a rapid shake by 6.2 per cent. The effect is lost, however, on the remaining table rolls.

Finally, it was confirmed that shake gave a better formed sheet, especially with wet stuff.

TABLE 2

Papermachine and experimental conditions		*Amount of water removed by the groups of table rolls, litres/min.*			*Total amount, litres/min.*
		1 – 3	4 – 6	7 – 9	
PM III, Mixture I 70 g./m.^{2}, 36° S.R., v_s = 141 ft./min.	Unshaken 16.5/150 6.5/260	214 214 207	87 83 80	52 49 48	353 346 335
PM III, Mixture II 70 g./m.^{2}, 50° S.R. v_s = 141 ft./min.	Unshaken 16.5/150 6.5/260	162 169 172	72 70 73	50 47.5 46.5	284 286.5 291.5
PM III, Mixture I 70 g./m.^{2}, 36° S.R. v_s = 187 ft./min.	Unshaken 16.5/150 6.5/260	267 247 240	103 102 111	67.2 67 66	437.2 416 417

A consistency regulator that varies with the stock consistency in the chest

F. Hassman

Wochbl. Papierfabr., 1959, **87** (1), 16–17

THIS is a new and simplified version of the consistency regulator described in *Wochbl. Papierfabr.*, 1954, **82** (15), 619. If the consistency of the charge from the Hollander going into the chest is such that, with the stuff already present in the chest, the consistency after mixing is 5 per cent., then the result is a high stuff level in the indicator. This level is controlled by a shut-off valve and recorded by a needle moving over the indicator scale. Consequently, the control apparatus must immediately release the necessary amount of diluent to produce the lowest stuff level (for example, 3 per cent. stuff consistency) and the pointer should show this on the scale. At this moment, the control apparatus is switched off, with the result that the maximum amount of diluent necessary is retained and the low stuff level caused in this way is artificially raised to the former stuff level at 5 per cent. consistency by closing the shut-off valve. The control apparatus is then switched on again and the artificially raised 3 per cent. stuff level now meters the necessary amount of diluent for the initial 5 per cent. chest consistency.

The operation of the apparatus is purely mechanical, the indicator does not require periodic cleaning, it empties automatically when production is interrupted and it can be used over the consistency range 5–2 per cent. The apparatus operates in the main stock line—that is, all the stuff from the stuff pumps is diluted and thoroughly mixed in the apparatus. The maximum capacity of the apparatus is 50 tons/24 hr., but production can be increased by using 2 or 3 regulators in parallel.

The problem of smoothness testing

E. Bayer

Das Papier, 1959, **13** (5/6), 85–92

THE best known and most widely used methods of testing smoothness are based on the measurement of the amount of air escaping through the surface layer of a paper at a given pressure. This is the principle used in the Bekk, Bendtsen and Gurley-Hill apparatus, but it suffers from the fundamental drawback that it gives no indication of the type of irregularity in the sheet allowing the air leak, so that it is really essential to supplement it with a good optical method.

Oblique illumination method

This method is based on the principle of illuminating the sheet obliquely so that the surface irregularities cast shadows and the smoothness of the surface can be judged by microscopic examination. It is suitable for both rough and moderately smooth papers and, in experienced hands, gives a very clear picture of the type and distribution of irregularities. The limit of the method's effectiveness is attained with an illumination angle of approximately 4° and a magnification of about 20: this is adequate for irregularities with a depth of not less than 2 μ. Theoretically, the range of this method could be increased with larger angles of incidence and higher magnification, but in practice this reduces the sharpness of contrast; consequently, the method cannot be used for very smooth papers. Optical methods all have the disadvantage that they measure smoothness in the 'isolated' state, not the printing smoothness—that is, they do not take account of the fact that the pressure to which the sheet is subjected during printing compresses the surface and increases the smoothness.

Interferometer method

If a beam of light is allowed to fall on two parallel glass plates separated at a fixed distance, some of the light will be reflected by the bottom surface of the first glass plate and some by the upper surface of the second plate. The reflected beams will either reinforce or cancel one another according to the relationship between the path difference and the wavelength. If the light is reflected by a rough paper surface, the path difference will be affected by irregularities on the surface of the paper and this forms the basis for the extremely sensitive method of measuring smoothness with an interferometer. This method is too sensitive for normal papers, but is useful for highly glazed speciality papers.

A variation of this method is to use a surface replica immersed in oil. In this case, the path of the light is partly through oil and partly through the replica, thus irregularities on the surface of the replica cause path differences and interference. If the refractive index of the immersion oil is close to that of the material used for the replica, the path difference will be small, the sensitivity will be reduced and the method can be used for rough papers. With a suitable choice of immersion oil, sensitivity can be reduced by a factor of 30 and surface irregularities in the region of interest to the papermaker (that is, about 10 μ) can be conveniently measured.

Chapman smoothness tester

This apparatus employs the principle of total light reflection and consists essentially of a prism, under which the sample is placed. Its main advantage is that the test piece can be forced against the base of the prism, thus simulating the pressure exerted on the sheet during printing. The ratio of light-reflecting area to the rest of the surface is measured for different known pressures.

Profile apparatus

This type of apparatus is used extensively in the metal-working industries and, in contrast to the optical methods described, its operation is either mechanical or electromechanical. The principle is that a very fine stylus moves over the surface to be tested and a record is made of the rises and falls caused by irregularities on the surface. The main problem here is to produce a very fine point for the stylus and this has been solved by using a sapphire or diamond with a point radius of approximately 2μ. The movement of the stylus is increased 10 000–30 000 times by an apparatus that employs optical, mechanical and electrical means and the results are recorded by a profiler. The sensitivity of the apparatus can be altered, making its use possible over the wide range 0.03–60 μ. This type of apparatus is still very new and its potentialities have not been fully explored, but it should prove a valuable tool in the future.

The use of activated chlorate for delignification and bleaching

P. Marpillero
ATIP Bull., 1959, (2), 57–67

ACTIVATED chlorate (*ACl*) is made by treating sodium chlorate with a catalyst and finds uses in various stages of pulp preparation.

Delignification—*ACl* can be used in a hot (60 - 70°C) or cold process in towers similar to bleaching towers. The salt acts as an oxidising agent and, since it also oxidises the vegetable dyes present in bark, it is not essential to debark the pulpwood.

Treatment with *ACl* is best carried out after a cold soda stage and merely consists of spraying the pulp with the salt solution. It then acts during shipment or storage of the wet laps and gives a semi-bleached pulp that can be used directly or bleached further.

Additional delignification—For pulps that are to be bleached with peroxide, the lignin content of sulphite pulp can be reduced to 5 per cent. and of kraft pulp to 10 per cent. by a simple additional treatment with *ACl*.

Oxidative bleaching—The hypochlorite treatment can be reduced by substituting an *ACl* stage for the caustic extraction after chlorination. If chlorination is replaced by an *ACl* stage, peroxides can be used without a hypochlorite stage. According to the number of stages used, brightnesses of 80–93° G.E., can be attained, without any significant reduction in viscosity. If a cold *ACl* stage is used after the chlorine dioxide stage, the brightness can be increased to 97–98° G.E.

Bleaching of semi-chemical pulps—After *ACl* treatment, the pulp can be increased in brightness from 50–70° G.E. by a simple hypochlorite stage; with further treatment (hot or cold), it is possible to reach 85° G.E.

General view of the Technical Service and Development Laboratories of I.C.I. Plastics Division, Welwyn Garden City, Herts.

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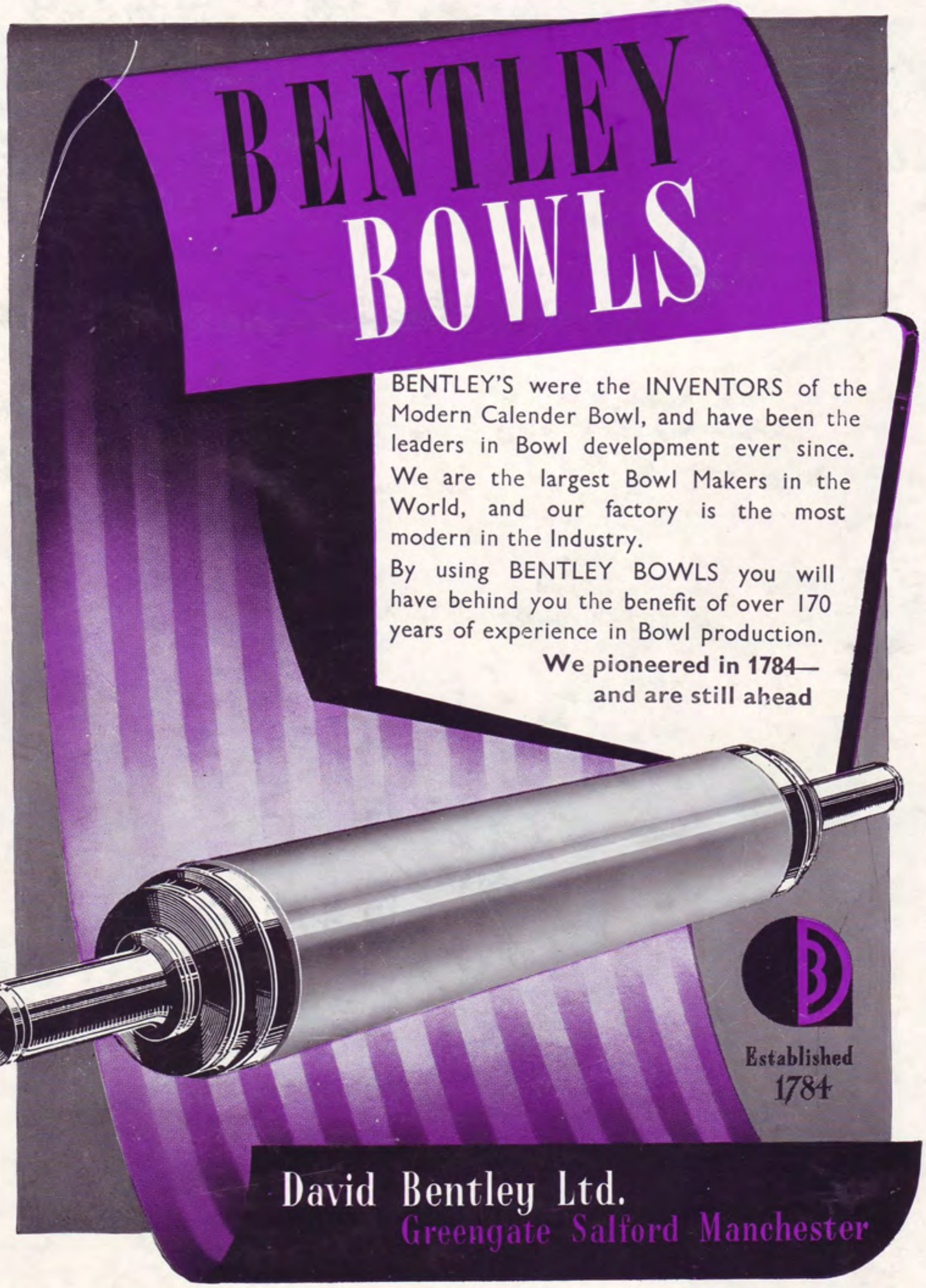
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