paper technology

No 6

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

INCORPORATING TECHNICAL BULLETIN AND PROCEEDINGS OF THE TECHNICAL SECTION

December 1960 Vol. 1 No. 6

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* IMPORTANT NOTICE ON PAGES **601** & **602** *

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Assistant Editor – W. J. Abercrombie

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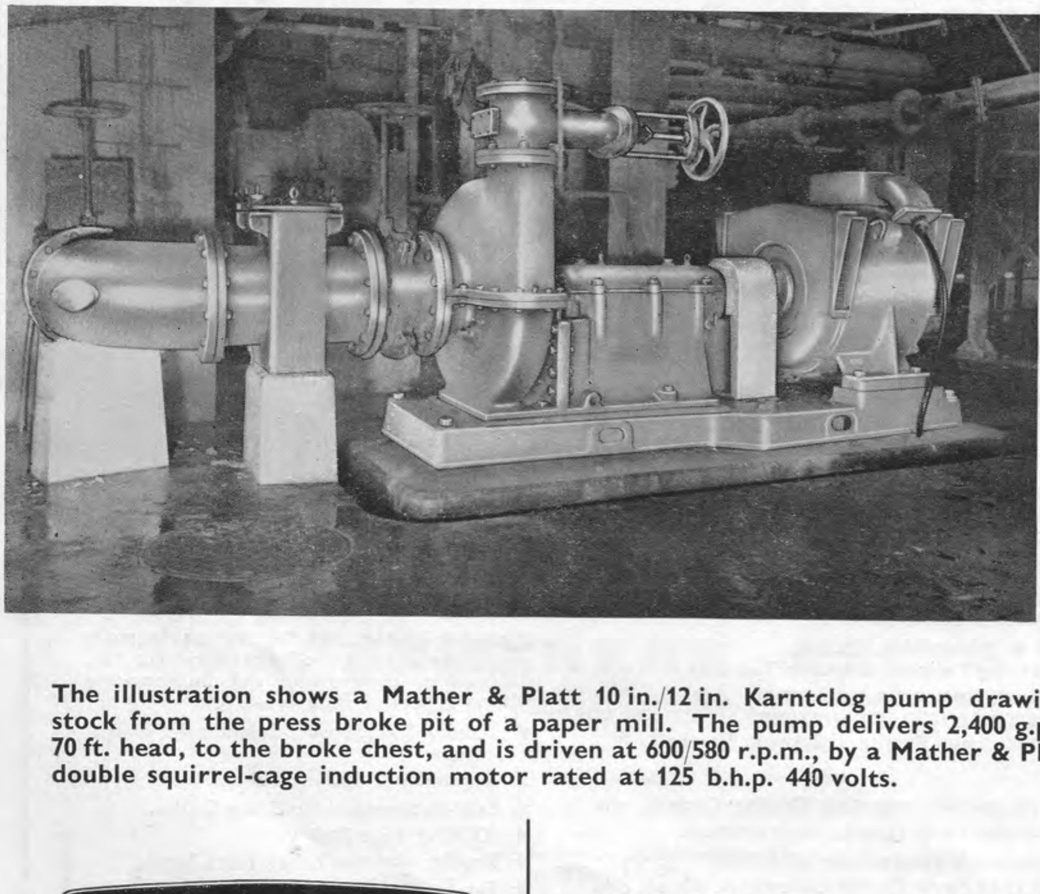

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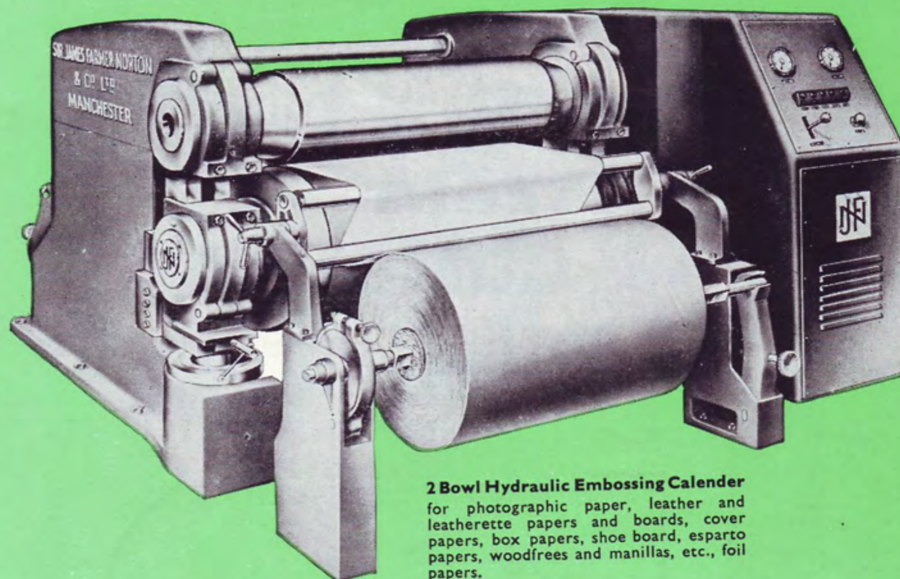

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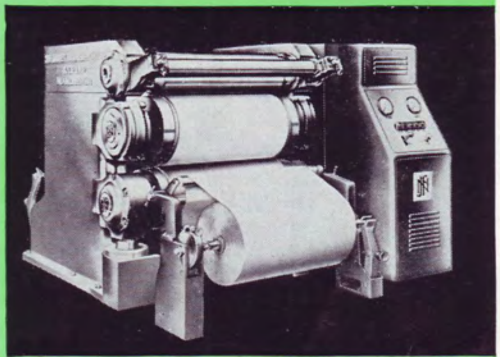

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GOING WEST

WHO did go west?—and where did they go? Well, the Technical Section visited Canada for the second time with 28 men, 6 ladies and 4 teenagers—

Mr. O. G. D. Acland	Mr. J. Lomax
Mr. F. M. Bolam	Mr. D. W. Lyddon
Mr. W. Chantler	Mr. A. P. McDonald
Mr. E. F. J. Dean	Mr. R. J. B. Millar
Mr. P. A. Duxbury	Mr. P. H. Prior
Mrs. Duxbury	Mrs. Prior
Peter Duxbury	Mr. N. G. Rackley
Simon Duxbury	Mr. C. Savory
Else M. Duxbury	Mr. A. W. Sidebottom
Capt. F. H. Fletcher	Mr. T. Somerville
Mrs. Fletcher	Mr. W. Tait
Mr. R. C. Gardner	Mr. J. A. H. Tod
Mr. W. A. Gilmour	Mr. A. F. Tout
Mrs. Gilmour	Mr. N. C. Underwood
Mr. G. Gordon	Mr. C. G. Wallace
Mr. H. E. Higginson	Mrs. Wallace
Mr. T. R. Johnson	D. Jane Wallace
Mr. L. A. Lawrence	Mr. J. D. Whittaker
Mrs. Lawrence	Mr. N. W. Willink

(Let it be said right at the beginning that these youngsters were exemplary among so many adults and with such a businesslike programme.)

We went right across Canada to Vancouver and Vancouver Island, travelling back east to Montreal. It took three weeks and by the time the passengers got back home they had covered about 12 000 miles.

THE purpose of the visit was to see representative mills in the Canadian industry, to attend a technical conference and to meet Canadians in the industry. The rigorous itinerary was closely packed and the organisation meticulous—it meant success and an interesting tour. Everyone in the party stayed the whole course and, having quickly formed themselves into a band of good friends, undertook the programme and enjoyed the social events as a group.

At the end of the journey was a visit to the Montreal laboratories of the Pulp and Paper Research Institute of Canada and the new building at Point Claire: in the previous weeks, the following 22 pulp and paper mills had been seen—

Powell River Co. Ltd., B.C.
MacMillan & Bloedel (Alberni) Ltd.—Alberni Pulp and Paper Division, Port Alberni, B.C.
MacMillan & Bloedel (Alberni) Ltd.—Harmac Pulp Division, Nanaimo
British Columbia Forest Products Ltd., Pulp Division, Crofton, B.C.
Westminster Paper Co. Ltd., New Westminster, B.C.
Sidney Roofing & Paper Co., Vancouver
North Western Pulp & Power Ltd., Hinton, Alberta
Alliance Paper Mills Ltd., Ontario
Garden City Paper Mills Co. Ltd., Merritton, Ontario
Interlake Tissue Mills Co. Ltd., Merritton, Ontario
Provincial Paper Ltd., Thorold, Ontario
The Ontario Paper Co. Ltd., Thorold
The Beaver Wood Fibre Co. Ltd., Thorold
Hinde & Dauch Paper Co. of Canada Ltd., Toronto
Don Valley Paper Co. Ltd., Beechwood Drive, Toronto
Dominion Cellulose Ltd., Toronto.
Gair Paper Products—Division of Continental Can Co. of Canada Ltd., Boxboard Mill, Toronto
The E. B. Eddy Co., Ottawa
Canadian International Paper Co., Gatineau Mill
Howard Smith Paper Mills Ltd., Cornwall, Ontario
Rolland Paper Co. Ltd., St. Jerome and Mont Rolland, Quebec

The pipers bidding the party aboard M.Y. 'Fifer' farewell at Powell River jetty

Travel was by air as far as possible, with a night journey from Vancouver to Hinton by train and the return journeys between Toronto and Niagara, Montreal and Cornwall also by train. The trips to St. Jerome and Mont Rolland were by coach, as were the two sightseeing days in the Rockies and the connection Banff to Calgary. The start of the tour in this country was muffed, for an engine broke down on the take-off at Prestwick, causing 24 hr. delay by everyone being returned to London.

ON Saturday, 27th August, the journey really began and, after 19 hr. in the air (with only $\frac{3}{4}$ hr. at Toronto to change planes, check luggage, placate the immigration authorities over a wrong passport and cope with a temperature of 90°), the weary party reached Vancouver just before midnight (local time) to be met at the airport by—

Mr. Weston Bennett (*Chairman of the Canadian Technical Section*) and Mrs. Helen Bennett

Mr. Douglas Jones (*Secretary of the Canadian Technical Section*) and Mrs. Marguerite Jones

Mr. and Mrs. Wilfred Mosher (*Consolidated Paper Company*)

Despite rainy weather, the programme started with a flight to Powell River on Monday morning at 7.30 a.m. (breakfast at the airport) and this set the style and pace for the whole tour.

The highlights were undoubtedly a mixture of scenic beauty and the most cordial of hospitality: the Rockies were stupendous, the friends we made unforgettable. In 1955, the group travelled across Canada by train (three days between Toronto and Banff, nearly a day from Banff to Vancouver) and was impressed by its vastness; this time by flying, it seemed to have shrunk. Many of the friends we made in 1955 and 1956 when the Canadians visited this country were there again to renew the acquaintance: many new introductions were made, but none of these was a whit less than before.

Several Canadians joined the group at different stages and we parted with them regretfully each time—

Mr. and Mrs. Grant McDonald (*J. Ford & Co. Ltd.*)

Mr. and Mrs. Monte Marler (*MacMillan & Bloedel (Alberni) Ltd.*)

Mr. S. W. Forstrom (*MacMillan & Blodel (Alberni) Ltd.*)

The group taken at Powell River before boarding the boat to ferry the party to Comox on Vancouver Island

The ladies in the party on the terrace at Banff Springs Hotel
(the Bow Valley in the background)

Marie Joss and Mrs. Gilmour

Mrs. Bennett and Mr. Weston Bennett with Douglas Jones at the presentation

EVENTS that will linger in most memories were—

The rough crossing from Powell River to Comox on Vancouver Island.

The fun at Qualicum Beach when the intrepid fishermen killed a salmon.

The solemnity of Cathedral Grove on the way to Alberni (200 ft. high Douglas firs).

The size and efficiency of the Harmac, Alberni and Hinton pulpmills.

The grandeur of Columbia icefield, Peyto Lake, Moraine Lake, Jasper, Sulphur Mountain in the Rockies and Niagara Falls out east.

The snow and gale at Lake Louise, the warm sunshine at Banff.

The modernity of Ottawa airport buildings.

The extent of the Great Lakes even when seen from the air.

The happy, unrestrained way one can talk man-to-man to anyone in Canada, whatever his or her role in life may be.

THE summer meeting at Banff (6th–9th September, inclusive) was attended by 285 men and 123 ladies. Under the general heading of *Towards the more complete and efficient utilisation of our material and manpower*, the British party presented the five papers—

1. *Towards greater objectivity*—A. F. Tout
2. *The more efficient use of starch in papermaking*—R. J. B. Millar
3. *Trends in automation*—R. C. Gardner
4. *The use of manpower in research*—N. C. Underwood and L. W. Causer (Mr. Underwood presented the paper)
5. *A forced convection hood applied to the dry part of paper and board making machines*—J. D. Whittaker

These and all the other papers will be published in due course in the *Pulp and Paper Magazine of Canada*.

At the dinner during the conference, the guest speaker was Mr. M. J. Foley, President, MacMillan, Bloedel & Powell River Ltd.; honorary life membership of the Canadian Technical Section was extended to Mr. I. H. Andrews, Vice-President, Planning Research and Development, MacMillan, Bloedel & Powell River Ltd. for outstanding contributions to the technology of the industry; Mr. W. A. Gilmour, leader of the Technical Section party conveyed greetings from Britain.

On two occasions, the British group was able to show in kind its appreciation of what they had enjoyed. At Banff, there was time and opportunity to entertain the Canadians to a cocktail party; then to a dinner party at Montreal. It was on this latter occasion that presentation was made to Douglas and Marguerite Jones and to Bert and Marie Joss for their efforts in planning and carrying out the programme, for their good company and unflagging assistance.

FOR the rest, perhaps it is best to let some of the photographs taken tell their own story. A small selection illustrates this account maybe further items will be published in future issues when they come to hand.

The Canadians have been invited to come to Britain to see our industry (and our spring at the same time) in May 1962; we must not fail to give them of our best to return the compliments.

Technical Section membership

DURING September and October 1960, the changes in membership were as shown—

Newly enrolled

Corporate—
Barry, Ostlere & Shepherd Ltd.

London Division—
D. Batchelor—*Junior*
B. M. Betts—*Full*
W. E. Braybrook—*Associate*
A. M. Choudhury—*Associate*
E. J. Cuffe-Adams—*Full*
D. I. Davies—*Full*
A. Dobson—*Full*
J. N. Findlay—*Associate*
T. G. Gulliksen—*Associate*
K. K. Halsas—*Associate*
S. F. Jay—*Associate*
M. D. Newns—*Junior*
A. E. Reid—*Full*
D. M. Rolfe—*Full*
P. J. L. de Snoo—*Junior*
C. A. Wright—*Associate*

Scottish Division—
W. H. Barclay—*Associate*
D. G. N. Stirling—*Full*

Northern Division—
F. Duckworth—*Full*
J. Emmett—*Full*
C. Handley—*Full*
B. A. Kamath—*Associate*
H. W. Loveday—*Associate*
G. Partington—*Full*
R. Speechley—*Associate*
A. B. Stirling—*Associate*
T. H. Trickett—*Associate*

Western Division—
G. A. D. Lipley—*Junior*
G. A. Stobart—*Full*

Overseas Associate—
J. G. Aggarwala
T. M. Cook
K. F. Hodge

Resignations and withdrawals

Corporate—
Hampstead (Roughway) Paper Mills Ltd.
C. Townsend Hook & Co. Ltd.

London Division—
D. L. Ashdown—*Junior*
S. A. Brandon—*Associate*
N. W. Brown—*Full*
E. W. Busbridge—*Full*
B. Cartwright—*Full*
J. M. Dempster—*Full*
English Clays Lovering Pochin & Co. Ltd.—*Associate*
J. V. Faulks—*Full*†
G. Foster—*Full*
R. T. Foster—*Full*
A. F. Francis—*Junior*
A. S. Godfrey—*Junior*
R. P. Hurd—*Full*
J. Lauer—*Full*
J. S. Lindsay—*Associate*
D. M. McLeod—*Associate*
S. L. Martin—*Associate*
J. E. Rouse—*Associate*
Shell-Mex & B.P. Ltd.—*Associate*
S. Vincze—*Full*

Northern Division—
A. W. Ayres—*Associate*
W. D. Brooker—*Associate*
J. B. Bush—*Junior*
N. Callaghan—*Associate*
M. Ferguson—*Full*
C. R. Keyte—*Full*
C. W. Lee—*Full*
A. J. Middleton—*Associate*
S. Newton—*Associate*
J. F. Puddifoot—*Full*
R. Reed—*Full*
W. Riley—*Associate*
F. A. Wallis—*Full*

Scottish Division—
C. R. Baines—*Associate*
B. Black—*Junior*
R. A. Hudson—*Associate*
J. D. Scott—*Full*
W. Smith—*Full*
A. Tait—*Full*

Western Division—
H. H. Aston—*Associate*
T. Bond—*Full*†
G. A. Cade—*Full*
D. D. Herring—*Junior*
R. Keay—*Full*
K. E. Lidstone—*Full*

Overseas Associate—
A. Beveridge
W. P. Bookless
P. B. Carr
G. K. Dickerman
A. S. Gill
P. S. Kothari
D. N. Mitra
A. P. Mulders
B. Piaser
M. L. Shaw
S. A. Trivedi
G. S. Welsh

† Deceased

NEWS PAGE

Overseas meetings in 1961

DETAILS of conferences arranged by the technical associations of paper industries in countries abroad are given below —

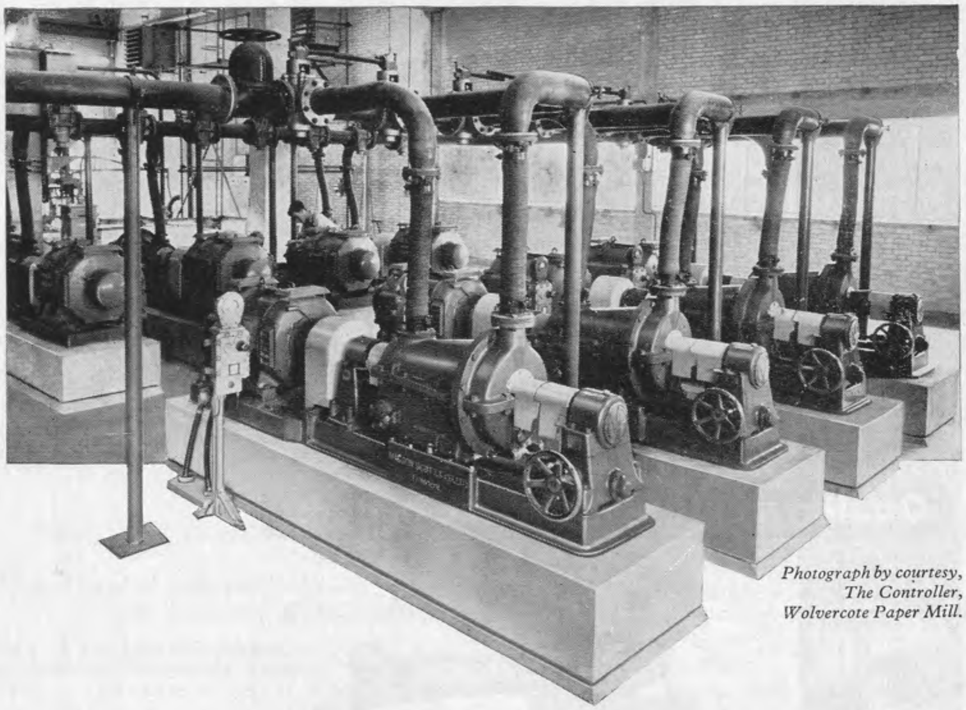
Association	*Annual conference date 1961*	*Place*
Technical Section, Canadian Pulp and Paper Association	24th–27th January	Queen Elizabeth Hotel, Montreal
TAPPI (U.S.A.)	19th–23rd February	Commodore Hotel, New York
Swedish Paper and Pulp Technologists' Association	21st–23rd March	Stockholm
APPITA (Australia)	10th–14th April	Yallourn, Victoria
Finnish Paper Engineers' Association	13th–14th April	Helsinki
Austrian Association of Pulp and Paper Chemists and Technologists	18th–19th May	Linz, Upper Austria
Scandinavian Pulp and Paper Technologists' Congress	29th May–2nd June	Oslo
Technical Association of the French Paper Industry	29th May–3rd June	Cannes
German Association of Pulp and Paper Chemists and Technologists	27th–30th June	Baden-Baden
Norwegian Paper and Pulp Engineers' Association	5th–6th December	Oslo

New sintered nylon composition for long-life bearings and rolls

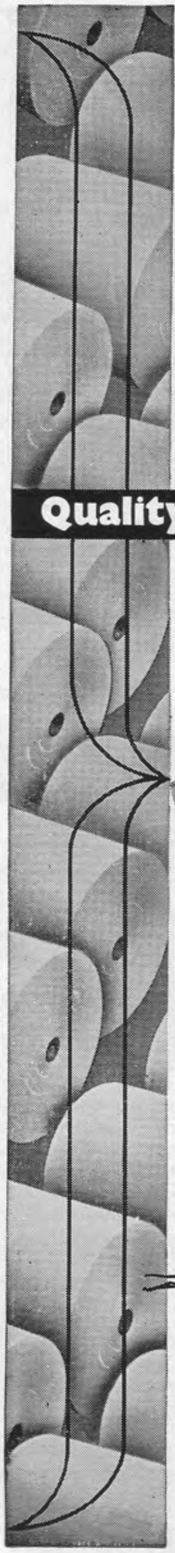
THE new material *Nylasint* is formed by cold pressing and sintering crystalline nylon powders alloyed with inorganic additives.

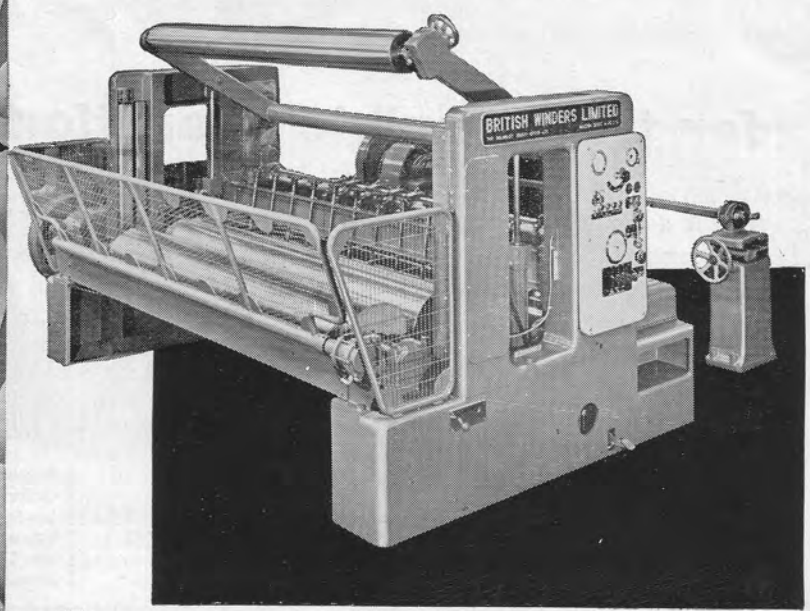
It is claimed that the lubrication characteristic of Nylasint reduces static and running friction and increases wear resistance. The cold pressing and sintering techniques used in producing Nylasint components mean that internal strains are minimised, shrinkage is uniform and accurate profiles are obtained.

Typical uses of the new material are for parts that must have low starting and running friction where applied lubrication is undesirable and in applications where a lightweight, porous structure with high wear resistance and good dimensional stability is required.



Photograph by courtesy,
The Controller,
Wolvercote Paper Mill.




BRITISH WINDERS LIMITED

RUSSIAN PAPER INDUSTRY

(*continued overleaf*)

Book review

Pulp and Paper from Annual Plants (Zellstoff- und Papierherstellung aus Einjahrespflanzen)— O. Wurz (German text)

(*Edward Roether Verlag, Darmstadt, 107 pp., 63 references, 1960, 34s.*)

THE author's choice of title for this book is possibly a little misleading, for the contents do not seem to justify the use of such a broad term as *annual plants*. The group of annual plants that produce the bast and leaf fibres and seed hairs of commerce is entirely excluded. With the exception of brief paragraphs on two Indian grasses, there is no information in the book on the many tropical grasses that have from time to time been put forward as potential pulp and paper-making materials, one or two of which are at present being pulped commercially.

In fact, the greater part of this book deals with materials that can (with the exception of bamboo and some reeds) be termed *agricultural residues*. Of these materials, only those that are being pulped commercially are covered and nearly half of the book is devoted to the cereal straws alone. Within these limits, the subject treatment is essentially practical with excellent descriptions (supported by ample data, photographs and drawings) of commercial pulping processes at present in use with the materials concerned. The data on pulping chemical consumption, bleach requirements and yield are particularly useful. The last section (No. VIII, which was omitted from the notice about this book in *Paper Technology*, No. 4) is concerned with cost data. The material in the section is almost entirely abstracted from the relevant F.A.O. publications. There is, however, no index and the table of references at the back of the book is not very comprehensive, since only 63 are offered for the whole of this very much publicised subject.

On the whole, the reviewer has a feeling of disappointment about this book (probably engendered by the title) since, but for its limited scope, it could have filled a long vacant gap in the specialised literature on pulp and paper making raw materials.

A. E. Chittenden

TECHNICAL SECTION LIBRARY

★ Publications received

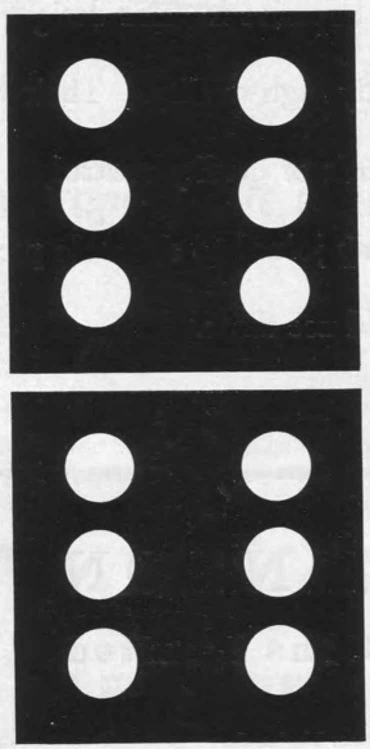
B.S. 1340 : 1960—Prepared and natural tracing paper
(*British Standards Institution, London, 1960, 4s. 6d.*)

B.S. 2698 : 1960—Containers and notes for filmstrips
(*British Standards Institution, London, 1960, 4s.*)

B.S. 3253 : 1960—Phenolic-resin bonded asbestos paper sheets for electrical insulation at power frequencies
(*British Standards Institution, London, 1960, 6s.*)

B.S. 730 : 1960—Papers and boards (Stock sizes, packaging, labelling and substances)
(*British Standards Institution, London, 1960, 4s. 6d.*)

Russian Paper Industry (continued from page 595)



ATTENTION

This is the sixth issue of the new journal

PAPER TECHNOLOGY

- The Journal combines and replaces the Technical Section's previous two publications, *Proceedings* and *Technical Bulletin*.

- PAPER TECHNOLOGY, 1960, vol. 1 follows on from *Proceedings*, 1959, vol. 40 and *Technical Bulletin*, 1959, vol. 39.

(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

● A number of cloth-board bound copies of the collated *Proceedings* sections from each of the six issues for 1960 can be prepared for special subscribers. The preparation and cost will depend on the demand and members interested in buying the bound volume should advise the Secretary of the Technical Section at once.

● Binders with gold blocking on the spine can be obtained from the Technical Section at special rate — enquiries are invited. Each binder will hold six issues.

● The register of members will be made up on 30th September 1960 for publication in the December issue of *Yearbook* 1960. 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.

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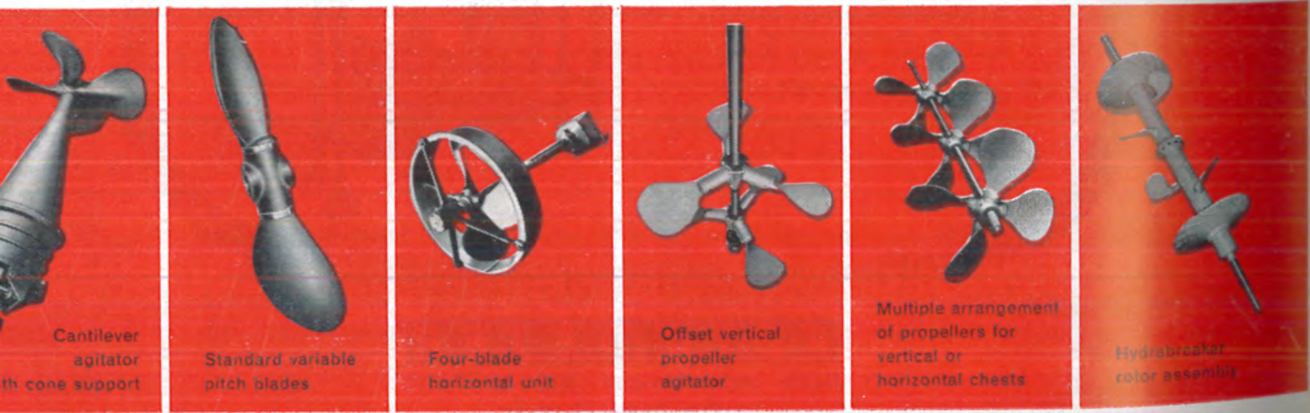
Cantilever agitator ...th cone support
Standard variable pitch blades
Four-blade horizontal unit
Offset vertical propeller agitator
Multiple arrangement of propellers for vertical or horizontal chests
Hydrabreaker rotor assembly


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AUTUMN CONFERENCE 1960

SCOTTISH DIVISION was the host for the Eightieth General Conference of the Technical Section and had the pleasure of welcoming the largest attendance ever at an autumn meeting.

Edinburgh provided an attractive backcloth to this scene and the two days taken for the conference were packed with events.

ON Thursday, 28th October 1960, a golf competition was held at Luffness course. There were 30 players, who had an enjoyable day despite damp conditions in the morning and really wet ones in the afternoon. The competition was run under Stableford conditions on handicap and the first four prizewinners were —

1. I. A. MacLean, 33¼ points (Winner of the Northern Division Cup)
2. G. W. Adam, 32⅛ points
3. I. G. Burns, 31⅜ points
4. J. B. Henderson, 31¼ points

The veteran's prize: R. G. Graham, 28⅜ points.

Thanks are due to G. W. Drysdale who acted as secretary and made all the arrangements.

IN the evening, 135 members and conference guests met at the Carlton Hotel for a cocktail reception. This eve of conference reception is now regarded as the opening event of the autumn meeting to provide a happy occasion for people to renew acquaintance since the last conference (a circumstance that applies chiefly to the ladies, who were much more in evidence this autumn than previously).

After this, a couple of dozen or so who had recently returned from the Technical Section visit to Canada met to look at each other's films and slides. One or two people from the 1955 party were also there and the miniature reunion was a jolly one, but too brief.

THE day itself—Friday, 28th October—was devoted to consideration of *Developments in coated papers for printing*. The meeting was held in the Adam Rooms, George Street, Edinburgh and proceedings commenced with the Autumn General Meeting. The Chairman's progress report formed the chief item and he had much of interest to say (*see* pages 607–8).

The number registered for the conference was 300, filling the ballroom to capacity. They heard four speakers present the papers —

Equipment for machine coating—R. S. Haven
Machine coating—past, present and future—Dr. R. C. Rose
Traditional coating meets the challenge—W. A. R. Hilton
A printer's views on coated papers—N. B. Erskine

The discussions were full and lively, as can be seen from the record of the proceedings on pages 609–634 of this issue.

Demand for the conference lunch was another high mark—in fact, 270 registrants—which required the use of the largest part of the George Hotel Restaurant, as well as the Chandos Room in the Adam Suite.

DURING the afternoon, the ladies formed themselves into two parties to visit the factories of Munrospun and Edinburgh Crystal Glass Co. For the first, there were eight in the group; for the second, thirteen ladies. It was found interesting and enjoyable by all of them and the only regret was—no samples!

The day ended gaily with a dinner and dance in the Adam Rooms. Never has such a function been attended by so many—134 on this occasion—and it promises well for future conferences: already, the ladies regard these social events as a rendezvous where they can meet again all those from other Divisions whom they may not see in the year between. This feature of the autumn meeting is very pleasant. The highlight was undoubtedly the exhibition of Scottish dancing, though the other dancers did not fail to fill the ballroom floor for the rest of the evening.

Next year, we are at Southport, so —!

Mrs. D. Verden Anderson and Mr. I. G. Burns during the reception before the dinner dance

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—

A comparison between different types of dryer felt

S. Ponton

Svensk Papperstidn., 1959, **62** (19), 692–699

THE research here reported was carried out on the Swedish Central Laboratories experimental dryer and investigations were made with wool, cotton, Terylene and tacryl felts and with a perlon wire. These materials were compared with respect to drying capacity and steam economy.

It was concluded that natural fibre felts should be used on the first dryer section for maximum drying capacity. On the later dryer sections, synthetic fibre felts have the advantage for efficient operation; in certain extreme cases, a synthetic wire can be used (as a felt) with good results. It was found also that steam consumption was at its most economic level when the lightest felts were used.

Opacity of newsprint

O. Antonsen and V. Lorås

Norsk Skogind., 1960, **14** (2), 44–57

FACTORS influencing the opacity of newsprint paper have been studied both experimentally and theoretically. Opacity problems connected with the printing of paper (show-through) have not been taken into consideration in the present investigation.

The basic idea of the Kubelka-Munk theory and a few of Kubelka's solutions of their equations have been given.

Diagrams have been worked out—(*1*) for correcting the opacity of newsprint to a basis weight of 52 g./sq. m., (*2*) showing the interrelationship between opacity, basis weight, reflectivity and specific scattering coefficient.

The scattering coefficients have been determined for mixtures of groundwood pulp and unbleached spruce sulphite, unbleached pine sulphite and semi-bleached sulphite pulp, respectively. The semi-bleached sulphate pulp gave a somewhat higher scattering coefficient than did the sulphite pulps at the same percentage of chemical pulp in the mixtures. The spruce and pine sulphite pulps were quite similar in their optical properties. Reduction of the chemical pulp content increased the scattering coefficient because the scattering coefficients of the groundwood pulp are considerably higher than those of the chemical pulps. The hardness of the pulp seemed to have little influence on the scattering coefficient.

Groundwood pulps have been fractionated into a fine, a medium and a coarse fraction. Of these, the fine fraction had the highest and the coarse fraction the lowest scattering coefficient. Beating the groundwood pulp in the PFI beater at first shortened the long fibres to medium length. When the content of long fibres was reduced almost to nil, the fine fraction increased with a corresponding increase in the scattering coefficient.

An empirical correction for the variation in opacity with basis weight has been found.

Handsheets of unbleached sulphite pulp, groundwood pulp and mixtures of these two, pressed at different pressures while wet, showed a decrease in opacity with increasing pressure. The decrease was considerably less, however, for the groundwood than for the chemical pulp.

Samples of newsprint taken on five different papermachines, before and after calendering, showed that normal calendering seemed to have very little influence on the opacity.

The influence of sheet formation on the measured opacity has been investigated for three different papers—one with a good, one with an average and one with a poor formation—by disintegrating the paper and forming handsheets. The opacity was increased by this operation, but the increase was largest for the paper with the poorest formation and lowest for the one with good formation. It is suggested that these effects are caused by better formation in the sheetmachine than on the papermachine, from which it follows that an even distribution of the furnish in the sheet should have a favourable effect on the opacity measured photometrically, as well as on the visually estimated value.

This assumption has been confirmed theoretically by application of the Kubelka-Munk theory, as well as experimentally. Other factors of importance for the opacity of newsprint are low chemical pulp content and a groundwood pulp with high opacity.

AUTUMN GENERAL MEETING

HELD AT THE ADAM ROOMS, GEORGE HOTEL, EDINBURGH ON FRIDAY, 28th OCTOBER 1960 at 9.45 a.m.*

In the Chair—Mr. W. A. GILMOUR

1. NOTICE OF MEETING

The Secretary read out the notice convening the Autumn General Meeting.

2. MINUTES

The minutes of the Annual General Meeting, held on 23rd March 1960, were available to members in *Paper Technology*, 1960, **1** (3), 231. These minutes were unanimously approved as a correct record on a motion by Mr. G. F. Underhay, seconded by Mr. G. Thompson. The Chairman then signed the minutes.

3. CHAIRMAN'S PROGRESS REPORT

'It is very gratifying to be able to record considerable progress and it is obvious that the Technical Section is moving from strength to strength. This is quite clearly reflected in the numbers of members: more people are joining the Technical Section and finding it very much worth their while to do so. Because of publication of a new yearbook, which will have a complete list of members, it has been essential to close the list at the end of September so that it can be published in December. I have been asked by the Secretary to mention that the total would be increased by about 60, but people whose subscriptions were due and not paid on that date have been omitted from the register: this ought to bring our figures up by about 60—so a word to the wise!

It is most gratifying to see that there is an increase in the number of Junior and Overseas members. It means that our activities are becoming increasingly recognised abroad.

Corporate members	173
Honorary members	3
Full members	1 086
Associate members	705
Junior members	108
Overseas members	222
Total	2 297

As to our other activities, the period between March and October is normally one that is not so vigorous as that between October and March. Among the committees' work that has been going on, I would like to draw attention to the two further meetings planned by the Statistics Committee—29th November 1960, an all-day meeting to deal with the design of experiments and 25th January 1961, an afternoon meeting dealing with basis weight variation. There are also plans to hold a week's residential school in elementary statistics in September 1961 and it seems at the moment that this will be held in Southampton University. With the increasing application of statistics to quality control—something that one sees in very many papermills both here and abroad—it is felt that every encouragement should be given to people who, though not expert statisticians, have the mathematical equipment to acquire these techniques at least on an elementary level. They can thus have the basis for further study on their own.

You will know that there are plans to have a papermaking museum in Britain and, through the kindness of Vegetable Parchment Mills (Delcroix) Ltd. of St. Mary Cray, premises have been provided. The Museum Committee is now compiling a list of items that can be called in as exhibits and we would ask individuals and firms who have materials of historical importance to let the Committee know so that a selection can be made. I would urge you to do this soon, because plans are afoot to get the actual displays organised in the premises. There is a fund administered by trustees that is standing at about £850, but we would also like to have individual subscriptions to this very worthy enterprise. The most suitable way is on the basis of a 7 or 10 year covenant.

One of the other activities during the summer months has been a visit of a very representative party of Technical Section members to Canada. This was an intensive and extensive tour. It started on the west coast where most of the modern pulping installations are, as well as the papermills. We had a very lively conference at Banff, held under the auspices of the Technical Section of the Canadian Pulp and Paper

* These draft minutes are due to be presented for approval at the Annual General Meeting on 22nd March 1961

Association. We then moved east and saw a really surprising number of fine papermills in the time available. In a period of 3 weeks, the going was very hard: about 21 mills in 16 days set apart for this, while the rest of the time was spent travelling and being members of the convention. I must say that all the arrangements went extremely smoothly and we are greatly indebted to the secretariat of the Canadian Technical Section for the most efficient way in which everything was organised for the party that varied between 25 and 40.

We made some preliminary arrangements for a return visit of the Canadians in 1962 and the Canada Committee has been reconstituted to look after the details. The hospitality of the Canadians to us who were on the trip was really beyond words. We were treated with extreme kindness and shown everything that was possible in the time. Everyone who was on this trip and anyone who took part in the former visit in 1955 will assure you that it is very much worth our while to put our best foot forward during the Canadians' visit to this country in 1962 to make it both enjoyable and enlightening.

You will be aware that in September 1961 there is a symposium arranged by the Fundamental Research Committee at Oxford on the structure and formation of paper. The level of this conference will be the same as the previous conference held at Cambridge in 1957, of which proceedings have been published in the book *Fundamentals of Papermaking Fibres*. The arrangements are practically complete and we look forward to a very good turn-out of members from this country: we hope also from abroad, because these conferences are recognised as being outstanding in the international field.

I can assure you that the Executive Committee, the Divisional committees and other committees and sub-committees are doing what they can to keep the work going and advance our interests. It says a great deal for the enthusiasm of the people who travel to Executive Committee meetings and of the committee personnel who organise local meetings that the Technical Section runs as smoothly as it does.'

The meeting then ended.

DEVELOPMENTS IN COATED PAPERS FOR PRINTING

Equipment for machine coating

R. S. HAVEN
Black-Clawson International Ltd.

GIVEN AT THE EIGHTIETH GENERAL CONFERENCE: ADAM ROOMS, GEORGE HOTEL, EDINBURGH ON 28th OCTOBER 1960, Mr. W. A. GILMOUR IN THE CHAIR

Synopsis

In this discussion, the five most commonly used on-machine coating methods are described mechanically and illustrated with their physical arrangements. An indication is given of the amounts of coating that can normally be applied by each method and a short discussion of advantages and disadvantages of each method is included.

Introduction

TODAY, every paper and board maker is thinking seriously of the prospects and consequences of on-machine coating. It is a process by which a coating of clay (or other pigments), binders and additives are coated on the surface of a paper or board substrate while it is being made to impart an improved surface appearance and characteristic that results in superior printing and brightness qualities.

The most commonly used and talked about on-machine coaters in use today can be divided into five basic types—Massey or print roll coater, air doctor, metering bar, size or coating press and blade coaters. In this paper, I shall try to describe and illustrate at least one of each of these processes.

Massey or print roll coater

MASSEY coaters made possible high speed coating at papermachine speeds and, although many versions of the print roll principle have been built and are running today, the one originally developed by Massey (Fig. 1) has seen few changes since its inception. Basically, the coater consists of two large diameter, about 48 in., rubber-covered applicator rolls forming a nip to apply coating simultaneously to both sides of the paper web as it proceeds through the dry part of the paper-machine. It is usually located about two thirds to three quarters along the dry part when the base paper is 5–7 per cent. moist.

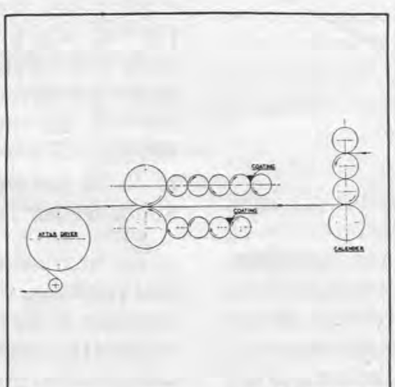

Fig. 1 — Transfer roll coater

Each applicator roll has its feed or metering rolls, which work and smooth the coating colour and spread it into an evenly distributed film of coating by the time it reaches the applicator rolls. It is usual to have all of the transfer rolls of a suitable diameter (say, 20 in.) to reduce deflections and import. One or more of the transfer rolls will oscillate and the coating, which can be applied at 50–65 per cent. solids, is fed into the last nip in the train of transfer rolls, which is equipped with edge dams to contain the coating puddle. Air cylinders are used to load the transfer rolls against each other and also to raise and lower the top applicator roll. One of the most common products produced by the Massey coater method is magazine coated paper with coating weights applied in the region of 9–32 g./sq. m. There is a considerable capital investment involved in such an installation, but it also produces a quality product at high speed.

Air knife coater

ANOTHER coating method now coming into more widespread use is the air knife coater, which was previously developed and used for many years only as an off-machine coater. The elements of the air knife coater are illustrated in Fig. 2.

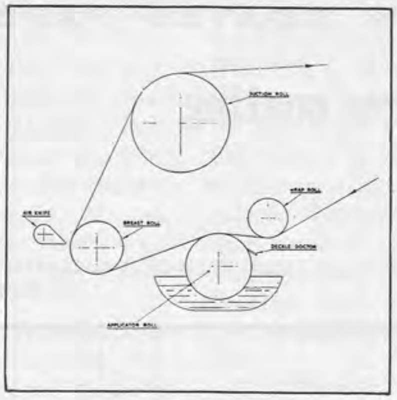

Fig. 2 — Air doctor coater

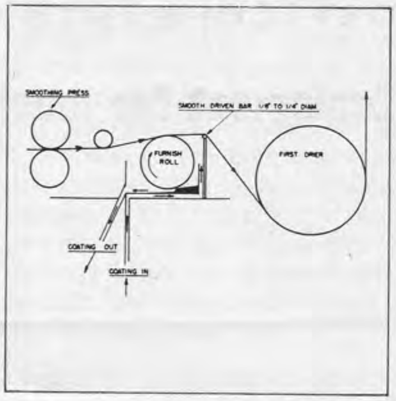

Fig. 3—Champion metering-bar coater

The coating is applied by an applicator roll running in a pan at a suitable speed, which is not usually the same as the web speed, but is varied to apply the correct amount of coating excess to the web. The paper or board then passes around the breast or backing roll, where it is doctored by the thin, sharp jet of air under pressure that is emitted from the precision machined lips of the air doctor itself. A non-pulsating source of air pressure must be assured and, of course, suitable filters as well, depending on the location of the blower, are a requirement. Naturally, the air doctor coating head is similar in make-up for either on- or off-machine application, but all roll diameters and the air doctor itself have larger cross-sectional areas to reduce deflection and provide the necessary accuracy to give a uniform coating across the web. Normal air doctor coating mixtures are applied at up to 45 per cent. solids and application of up to 35 g./sq. m. can be executed. The air doctor coater is usually located after the paper or board is finish-dried and has been through the first machine calender. Additional drying is needed before going on the second machine calender to return the coated stock to its finished dry state.

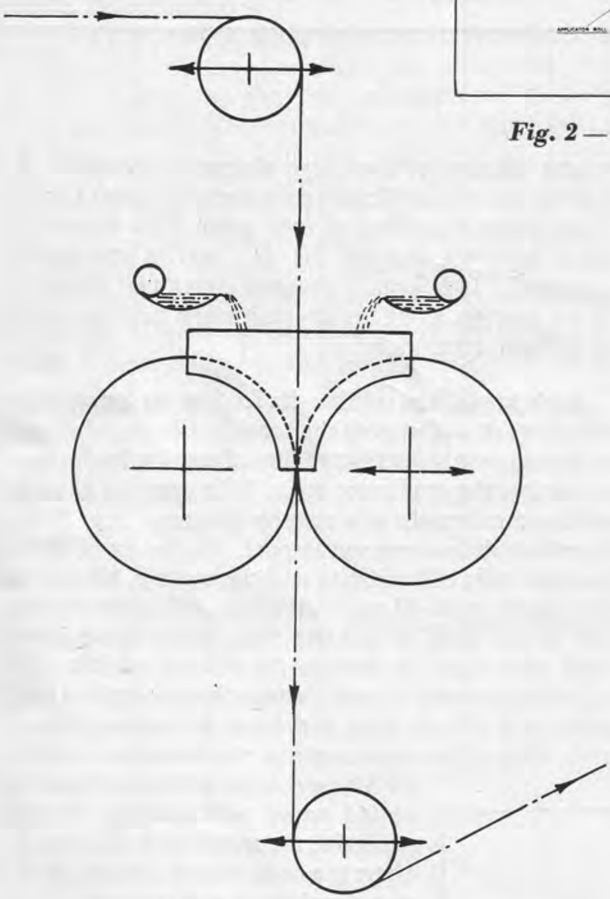

Fig. 4 — Size press coating

Champion coater

ONE of the oldest and most commonly used on-machine coaters is the Champion or metering bar coater, whose elements are shown in Fig. 3. In this coating method, too, we observe that an excess of coating is applied to the web by a rotating applicator roll running in the coating pan. The applicator roll does not have to run at the same speed as the web, since this provides a simple control over the excess coating that can be applied. A small diameter metering rod, which may be either a wire-wound roll or a plain rod, rotates in the opposite direction to the web and removes the excess coating and smooths the coating left on the web. The metering bar coater is normally located at a point where the paper or board is 40–50 per cent. dry and coatings are applied at about 60 per cent. solids.

The final coated surface tends to be less uniform than that produced on a Massey coater, but it is certainly a simple coater to install and it is now finding new utility as a primer coater when it is desired to double coat a web to produce a finer printing surface. Coating weights applied are usually 2–15 g./sq. m. Speed of this coater seems to be limited to about 900 ft./min.

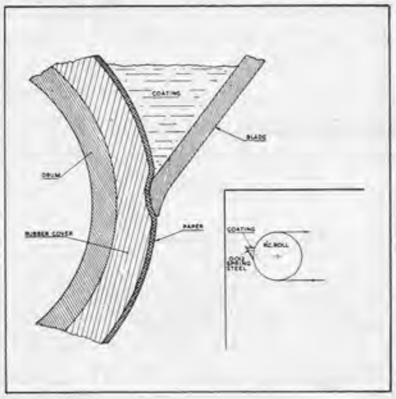

Fig. 5 — Trailing-blade type coater

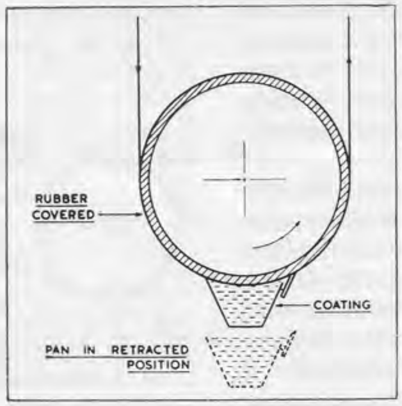

Fig. 6 — Flexiblade coater

and, of course, web tension or constant draw in het paper or board are extremely important. A superior surface can be produced by this coater, if it is preceded in the dryer section by a smoothing press. These coaters have the added utility of being able to be installed in the approximate area of a single drying cylinder, so they are popular as additions to existing machines. The newer models of this type of coater are semi-portable and can be rolled out of the machine dryer section for maintenance and cleaning.

Size press applicator

CONSIDERABLE interest has been evidenced in the last two years in applying coating at the size press. When coating is applied in this fashion, as may be expected, a wide range of coating qualities results, but it can be said that much is done in all cases to improve the brightness and surface appearance of the paper or board.

The latest form of the size press is the horizontal press roll arrangement (Fig. 4). The web travels in a downward vertical path and enters the pool of coating formed between the two rolls. After passing through the nip, it continues straight on until it contacts the first turning roll located at least 3 ft. below the nip. It can be argued that the distance from the nip to the turning roll is critical; indeed, for some coating formulations it is. Consequently, some of the coating presses are located high up in the dryer section and others at normal size press level. One recent installation was even suspended from above, leaving a clear web path following the nip, where close inspection and observation of the coated surface could be done with utmost ease.

Coating solids for size press coating may run within 35–50 per cent., but speeds have been noted of up to 1 000 ft./min. Normal maximum coating weight applied by this method has been noted as 10–12 g./sq.m. per side. Both rolls must be driven and some operators attach a great importance to the speed torque relationship between the two rolls. This seems to be a matter of individual practice or preference, however; there is as wide a variation in types of drive as there is in materials chosen for the two rolls. One roll is usually rubber, but the hardness is subject to conjecture. It can be said, however, that it is hardly ever less than 25 P & J and may be as much as 85 P & J. The other roll may vary in composition from bronze to stonite or chilled cast iron.

A recent innovation in size press coating was noted when it was desired to coat only one side of the sheet and this was accomplished most simply by locating an idler roll above the press, so arranged that it directs the web to wrap around one of the press rolls so that the pool of coating is only on one side of the web. If two idler rolls are arranged above the press in this manner, it is possible to coat alternate sides of the web as may be desired.

If the coating press is preceded by a three or four nip intermediate calender, then a much improved surface will result.

The first dryer following the coating press should be unfelted to avoid marking the coating. Many coating press installations incorporate some form of drying prior to the first after dryer, to insure that the side of the web towards the dryer is set before contacting the dryer. Either radiant or convection drying has been used most successfully in this position.

Blade coaters

THE newest directions for on-machine coating have taken the form of blade coating: first in the field was the trailing blade (Fig. 5). The web passes downward around a large diameter (32–38 in.) rubber-covered backing roll and held against the surface to be coated in a mechanical holder is a flexible blade that contains the coating in a puddle against the web. Height of coating in the puddle is controlled by rate of feed and recirculation and seems to have some effect on the amount of coating deposited on the web. Speeds of up to 2 500 ft./min. are claimed by this coating method and solids of up to 65 per cent. can be used, thereby simplifying drying requirements. Coating weights applied vary with formulation, but normally range 6–10 g./sq. m. per side.

It will be noted that, when it is desired to stop coating or if there is a web break, the entire puddle of coating must be dumped. Because of the mechanical method of adjusting and holding the flexible trailing blade, there is a slightly longer wear in time with this type of coater than with some other designs, but this is the oldest design of blade coater and a newer model has been developed to overcome certain features that were not wholly satisfactory with the first design.

In the last few years, a second blade coater has been developed called the flexi-blade coater, which operates on the principle shown in Fig. 6. In this, the coating mixture is contained in an enclosed fountain below a large diameter (32–45 in.) rubber-covered roll, around which the web is passed. The flexible blade forms the front of the box and is loaded continuously in pneumatic fashion along its entire length. This, it is claimed, permits a minimum wear in time and also provides an easy method of controlling the pressure of the blade against the web. Coating solids of up to 65 per cent. are common and as low as 40 per cent. on certain coating mixtures have been tried successfully on a pilot plant scale. Although most production installations of this coater apply 6–18 g./sq. m. regularly, coating weights of as high as 25 g./sq. m. have been obtained in the pilot plant.

It will be noted that the coating trough can be readily dropped from its operating position against the web. It is not necessary to dump the coating from the trough each time it is wished to stop, but only necessary to divert the flow of coating to the trough so that the pressure inside the trough drops sufficiently to permit lowering it for as long as required. The top speed of this coater is not known; since it has been run at speeds of up to 1 500 ft./min., it seems likely that it will eventually be possible to run it at speeds in excess of 2 000 ft./min. Continual work is also being done on higher and higher solids contents in coatings being applied by the Flexi-blade and indications are that appreciable improvements will be made in this direction. Of course, any improvement in the percentage of solids that can be applied satisfactorily gives a double benefit in savings in dryer capital cost and operating expenses, so it is a real goal to be attained.

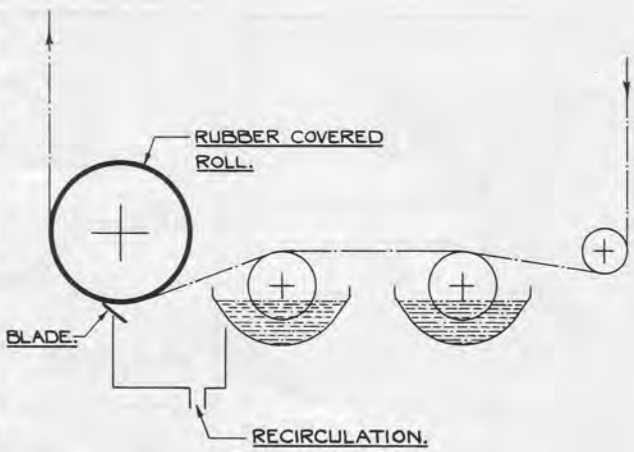

Fig. 7 — Blade coater

About two years ago, a third version of the blade coating process was introduced—the inverted blade coater. The basic principle is illustrated in Fig. 7, although it is understood that several versions of the coater have been tried with varying degrees of success. As in the air knife coater, an excess of coating is applied to the web by two applicator rolls and then the web passes around a rubber-covered drum where a flexible smoothing blade removes the excess material and at the same time leaves a smooth surface on the coating. It would appear that because of the application method adopted for the coating, this coater may find an excellent field of application in the lower percentage solids coating mixtures. One pilot plant version of the coater used a series of spreading and metering rolls as in the Massey coating process to apply the coating colour to the web before it reached the smoothing blade and it is conceivable that this modification permits higher solids content coatings. One set of test results with this coater, when followed immediately by an air knife, applied coating at 60 per cent. solids, but coating weight was 6–10 g./sq. m.

The newest blade coater to be introduced to the industry is one named the Champflex coater (Fig. 8). The web proceeds in an upward path having an excess of coating applied as it goes over two reverse running applicator rolls. It is interesting to note the method used to apply the coating to the rolls. The coating is pumped at 50–55 per cent. solids up to the top pan, from which it overflows into the second applicator pan and then overflows to recirculation. Metering or smoothing of the coated surface is done by a small diameter doctor bar held in a welded spring steel clip type of holder. The bar itself is chromium-plated to reduce wear and it is claimed that the coater is self-cleaning, since the bar rotates in the reverse direction to the web travel at 10–20 rev./min. Coating weights as high as 23 g./sq. m. have been applied at speeds as high as 1 000 ft./min. on paper and 500 ft./min. on board. For best results with this coater, Champion recommends double coating, which thus permits use of differing formulas for base and top coats.

How and when to coat

ALONG with the various results that it is hoped to achieve through applying coating to paper and board surfaces, smoothness of surface and good printing receptivity are probably the most important from a surface visibility standpoint. The type of coating process that will produce the best results for any given paper or board must be carefully selected and naturally it is not possible to cover up trash and produce a smooth-surfaced, top quality art paper at machine speeds. It is still correct to say that the better qualities of coated paper require close attention to all parts of the papermaking process from the preparation and selection of the fibres to be used onwards.

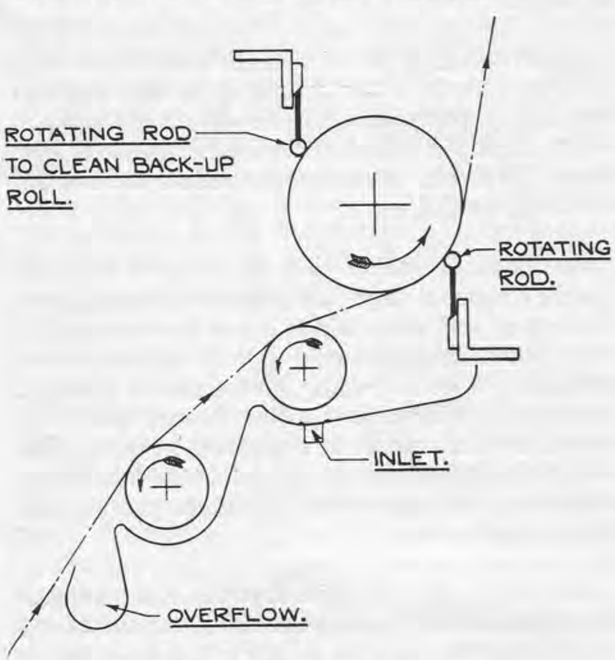

Fig. 8 — Champflex coater

A brief reference was made in the description of the last coating method to double coating and any discussion of on-machine coating would be incomplete without a word on double coating. Many of the coating methods discussed herein have been and are used in combination with one or more other types of coating applications with great benefit. Some coating methods that have been devised even go to the extent of installing as many as five coating stations of various types in the papermachine, starting at the dandy roll: however, excellent results are being obtained with only two application points. Either the metering bar coater or the horizontal size press coater are seeing increasing application as prime coaters and several installations are also being made, utilising either a blade or air knife coater as a second coater to apply the top coat.

Much depends on the basic sheet surface texture. For example, if an extremely rough surface is to be coated, it may be best to consider using a blade coater first to ensure that the base coat fills the surface irregularities, then after drying and possibly a light calendering, a second coat would be applied by an air knife to produce the depth of coating and coverage that when finally calendered will give a first class product. When the base stock is a smooth, highly refined paper or board, it may well be that a single coating applied either by coating press or by air knife will produce the desired result, but the current thinking also gives much credence to the application of the second coating in these cases, using the blade coater as the second coater, because of the smooth finish it produces, requiring a minimum of calendering.

Each coating problem deserves the right to separate and careful analysis in order that the best coating method is selected to produce the best finished product. Of course, the job of installing coating equipment on an existing paper or board machine involves not only the coaters and dryers, but also the physical building space available, which may require a compromise resulting in a different type of coater being installed than would be ideally selected if no length or headroom problems existed.

Conclusion

IN conclusion, it can be said that the developments of on-machine coating over the past few years have been the result of a continuing search for perfection and for product improvement that reaches out to all phases of the papermaking processes. Such great advances have been made already and so many people in all countries who are concerned with paper and board making and with coating chemistry are spending all their energies in improving existing processes and in developing new ones that it can be said that the next few years will see great progress in improved coating and papermaking techniques.

discussion

QUESTIONER 1: In one of your slides, you showed a magnetic metering bar coater. What is the significance of magnetic in that connection?

MR. R. S. HAVEN: That particular coater is developed from the Champion coater, but has a different method of holding the bar. The bar itself is held between two machined metal holders by means of a permanent magnet located below.

QUESTIONER 2: Could Mr. Haven please amplify his statement that the recirculation rate in a blade coater affects the coating weight?

MR. HAVEN: It has been found, as near as I have been able to determine, that the pond should be in the region of 9 in. in length of contact with the paper to achieve the maximum coat weight. One way of controlling coat weight is to reduce the exposure time of the paper to the coating as it passes through the coating pond.

QUESTIONER 3: In single coating paper, you have a problem of picking of the surface. In double coating paper, do you have a similar problem with the primary coat for the second one?

MR. HAVEN: In some cases, it is recommended that size application should be done at the water box or calender before the first coating is applied. There is also considerable work being done on the composition and compatibility of coatings. Naturally, you do not want the top layer to pick off when you are printing.

MR. G. F. UNDERHAY: In the last picture, you showed the rotating roll to clean the pick-up roll in the Champflex process, but there was no indication of where the material that was removed went.

MR. HAVEN: Unfortunately, I have not seen the Champflex coater, but the basic description that was presented at the Coating Conference this spring in Chicago indicates that solids in the region of 50 per cent. are removed from the rotating roll.

MR. R. J. B. MILLAR: Mr. Haven mentioned that one press roll is normally rubber-covered and the second press roll manufactured from another material such as cast iron or brass. Is there any objection to using two rubber-covered rolls and, if not, should one be harder than the other?

MR. HAVEN: There is no objection to having two rubber-covered rolls. I understand that one manufacturer specialises in two rubber-covered rolls, usually specified with a difference in hardness. One reason for the difference in hardness is to offset the tendency to two-sidedness in the coated sheet.

MR. P. H. PRIOR: In speaking of using the blade on rough paper to fill in the sheet to make a level surface for later coating, I presume that means that the amount of coating to be put on by the blade coater depends a very great deal on the initial roughness of the sheet.

MR. HAVEN: That would apply to board rather than to paper. Most of our experience in that field has been that, if you wish to fill the surface of the board with a coating in order to produce an absolutely level finish, the surface roughness determines the amount of coating needed.

MR. PRIOR: I believe that the amount of blade coating you put on paper will depend on the roughness of the sheet and will diminish if you have a smoother sheet put through smoothing rolls or smoothing calenders. When you speak in one case of having a preliminary coating, say of the Massey print roll type or the size press type, it was then suggested that a blade might coat on top of that as the final finish. Presumably, on that surface, it might put on only quite a small amount of coating.

MR. HAVEN: That is quite correct. The smoother the surface, naturally, the less coating one should put on. It should be up to the printer to decide the necessary amount of coating to get a good printed image.

MR. J. H. POTTER: Has Mr. Haven any information on ways in which the various metering devices he has described put the coating on to the surface? There would presumably be a difference between the flexible blade and an air knife.

MR. HAVEN: Some of the larger coating companies have conducted very extensive studies. This is usually done by a microscope examination of the coated, calendered, printed surface. You can see very definite differences among the different coating methods that I have discussed here and it is merely a matter of trying out the different methods with the various paper base stocks that you wish to coat in order to determine which one will be best for the particular application.

MR. PRIOR: The print roll and the size press methods you have shown are by application to both sides of the sheet at one point and most of the discussion has been on coating with a papermachine. It strikes me, although it did not show in the diagrams, that it is a complication to have a one-sided coating unit on a machine and the second one has to be done in the reverse way. Is this thoroughly satisfactory?–trouble in this section means stopping production on the whole machine.

MR. HAVEN: I believe there is definitely a trend towards incorporating either one or two coating methods on the papermachine. It is quite common to put a pigment-applying press in the dry part and then, if you want to put on either an air knife coat or a trailing blade coat, this would normally be done at a point after the first calender when the paper is just about completely dry. There is a great deal of interest being shown at the present time in the United States in what is known as 'wet on wet' coating, but this is in the preliminary experimental stage.

MR. J. POPELIER: It can be argued that the distance from the nip to the bottom roll is critical. We have about 27 size presses running in Scotland and on the Continent and we have found that 2 m. from the nip to the bottom roll is a good average in most circumstances. In our view, this distance really is of paramount importance.

Whether sizing or coating is done on the press can make a lot of difference. We have used a distance between the nip and bottom roll of 1 m. in sizing, but we should not like to do the same in coating, since there is a danger that the sheet will stick to the bottom roll.

DR. B. R. S. JONES: Is there any minimum solids content for the first coat in 'wet on wet' coating? The top coat could disturb the first coat and so the advantage of double coating be lost.

MR. HAVEN: You want to disturb the coating just enough to produce a more uniform coated finish. In general, a great deal of thought has been put into the application—in the first instance, by a blade, for example, followed by an air knife. This tends to cover up the deficiencies of the blade (streaks) and will tend to give a more uniform final product. Obviously, to cover up the streaks will disturb the first coating a little.

QUESTIONER 4: Has Mr. Haven any information on the effect of the type of drying after coating on the properties of the coating?

MR. HAVEN: A great deal of work is being done on this at the present time. There are, of course, the two broad categories of drying—high velocity and convection drying—the first involving a high velocity hood and primarily used for high solids coating of upwards of 50 per cent. The convection tunnel dryer is more commonly known and is, I would say, primarily devoted to low solids applications.

It would be advisable first to ascertain the coating method and then to consider the type of drying that will best dry that particular coating. To a large extent, the drying considerations are basically controlled by capital expenditure and space limitations. Naturally, the tunnel dryer takes up a considerable amount of space. Consequently, you may favour high solids coating involving a high velocity hood, which would not take up so much space. These are all questions that will, of course, vary with each installation and with each coating method.

QUESTIONER 5: Mr. Haven has quoted a figure of 9 in. for the length of contact with the pool for giving the highest solids. Judging from the diagram of the flexible coater, this distance is fixed by the design of the machine, the width of the trough. Does this mean less flexibility of coating widths that can be applied on this machine?

MR. HAVEN: No, because the width of the coating trough is more than 9 in. and we can also vary the pressure of the coating inside the trough. In a trailing blade coater you are limited by the weight of the coating against the web.

QUESTIONER 6: Could Mr. Haven give any typical examples of blade life in the flexible blade coater?

Secondly, speeds of 2 000–2 500 ft./min. have been quoted—is there a minimum speed for the coater?

MR. HAVEN: When trailing blade coaters were first introduced, it was found that you had to change a blade about every 1–2 hr., which made it highly impracticable. Now blade life has been increased through proper control of the pressure on the blade and better blade material, so that blade lives of up to 3–4 days can be expected in normal operations.

The minimum operating speed we have run at is 300 and 400 ft./min.—in some cases 200 ft./min. In all cases with a trailing blade coater, because of the hydraulics operating at the blade point, increased speeds achieve a higher coating weight. Further control is obtained by adjusting the pressure of the blade and the recirculation rate of coating in the box and pressure in the box.

QUESTIONER 7: With all these processes, what is the minimum run that makes it worthwhile?

MR. HAVEN: Mill economics may indicate that you should not attempt a coating run of less than a day. It is wise to accumulate orders for coated stocks until there is a full day's run, say, of a single grade of paper. Of course, this applies strictly to on-machine coating and that is where some of the other methods of coating off the machine have a certain amount of flexibility and advantage. In the United States, I believe it is sometimes considered uneconomic to attempt a production run of less than two or three days, but that again, will vary with the mill economics.

QUESTIONER 8: Would any of these methods be suitable for saturating a paper?

MR. HAVEN: Certain experiments have been done in that respect, but I know of no one who is doing it on the machine yet. It would appear that these methods of coating are applicable to a great many different coating substances, though, so far as I know, no commercial experiment has been done using a blade coater, for example, to apply a lacquer or similar coating. It seems to have certain advantages —no worry about the amount of solvent evaporation, for example—but this is a field yet to be explored.

MR. UNDERHAY: In reply to an earlier question, you mentioned that you could apply pressure in the flexible blade process. How do you stop the coating from going downward, if you apply pressure?

MR. HAVEN: This is a very interesting problem and has been the subject of a considerable amount of work. We do this by very accurately controlling the height of the rear of the box. There are some operating methods being used with this particular coater in the United States, whereby they recirculate over the back plate to control the amount of the inflow, the amount that goes on to the paper and the amount that goes over the bar. This is possibly the best way of operating, particularly on a sheet with loose surface fibres that cannot be cleaned off beforehand, because recirculation overflow on the back of the box will carry away any loose surface fibres, which would also tend to stick at the blade and cause streaks. The tendency to develop light streaks is one main difficulty that all blade coaters have to date.

Another satisfactory way of operating is to control the space between the back plate and the paper to, say, 0·005 in. Then, if the paper caliper is uniform enough to keep the space so small, the air that comes along the surface of the sheet keeps the coating from overflowing.

QUESTIONER 9: Mr. Haven has not mentioned a vertical size press: has that special arrangement been found unsuitable for coating?

MR. HAVEN: By no means: it is still being used satisfactorily in many mills. I have mentioned just the horizontal press because it is one of the commonest installations in size presses. With a vertical roll arrangement, there are the problems of a shower pipe and maintaining a pond. Then the roll feed is on the bottom and a shower pipe on the bottom roll, but it does not guarantee as uniform a coating as the horizontal press. For many purposes, it is quite satisfactory.

QUESTIONER 10: Have you any information on the Kohler process?

MR. HAVEN: I have none other than what was reported over a year ago at the first Coating Conference. I believe no other experiments have been made. The first work was done at Abitibi, I believe.

DEVELOPMENTS IN COATED PAPERS FOR PRINTING

Machine coating — past, present and future

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GIVEN AT THE EIGHTIETH GENERAL CONFERENCE: ADAM ROOMS, GEORGE HOTEL, EDINBURGH ON 28th OCTOBER 1960, Mr. W. A. GILMOUR IN THE CHAIR

Synopsis

Machine coating of printing papers and board started about 25 years ago with the introduction of the Massey coater and this invention has been followed by the Champion machine coater, the size press coater and by the use of the air knife coater and the trailing flexible blade coater as machine units. The trend is now towards double coating on the papermachine by using two similar coaters, or two different coaters, in tandem on the same side of the web. Such improvements in machine-coating methods have narrowed the gap in quality between machine and off-machine coated papers.

Introduction

MACHINE COATING is a term that came into our vocabulary about 25 years ago. To papermakers, it means coating paper on the papermachine as an integral part of papermaking and we use it exactly the same way as we speak of machine calendering or machine finishing. To printers, machine-coated means a class of paper and there is nothing inconsistent in this meaning, because machine-finished also means a type of paper. There are papers, however, that a printer would regard as machine-coated and a papermaker would not. For the purpose of this discussion, machine coating is defined as coating as an integral part of papermaking.

When machine-coated papers first appeared, they were much inferior to coated art papers and one could not be blamed for asking why they were invented. The answer is simple and can be given in one word—price. In the early thirties, nearly all art paper was coated on brush coaters, which coated narrow webs at slow speeds, only on one side at a single pass through the machine. Moreover, relatively expensive pigments were used and the process suffered from a high proportion of downtime. As a result, the coated paper was too costly for general use in inexpensive publications. At that time, particularly in the United States, magazines were the principal medium of national advertising and advertisers demanded better quality reproductions. After all, no car manufacturer wanted the advertisement of his car to look as if the paint was chipping off.

Massey coating

IT seems probable that printers were aware of the demand for cheap coated papers before the papermakers, because it was a printer, Peter Massey, who first patented one method of machine coating paper that is still in wide use today: this was in 1933. Massey worked on the principle that, as one can print a solid black, one should be able to print a solid white, but it is a very big step from printing a pigment bound with oil to printing a pigment bound with a water soluble adhesive. The mechanism of coating transfer is very complicated and it depends on what is known as 'splitting a film'. When the film of coating splits, under conditions such as occur on a Massey coater, the coating must neck out in local spots and the necks break. Consequently, the coating is stippled on. With low solids coatings, the stipple pattern is coarse and unsatisfactory and, as Massey and his associates at Consolidated Water Power & Paper Co. could not get the solids high enough with the conventional coating materials of that time, they turned to starch and clay. The starch had to be modified and suitable clays found, but they did succeed in getting high solids coatings that transferred with a fine pattern. Important as Massey's coater was, it seems safe to say that the work done on formulating a coating to suit the coater was an even bigger contribution to the science of paper coating. Fig. 1 shows a typical pattern caused by the necking out effect.

It is safe to say that Massey coating or, to use a broader term, transfer roll coating revolutionised the periodical publication business in the United States and it is worthwhile examining the main factors that contributed to this revolution. One was that Massey papers were mass-produced, which enabled them to be produced in a quantity and at a price of interest to publishers. Secondly, cheaper coating materials were

Fig. 1—Uncalendered Massey coated paper [linear × 10]

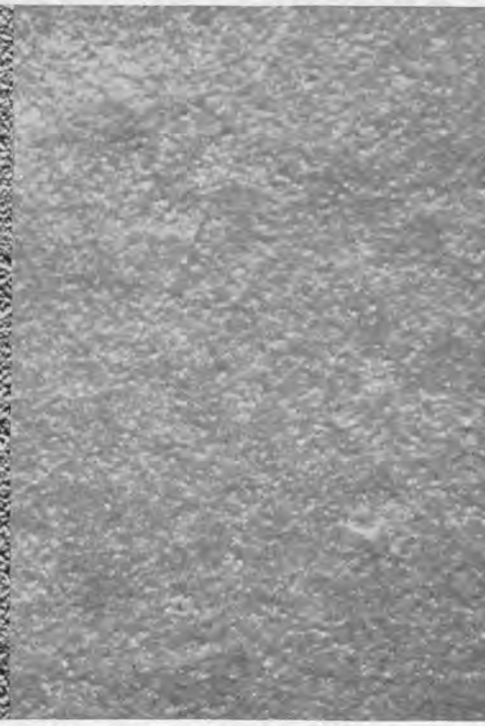


Fig. 2—Supercalendered Massey coated paper [linear × 10]

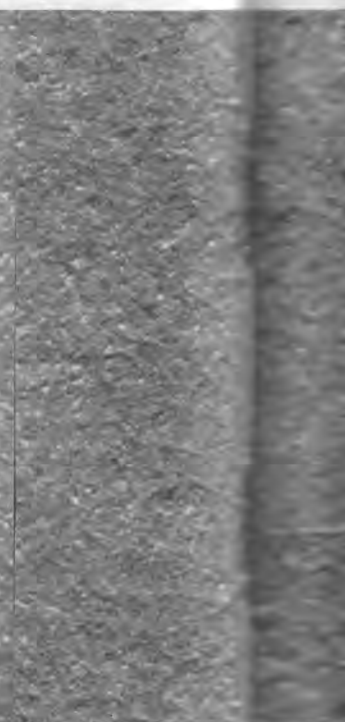


Fig. 3—Cha

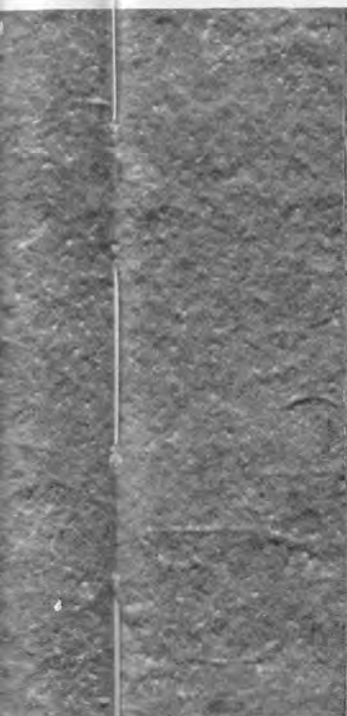
used: cheaper mineral and cheaper adhesive. Finally, these were applied to mechanical printing base papers, which are relatively inexpensive compared with pure papers. These three factors account for the enormous growth of Massey coated papers.

It may also be worthwhile to consider the requirements of a machine coating process. Obviously, it must operate at the width and speed of papermachines, it must not cause very much downtime and the machine must be such that the papers can be fed through it at the speed of the papermachine, because it would be impractical to pull back the speed of a papermachine each time a break occurred. The width factor is of special significance: if the application of coating caused a 24 in. wide web to expand 0.5 in., it would cause a 120 in. web to expand 2.5 in. and it is difficult with this amount of expansion to avoid wrinkles and creases. Even with a Massey coater (which causes relatively little lateral expansion), trouble with creases has been experienced on wide machines.

The early machine-coated papers were a big step forward from mechanical printings for publications, but they fell a long way short of coated art papers in quality, mainly because of the stipple pattern. The conventional way to smooth a paper is to calender it and, in the years following the introduction of Massey papers, the calenders themselves and the method of calendering were improved. As methods improved, Massey coated pure papers were introduced and these began to compete with coated art papers. Fig. 2 shows a supercalendered Massey coating. As a result of heavy calendering, Massey papers are denser and less ink absorbent than coated art papers. This has demanded the introduction of different ink and today all the main ink producers supply inks that are suitable for Massey papers. With such inks, transfer roll papers are suitable for high quality work and today thousands of tons of Massey coated pures are sold for letterpress and for offset printing; though the bigger Massey tonnage is in coated mechanical papers.

Champion coating

Less than six months after the first Massey patent was issued, the forerunner of the Champion machine coating process (which has also proved a great success) was patented. In its original form, the process was described as a means of leaving coating in the surface pores of the paper and it was not until 1941, seven years



3—Champion coated paper [linear × 10]

Fig. 4—Size press coated paper [linear × 10]

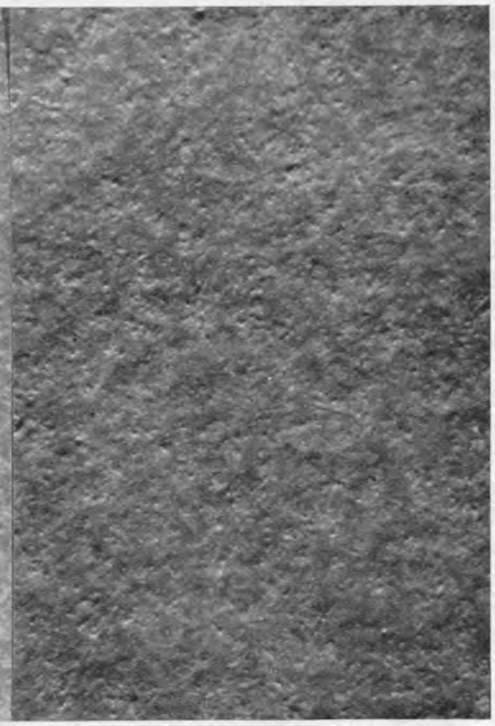


Fig. 5—Double-coated Champion paper [linear × 10]

later, that the Champion doctor bar coater was patented as a process of making coated paper. The inventor of this process was Donald Bradner and his approach was very different from Massey's; whereas Massey developed a new coating to suit his coater, Bradner developed a coater and technique to suit an orthodox coating. The coating that Bradner used was clay and casein at about 40 per cent. solids and it was very similar to that used on off-machine coaters, since by that time clay had begun to displace more expensive minerals. As was to be expected when dealing with low solids coating, Bradner experienced trouble with lateral expansion of the web and he mastered this difficulty, to a large extent, by applying the coating to a moist web. Different mills set different conditions, but some apply the coating to the first side when there is as much as 45 per cent. moisture in the sheet. When it carries this amount of moisture, the web has not contracted very much and it does not expand appreciably therefore on being wetted with the coating. The mechanism of coating by the Champion process is most interesting. An excess amount of coating is applied to the paper and, owing to the water absorbency of the web, water drains from the coating into the web. This produces a layer of high solids coating, called a filter cake, adjacent to the web and leaves the excess coating in a fluid state. The excess coating is then removed with a doctor.

As previously mentioned, the forerunner of the Champion coater was described as a means of leaving coating in the surface pores of the paper and such a coating was very light, only 2–3 g./sq.m. Since this beginning, great studies have been made in increasing the coat weight and today about 12 g./sq.m. of coating can be put on each side of a medium weight web, using coatings formulated with clay and casein. As is to be expected, such papers resemble coated art papers, with the difference that the coat weight is about half that normally put on coated art papers. Fig. 3 illustrates a typical Champion coated surface. Some mills have increased the coat weight further by using a high proportion of latex in the coating. The latex permits an increase in the solids in the coating and a point, which may be more important, is that latex parts with water freely, thereby increasing the amount of coating that remains on the web as a filter cake.

Size press coating

In recent years, the size press has become a popular machine coater, especially in continental Europe. Size presses, as everyone knows, have been used for many years to force gelatine solutions and starch solutions into paper and the development has been to incorporate mineral along with the adhesive so that some mineral is left on the surface of the paper. It seems probable that the same mechanism of drainage of water from the coating into the web, as was discussed in the Champion process, plays a part in size press coatings and it has certainly been established that the use of a high proportion of latex in the coating increases the coat weight that can be applied by a size press. Fig. 4 shows a photomicrograph of a sizepress-coated paper, using clay, starch and latex in the coating. The coat weight in this case is about 8 g./sq.m. per side. It might be mentioned here that when latices were first introduced some of them broke down or coagulated in a size press, but there are many latices today that give no trouble in this respect.

Air knife coating

Another development in recent years has been the incorporation of well-known off-machine coaters into the papermachine. An example of this concerns the air knife coater, which has been used as an off-machine unit for about 20 years and has only recently been built into boardmachines. As with the Champion coater, excess coating is applied by a pick-up roll of the air knife unit, but, instead of the excess being scraped off, it is blown off with an air slice. The air knife is sometimes described as a contour coater, because, whereas a mechanical doctor tends to leave the hollows in the web full and the high spots bare, the air knife tends to follow the contour of the web.

Flexible trailing blade coating

The coater that is currently receiving most attention in the U.S.A. is that in which the coating is held back by a thin flexible spring steel blade trailing in the direction of travel of the web of paper. This coater is not new—in fact, Trist's original patent in this country on the open pond type of trailing blade coater and the original patent on the closed pond, flexible blade coater have both expired. These coaters have been used for at least a decade on certain speciality papers, both on- and off-machine, but their use on printing papers is of recent origin. They are capable of applying high solids coatings thinly and evenly, even to lightweight papers. This latter feature is at least partly responsible for the great interest that is being shown in them, as increases in postal rates have caused publishers to look for lighter weight coated papers. It is too soon to predict what place trailing flexible blade coaters will occupy among machine coaters, but, with many mills devoting so much attention to them, their importance seems assured.

Double coating

There is another development that must be reviewed. It does not involve any new invention, but a new use of one or more of the well-known methods to double coat paper on both sides. Double-coated papers have been known for at least a decade and they were usually made by first machine coating a paper and then off-machine coating it by a conventional off-machine coater. A common example is coating with a size press coater and then with an off-machine air knife coater. Massey papers are also used as base paper for off-machine coaters. Double coating on one side only was then made an all-machine process by mills that had Champion coaters, as they improved the quality of their label paper by coating one side twice. Recently, at least one mill has carried this development a stage further and is double coating both sides of the web. Earlier in this paper, it was mentioned that a Champion coater applied less coating than conventional off-machine coaters. Now, by double coating, a coat weight about equal to that on coated art papers can be achieved (Fig. 5). Some machines in the United States have a size press coater and a Massey coater; others have a size press coater and trailing blade units; one machine, recently completed, has a Massey coater followed by top and wire side trailing blade units.

In the foregoing, an attempt has been made to review the main methods of machine coating from the standpoint of the type and quality of the resulting coated paper. Before going further, it must be stated that a very important factor in the quality of the finished paper is the quality of the base paper. The furnish used is fundamental and it is generally agreed that no Champion coated paper made in the United States is equal to that made here in Scotland on esparto-based paper. In making coated papers, there is no substitute for good papermaking. The way the furnish is put together, whether the sheet is sized and whether it is calendered prior to machine coating all play an important part in the final coated paper.

In the title of this paper, reference was made to the future. What does it hold? Certainly, existing machines will be improved, but the writer is unaware of any new basic invention in coating machinery. It seems rather significant that the original patents of all the coaters reviewed above have either expired or are about to do so after having been given an extension as a result of World War II: however, this does not mean that we have reached stalemate. The field of double coating has only been scratched and it is in this field that the biggest strides may be anticipated in the near future. Five methods of coating have been reviewed in this paper. Any one of these five could be used to apply the first coating and, with the possible exception of the size press coater, they could be used to apply the second coating. This gives twenty possible combinations of coating units and some of these combinations will produce exceptionally good printing surfaces. In most of the double coaters in use today, the first coating is dried before the second is applied, but it is possible to apply a high solids coating with a coater such as a Massey unit and then a lower solids coating with a coater such as an air knife unit, without any intermediate drying. After the recent TAPPI coating conference in the United States, one paper machinery manufacturer demonstrated a coater in which excess coating was applied with a Massey type of coater, the excess removed by a trailing blade, then a second coating applied with an air knife unit. The model was an off-machine coater, but it had been designed with machine coating in mind. This coater contains features of three different coaters to produce double coating and may be an example of what the future holds now that the patents on the different coaters have expired.

Double coating will also give the greatest possible scope in the formulation of coating mixtures, because each coating can be formulated for a specific purpose. The undercoat may be made for opacity and the top coat for gloss, just as the undercoat and top coats in paints may impart these characteristics. Earlier in this paper, it was stated that latex had let papermakers increase the coat weight with certain coaters; now double coating will let papermakers use latex to its fullest advantage and thereby achieve better paper. Double coating and the better use of materials are at least two things that will grow in the future.

Conclusion

THIS paper was begun with a definition of machine coating. Twenty five years ago, the term had a stigma attached to it: now, with the improvement of the earlier methods and the introduction of new methods and materials, the stigma has gone. This is the first conference in which this Division has featured machine coating. Perhaps it will be the last, because the day may not be far off when, from a quality standpoint, it will not be justifiable to distinguish between on-machine and off-machine coated papers. When that day comes, some of the arguments against machine coating will end and whether to machine coat or to off-machine coat will be a matter of engineering and economics.

discussion

QUESTIONER 1: Was Dr. Rose referring to smoothing or machine calendering prior to coating?

DR. R. C. ROSE: Machine calendering with 1—5 nips.

THE CHAIRMAN: You mentioned that there is a considerable percolation of aqueous material from the coating into the paper. Does the effect of calendering not become nugatory because of the loss of finish from the raising of the calendered surface by moisture?

DR. ROSE: With our furnishes and the Massey coater, we know that calendering prior to coating enhances the smoothness of the final paper, but good formation is essential.

THE CHAIRMAN: Does the sizing or water absorbency of the coating base have a very great influence on the amount of coating that can be put on the surface?

DR. ROSE: Sizing has a pronounced effect on coat weight with coaters that rely on water absorption to give a filter cake of coating. With the Massey coater, sizing has little effect on coat weight.

MR. G. F. UNDERHAY: Would Dr. Rose expand on 'wet on wet' coating? What are its advantages?

DR. ROSE: I believe the principle is that a high solids coating is put on first and a lower solids coating is then applied to cover up the surface defects of the first coating. One advantage of omitting intermediate drying would be simplicity, which is important in relation to machine running time. To my knowledge 'wet on wet' has been used only on board and I doubt if lightweight paper would bear it.

MR. P. H. J. ABBOTT: May I have Dr. Rose's advice on the equipment most suitable for the preparation, circulation and screening of high solids mixes?

DR. ROSE: Mixing and pumping demand suitable equipment and adequate power. Screening is limited by viscosity, but it is possible to get high solids and reasonable viscosity by choice of materials and point of addition. We use soap in our coatings to increase viscosity and prefer to screen before adding the soap.

THE CHAIRMAN: Everyone seems to be doing all he can to get as high a gloss as possible on the paper. I find nothing more irritating than reading from glossy paper. Do you think this popularity of high gloss on publication grades will decline?

DR. ROSE: I fully agree that glossy paper causes eye strain and, in some of the United States, its use is prohibited in school books. I think its use in books will decrease. Advertisers prefer glossy paper and, as advertisers pay most of the cost of publications, they can specify the paper.

MR. UNDERHAY: I agree: the implication is that ultimately readers will neglect advertisements because they are too glossy.

MR. W. J. STEERS: The advertisers are not entirely to blame, as the advent of gloss ink has a bearing on the problem.

DR. ROSE: Gloss inks call for non-absorbent paper, but absorbency can be reduced by coating formulation and does not necessarily demand that the surface should be glossy.

MR. J. B. HEATON: Dr. Rose gave the impression that the type of stipple pattern obtained was related only to the formulation of the coating applied. Does the hardness of the rubber rolls not influence the character of this stipple pattern in any way?

DR. ROSE: Pattern is the result of splitting a film and, whereas coating formulation is the major factor, roll hardness and roll diameter play a part.

MR. G. F. GLOVER: What is the effect on the coating process of the temperature of the paper web? What difference does it make to pick-up and to uniformity of coating if the web is warm or cold as it enters the coating station?

DR. ROSE: With Massey coaters, the coating is premetered and web temperature has little effect. With a size-press coater, a hot web, being more absorbent, will give a greater pick-up of coating and greater penetration of adhesive.

MR. UNDERHAY: In what direction and at what speed does the magnetic rotating bar revolve?

DR. ROSE: Its speed is only 2–3 ft./min. and its direction is against the direction of travel of the paper. The bar is rotated to make it self-cleaning.

THE CHAIRMAN: Does stretching of the paper as it absorbs moisture from the coating have anything to do with development of pattern, which is often observed on at least one side of the paper coated on a size press?

DR. ROSE: Excess tension between the coater and drying section will certainly give a ridged pattern. Tension can also cause curl.

MR. K. C. WEEDY: Are there any developments in spray coating?

DR. ROSE: I am not aware of any such developments. Most sprayed layers are much thicker than the coating on paper.

MR. A. A. LAIDLAW: I have an idea that one of the early patents on air brushes (perhaps one by S. Lebel) dealt with spraying on of colour. It is not a very satisfactory method so far as my experience goes, since the coverage of the paper by the colour is patchy and requires very effective smoothing. This is difficult to achieve, because the colour is partially dried by atomisation before it reaches the paper and the result is a very rough and unequal coating.

DR. J. H. WILSON: Neither Dr. Rose or Mr. Haven has described the method of coating from a raised meniscus. It appears to be free from foaming troubles and is being used on pure latex at high solids.

(*Continued on page T 252*)

DEVELOPMENTS IN COATED PAPERS FOR PRINTING

Traditional coating meets the challenge

W. A. R. HILTON

Mill Manager, James Brown & Co. Ltd., Penicuik

GIVEN AT THE EIGHTIETH GENERAL CONFERENCE: ADAM ROOMS, GEORGE HOTEL, EDINBURGH ON 28th OCTOBER 1960, Mr. W. A. GILMOUR IN THE CHAIR

Summary

To meet the challenge of lower priced machine coated papers, traditional coaters have already developed or adapted faster methods and are moving away from those that depended entirely on brushes. Speeding up of production can lead to appreciable price reductions. Comments are made on existing procedures and an attempt made to foresee future developments.

Introduction

IT is becoming increasingly difficult to define those processes that can justly be described as 'traditional'. Up to some 25 years ago, the term would almost certainly have been unknown; had a definition actually been sought at that time, it would have covered only those various methods of applying and spreading the coating that employed brushes at some point. Today the term must undoubtedly have a much broader meaning and, for this discussion, it has been taken to mean all the processes that can be used by a converter after the paper has been reeled and removed from the machine. Essentially coating is undertaken with one end in view—that of improving the paper for a specific purpose. For very large tonnages, this desired end is an improvement in the printing properties.

What is this challenge that is being met?—surely only one of price. It must be accepted that anything a machine coater can do, a converter, using modern methods, can do better. This must be so, if only because the converter is using a more mature raw material and has far greater opportunity to adjust and improve his product before finally going into production. Since the question of selling price must be a most important consideration at all times, it is proposed to outline some of the modern techniques that are available to converters.

Brush coaters

IT must be accepted that the application and smoothing of coating slips by brushes cannot now compete on an economic basis with the much faster methods available. It is reasonably certain though that an appreciable market will continue to be supplied by these methods, since properly controlled brush coaters can produce printing papers higher in quality than can be produced by other methods.

The factors limiting speed of production on brush coaters are, firstly, the mechanical difficulties of oscillating brushes at speeds in excess of 200 ft./min. and, secondly, the necessity to change brushes for cleaning at intervals. The intervals vary, but are not normally more than 8 hr. and frequently a lot less. Each change means a shutdown, followed by further loss of effective production whilst the alternative set is adjusted.

Knife coaters

THIS is a general description applied to those arrangements in which an excess of coating slip is applied to the moving web and the surplus removed either by a stationary knife or by a jet of air.

The bar type coaters have been adapted for use in a variety of circumstances—for example, when very viscous materials are being used, the blade is above the web. Other applications can have the blade set under the sheet.

Air knife

ALTHOUGH this type of equipment is now being used increasingly by machine coaters it was originally developed for converters and continues to have a very big future in that application. No claim for maximum operating speeds appears to have been made—the drying capacity available is a limiting factor. Speeds of some 1 200 ft./min. have been recorded. This type of coater can handle slips of up to 45 per cent. solids content and has an appreciable range of coating weights.

The air knife is designed so that the air flow will blow the excess from the surface, either directly back into the colour trough or into a separate chamber. To improve the smoothness of the coated surface and help to reduce calendering pressures, it is possible to incorporate a series of smoothing rolls in the machine design. The rolls, normally 3 or 4, are highly polished and driven to run counter to the web. The wet coating is smoothed out by the action of the rolls. They are very effective.

Air brush

AIR brushes are rather different in design, since the object here is not to blow off the excess colour, but rather to roll it back and so smooth the surface. Instead of a jet of air the orifice produces more of a spray. The speed obtainable with this equipment is lower—some 300 ft./min. being given as the maximum.

One of the disadvantages of both air knife and air brush equipment is that only one side of a sheet can be coated at a time. This necessitates the use of two coating heads to complete the coating in one pass through the machine.

Roll coaters

THIS is undoubtedly the most versatile of the coating methods. Major development work was undertaken with machine coating as the objective, but the principles have been freely adopted for converters and all the many potential leads and roll settings are available to them. Versatility is an important consideration for converters since one piece of equipment can be used for a variety of applications governed by the body stock and type of coating slip being used. The surface after application can be smoothed out by smoothing rolls. It is claimed that 3 or 4 rolls are sufficient to ensure a completely closed surface.

Dual coating

THE reference here is to the simultaneous application of colour to both sides of the sheet. It has been normal practice over many years on some brush coating machines. The slip can be applied either by total immersion of the sheet with subsequent doctoring by squeeze rolls or by separate feeds above and below the nip. This latter is possibly the more satisfactory method. Modern roll coaters use similar methods for application, but smoothing of the surfaces is effected, once again, by passing through a series of rolls.

Trailing blade coaters

THIS is the latest development in coating techniques and could well have the biggest future potential. It is a method equally suitable for on or off the machine coating and currently it would seem that new installations are about equally divided. Indeed as improvements in design, materials and coating slips lead to increases in the coating weights that can be applied it seems highly likely that the process will become increasingly attractive to converters, since they have greater scope for extension of drying capacity and for alterations to the body paper characteristics.

Cast coatings

IN recent years printing papers produced by this method have been widely publicised and whilst the potential markets for the grades would appear to be limited, certain traditional coaters in this country are making use of the process. Furthermore, there is a potential use as a means of casting various types of self-supporting films.

Basically the method is one of applying wet material to a heated surface and then stripping it as soon as it is dry. The high polish of the heated surface is faithfully reproduced, giving a high gloss without the necessity for calendering. The claim is made that the printing properties of the sheet are much improved, since heavy calender pressures can lead to reductions in bulk and ink receptivity. Similar claims are made in respect of trailing blade methods. The slow running speeds at present associated with this technique would suggest that it is unlikely to be taken up by on-machine coaters.

Future trends

IN the foregoing review various methods of applying water-based coating slips to paper have been summarised. Very large tonnages of printing paper are involved and the struggle between the two systems of on- or off-machine coating has started.

Printing papers do not, however, exhaust the potential markets open to traditional coaters. There are further vast fields for future development. Plastics must be considered. These are already available in the various co-polymer latices currently flooding on the market, but their application to paper either as a reinforcement to increase strength or to improve other properties such as resistance to water, vapour or grease has very great potential. Extrusion of the heated material or the use of organic solvents are the two methods obviously likely to expand. The use of organic solvents necessitates provision of recovery methods.

Drying

HERE again, versatility is on the side of the converters. On-machine coaters are of necessity limited by the potential capacity of their machines. Extensions to the dryer part of a making machine are usually difficult to accommodate and always expensive. Dryers for converters are much easier to devise and extend. They too can be very expensive.

Slow natural drying is theoretically the most efficient method and it is safe to assume that something is lost when coated paper is exposed to too high temperatures. How important that missing factor is, is difficult to assess and it is certain that as production speeds are increased so will there be a corresponding rise in the temperature at which the paper is dried.

It is only in recent years that traditional coaters have turned from festoon drying. Although by no means perfect as a means of drying coated papers, festoons are in almost universal use with brush coaters. Various attempts have been made to speed up festoon drying, but there is the difficulty of proper festoon formation at speeds higher than 300 ft./min. The pressure of air being displaced is sufficient to cause the paper to turn in and buckle.

Festoon dryers occupy considerable floor space and it has often been possible to replace them by enclosed dryers running at much higher speeds but requiring no more space. Various types of dryer have been tried, but it is almost universal practice now to install tunnels. They can be expensive installations, though improvements by the various specialist manufacturers are leading to higher efficiencies with consequent reductions in length.

Tunnel dryers are essentially insulated enclosures through which the paper is passed and dried, normally by streams of heated air. The most satisfactory type dries the coating in a single pass, but sometimes to save space or expense the web is returned through the same tunnel. In this type, although the upper and lower divisions are separated, it is difficult to ensure that the temperatures are properly graded in the various sections. The establishment and maintenance of the most satisfactory temperature gradient for any paper is a most important factor in the design of tunnels. Each section of the tunnel is complete with heaters (usually steam coils) and fans both to feed in air and remove it. The air is blown through the heaters into a pressure chamber. It is then forced out through nozzles or slits at even pressure across the width of the machine. The design of the orifices and the angle at which they are set are most important factors in satisfactory dryer operation. Air is normally recirculated throughout the dryer and in practice very little has to be exhausted to waste.

Tunnels are quite commonly constructed in an arched back form instead of being flat. This is claimed to reduce troubles with papers likely to curl since the sheet breaks slightly over each support roll. Conveying the paper in the tunnel has presented problems. Some installations rely on a felt or woven mesh to support the paper, but drying is retarded, as there is reduced circulation at the underside. When a bar or rod conveyor is used, there must be a speed differential between the paper and the supports, otherwise the pressure of air holds the paper and trouble is caused by local overdrying with cockling, due to the tension, between the overdried strips.

With dual coated paper the method of conveying the wet paper presents no problem, since it must of necessity be supported on air until dry enough. The balance of pressures between the support jets and air circulating on the top side presents many problems and is critical. When the sheet is dry enough to be supported without damage to the coating on the underside, it is passed from the chamber over a suction device and transferred to a rod conveyor.

On those machines needing two heads to coat the two sides, it is usual to have separate tunnels, one above the other in the same structure. This economises in space and construction costs.

Other installations utilise the space above the tunnel dryer for conditioning. Sections are separated and conditions are automatically controlled for temperature and humidity so that the paper is in ideal condition for calendering.

Theoretically there is no limit to the speed at which coatings can be dried in tunnels, but increases in speed and heavier coating weights necessitate greater lengths of tunnel, which means that they can become very costly. In order to minimise this tendency, manufacturers are producing various patented devices. One such invention has a large diameter dryer drum enveloped in a type of evaporating hood. Another method is the use of radiant heat, which is claimed to be cheaper than other types of heating. Plant installation costs for the use of either electricity or gas are low and an interesting case can be put forward.

It seems certain that future developments in drying techniques will make use of much higher temperatures with consequent saving in space.

Calendering

CONDITIONS here are very similar for both converters and on-machine coaters. There is possibly some advantage to converters, because it is already an established procedure in some mills to lead straight through the calender without an intermediate wind-up.

Handling

HANDLING paper at high speeds has received a lot of attention—wind-up equipment is readily available and of course in every day use. For converters, the unwind is more important, for the question of making splices at speeds high enough to keep the coater in production is most important. It is being done by a procedure known as the flying splice.

One attempt to solve the problem of web change is the use of magazines under the dryer. Paper is fed into the magazine in figure-of-eight loops. It is stored there and moved forward on tapes. As the web runs out the magazine is full and the machine continues to draw from it. The splice is made and the storage procedure restarted with a sufficient increase in speed to ensure that the magazine is again full when the web runs out. A similar method can be used for the coated paper when some maturing of the paper can be effected.

discussion

MR. C. G. WALLACE: Have there been any developments in the pigments or the adhesives that give any particular advantages to the off-machine coater over the on-machine coater?

MR. W. A. R. HILTON: The problem of putting it on to paper and drying out is very similar for both processes: what applies in one will often apply in the other. There are differences, of course; various pigments can be used in the thinner colour coating slips that cannot possibly be used in the high solids slips. The off-machine coater might be prepared to make the claim that one or two of his traditional pigments are more suitable, but nothing of a new character.

THE CHAIRMAN: Machine coating naturally treats the web across the full machine deckle, whereas converters are very often content with much narrower deckles on their coating machines. Is there a tendency for the speeds of the latter to be increased to compensate for this? Do the advantages of the result justify what would appear to be the greater expense of off-machine coating?

MR. HILTON: Off-machines can be designed to undertake the full machine width. In general, converters take a narrower sheet, as it is a saving in installation costs and the narrower deckles run with less trouble. Each case must be examined on its merits.

MR. K. C. WEEDY: Regardless of quality, what is the fastest speed today that Mr. Hilton knows of at which off-machine coating is being carried out?

MR. HILTON: I know of no speeds higher than 1 200 ft./min.

MR. P. H. PRIOR: There are obviously very much higher speeds than that, not much far short of 3 000 ft./min.

DR. A. P. TAYLOR: This morning, a speaker referred to weights in on-machine coating of 10–35 g./sq. m. Would Mr. Hilton give us some comparable off-machine figures?

MR. HILTON: It has been claimed that up to 40 g./sq. m. per side can be applied.

MR. E. WALLACE: In my experience, 37 g./sq. m. is the maximum on each side and it is preferable to apply it in two coats. This improves the finish, but, of course, increases costs.

MR. A. A. LAIDLAW: Has Mr. Hilton any observations to make on the use of precoated base paper by converters?

MR. HILTON: Yes, it must be an improvement, but economics must be considered. For some types of coating, it is a necessity, I believe.

MR. C. G. WALLACE: What does the converter want in the way of body paper? So far as I can see, what is required is a comparatively rough finish. If this is suitable for coating by the converters, why go to the trouble of filling up holes with clay before you give it to them? The argument is that having the surface a little rough is, as the painter would say, to give a key for whitewash. If you want a key for whitewash, why smooth it over before you start?

MR. HILTON: A lot will depend on individual requirements. The smoother the surface at the time of application of the final coat, the better finish can be obtained, but the overriding factor is a surface receptive to the coating slip.

THE CHAIRMAN: Could someone explain what makes the coating stick to the paper? There is obviously a very complicated physical system at work.

DR. R. C. ROSE (*written contribution*): When discussing adhesion, it is necessary to distinguish between mechanical and chemical adhesion. Mechanical adhesion depends on keying as exemplified by the keying of plaster to a rough wall and the failure of plaster to stick to smooth surfaces. Chemical adhesion depends on molecular forces, the nature of which is outside the realm of this conference. It is well to remember that a film of water becomes a powerful adhesive when frozen. Chemical adhesion demands intimate contact and will occur only if the solution or dispersion of adhesive 'wets' the substratum; as 'wetting' is a visible effect of molecular forces, this statement does not help in understanding adhesion.

The adhesives used in paper coating depend principally on chemical adhesion and they will stick almost as well to a smooth paper as to a rough paper provided, of course, the surface has not been modified chemically during the smoothing process. One cannot, for example, attribute differences in sticking to a writing paper and sticking to a viscose paper to smoothness, as the two surfaces are chemically different. Even calendering can modify the chemical nature of a surface by bringing substances such as waxes to the surface.

Your chairman referred to the complicated physical changes of adhesives during drying. How right he is! The molecules of adhesives in solution move together and become oriented during drying, so that certain chemical groups of the adhesive are adjacent to the substratum and certain bonds develop. If an aqueous adhesive is frozen and dried in vacuo without thawing, the resulting bond is very weak, no doubt owing to the fact that the molecules of adhesive cannot move during drying. With latices, there is another complication, as latices normally coalesce during drying and there is some evidence that 'flash' drying interferes with coalescing and impairs bonding.

MR. E. WALLACE: Does anyone know of any high temperature (over 150°F) tunnel being used with a satin white furnish and, if so, what is the humidity in the tunnel?

MR. R. S. HESKETH: We should consider 150°F as being a low temperature in our float on the double coater. We are working at an air temperature of nearer 150°C.

MR. R. L. BUCKLEY: I understand the important point about drying coatings containing satin white is that the water of crystallisation of the molecules of satin white begins to disperse at about 80°–90°C (175°–190°F). It is necessary, therefore, to regulate the air temperature in the dryer to prevent the coating temperature rising to this value.

In high efficiency recirculation dryers, working at relatively low humidities (that is, if a considerable quantity of fresh air is introduced into the air circuit), air temperatures in the order of 120°C (250°F) would be quite safe.

My company has manufactured dryers that operate very satisfactorily on mixes containing satin white at temperatures in excess of 150°C (300°F).

MR. J. TWEEDIE: If I may ask Mr. Hilton to assume that he has a machine, say, 120 in. deckle to run at 1 000 ft./min., that he has no coating equivalent whatsoever in that mill and that he finds he has to coat in order to hold the market—will he install on-machine coating equipment or off-machine coating equipment?

MR. HILTON: As we said this morning, every case has to be examined on its merits. With 120 in. deckle —off the machine, I think.

MR. TWEEDIE: Why? I am not a technician, but the economics of these two processes interests me.

Quite frankly, I have seen a number of machines running with machine coating equipment, but I have never yet been in a mill that does off-machine coating. What are the relative labour requirements for each of these processes, what factors are common to the processes and what factors differ radically?

MR. HESKETH: In our mill, we make machine-coated and offmachine-coated papers. The labour required for producing machine-coated paper is less than that for the off-machine. Which process is the better depends on what you are trying to achieve; up to date, the quality of offmachine-coated paper has been higher (as also is the price) and the amount of colour applied is less than with the off-coated process.

MR. C. F. ROBINSON: Papermakers are these days sometimes converters as well and, however desirable it may be technically to coat on-machine, from the point of view of flexibility, it is important to be able to coat bought-in base stock and an off-machine coater therefore becomes essential.

(*continued from page T 246*)

DR. ROSE: This is an interesting method, but I do not think it is used to apply pigments. It demands low viscosity materials.

MR. T. CLAPPERTON: Do all adhesives migrate during drying and does this affect printing properties?

DR. ROSE: Adhesive migration results from low solids and uneven drying. It shows up in printing, because the areas with less adhesive normally absorb more ink.

MR. CLAPPERTON: Does this limit the drying temperature?

DR. ROSE: I think it does. Some mills have tried to use high temperature cylinders after a size press. Felts could not be used, contact was uneven and adhesive migration was serious. The quality of the paper was improved, but output suffered by reducing cylinder temperatures.

DR. WILSON: We have proof that it is not the rate of drying that causes migration of latex, but contact with a hot metal surface.

DR. ROSE: Thank you, I agree. Uneven drying is the basic cause of migration. I did not know that latices would migrate.

MR. N. BURAK: Is the gloss of the coating controlled by coating formulation or machine operation?

DR. ROSE: Supercalendering is the usual means of gloss control, but non-glossing pigments such as grades of barium sulphate and pigments that gloss very readily may be chosen.

MR. GLOVER: Would you agree that the binder migrates into the base paper to some extent and that in no particular coating process can this effect be avoided?

DR. ROSE: If all other things are the same, more fluid adhesives will migrate more than viscous adhesives. The Massey process uses high solids coatings and the starch does not penetrate to the centre of the web. Some penetration is desirable to give good bonding of the coating, but too much migration will leave the surface pigment loose. This is particularly objectionable in offset printing.

MR. MILLAR: We have found that, once a starch is in the sheet, it will migrate to the surface that is in contact with a heated cylinder.

DR. ROSE: I agree that migration in and out occurs during wetting and drying. This is affected by contact with a hot metal surface as Dr. Wilson mentioned earlier.

DEVELOPMENTS IN COATED PAPERS FOR PRINTING

A printer's views on coated papers

N. B. ERSKINE
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GIVEN AT THE EIGHTIETH GENERAL CONFERENCE: ADAM ROOMS, GEORGE HOTEL, EDINBURGH ON 28th OCTOBER 1960, Mr. W. A. GILMOUR IN THE CHAIR

Synopsis

Before the printer decides to use machine-coated or traditionally coated paper, he should ensure that the paper is delivered in the correct condition, as specified on his order. He should also discover the ultimate use of the printed article, as price can affect his decision. The printer should not be frightened by the term machine-coated paper, as the gap in quality between machine-coated and traditionally coated paper has been narrowed within recent years.

Introduction

WE have heard today about the equipment available to mills for the application of coating to paper, the development of machine-coated papers to present day standards and their future prospects. We have also been told about present day techniques of brush coating or traditional coating and about its future developments. As a printer, among a large number of papermakers, I think I should give my definition of machine-coated paper. In machine-coated paper, the body paper is coated on the papermaking machine and therefore contains a substantial amount of moisture when the coating is applied. Even if a second coating is applied at a later date, by a separate machine, this is still considered to be machine-coated. My idea of traditionally coated paper is when the body paper comes off the papermaking machine on to a reel and is coated as a separate operation, usually in a different part of the mill.

After the paper leaves the mill, we printers are responsible for various processes in the course of its journey to the consumer. I often wish that my suppliers were not so far removed from the consumer. Broadly speaking, the three methods of printing most commonly used are—

1. Letterpress
2. Lithography
3. Photogravure

Condition of all coated papers when delivered

BEFORE we can discuss the differences between machine-coated paper and traditionally coated paper, let us examine the condition in which all coated papers should be delivered to the printer.

1. The correct substance and size

You will appreciate that, if paper is not of the correct substance and size, it will be useless; however, if many stock papers are tested, it will be found that the weight per ream is very often heavier or lighter than that ordered.

2. If delivered in sheet form, the paper should be cut square

Why is it impossible for mills to guillotine cut paper square? My definition of squareness of cut is that, when paper is sheeted or jogged, the edges should be straight and at rightangles. You will no doubt agree that there is no excuse for this type of inaccurate work. Paper cut off the square causes innumerable problems to the printer, the binder and the boxmaker. Too often, reams are up to $\frac{3}{8}$ in. short of standard. During the run, when short sheets are encountered, these bleed off the print and partly print on to the cylinder or blanket causing a build-up of ink and a loss in production hours.

3. Sheets should be flat and have no wavy edges

The paper should be uniform in all its properties—that is, its properties should be constant from sheet to sheet and from ream to ream. You will appreciate that flat paper is one of the first requirements for good register. If the edges of the sheets are damper than the centre, a wavy edge will result. When the sheet is printed, this will cause a wrinkle to form from the centre of the sheet to the back edge and the back edge will be compressed laterally (or shortened) as it receives the ink impression and will then return to its original size. The printed image, measured along the back edge, will then be longer than the plate image.

If, on the other hand, the edges are drier than the centre, the sheet will have tight edges and this will result in the printed image measured along the back edge being shorter than the plate image. This shows how important it is to have an even moisture content all over the sheet and this can be achieved only if the paper is in equilibrium with the relative humidity of the press room. Papermakers can do much by controlling the moisture content at which they send the paper out of the mill. A printer also can do a great deal to help with this problem. He should check and keep a record of the humidity of the press rooms, paper store and the warehouse. It is almost certain that, if coated paper without moistureproof wrappers is subject to frequent variations in humidity either while in storage or in removal to the press room, it will develop wavy or tight edges. Moreover, if coated paper is exposed to varying conditions in the press room whilst standing between the printing of consecutive colours, changes in size and shape may occur, with resulting misregister.

Each press room should have its own seven-day recording thermohygrograph, but this will supply the printer with only an approximate continuous record of atmospheric temperature and relative humidity in the press room, whereas, by using the whirling hygrometer, he can supply readings alongside each press. If the relative humidity falls below 40 per cent., the machine-minder can expect trouble from static electricity.

Paper curl is the cause of hundreds of hours of wasted productive time in a year. With modern printing machines capable of producing 30 000 impressions in two colours per 8 hr. shift, it is very often more economical for the printer who is not used to working with machine-coated paper to use traditionally coated art and let the printing machine obtain full production than to use machine-coated paper with the possible result of less production per hour. If paper must curl, I should like to propose that you stop having in the same making some sheets curling up and some curling down.

I appreciate that printers are asking a great deal from the papermaker that paper should be uniform in all its properties from sheet to sheet. Is it not possible when cutting paper on the reel into sheets to keep the cut sheets from each reel separate? This would help to eliminate printing difficulties caused by the variation in the making of paper. When we get paper from various reels mixed, innumerable troubles arise. To give an example we experienced—two sheets from the same ream followed each other on the printing machine and were printed with the same ink on the same day: one dried, the other was still wet weeks later. The printer can do nothing to remedy this situation.

Nevertheless, I congratulate the machine-coated papermakers on the great strides that have been made in the stability of machine-coated papers, especially the paper containing esparto.

4. No dust on the surface or edges, no blemishes such as tears, hard spots, coating lumps, wrinkles and cracks

Dust is caused by coating or fibres lying between the sheets or the edges. This causes bad printing by getting into the ink and on the printing plate. I suggest mills should follow our factory practice of passing a vacuum cleaner over the edges of all coated papers before printing. Even after this treatment, it is amazing the amount of coating dust and fibres that collect on the automatic feeder when coated paper is being printed with its first colour: this is especially the case with one-sided art paper. This necessitates frequent washing up of the blanket and plate in lithographic printing and blocks in letterpress printing. Thus, productive time is lost and it becomes almost impossible to keep colour consistent.

Dealing with blemishes such as tears, hard spots or coating lumps is a problem that only papermakers can solve. It is an undisputed fact that, as incentive schemes in the overhauling department of mills have become universal, slackness has increased. This does not apply only to coated papers, but to all printings, with the possible exception of hand-made papers. The printer can certainly assist by keeping a careful check on the paper when it is being hung before going to press and in the loading of the automatic feeder. In this way, the majority of torn sheets are removed. Hard spots and coating lumps are quite a different matter. If detected before printing, the faulty sheets should be returned to the mill with the packing slip.

We very rarely have trouble with coating lumps in machine-coated paper and I presume that this is one of the advantages of this method of coating. Traditional coaters will have to solve this problem; until they do so, our procedure is to hold the mill financially responsible for the damage caused to the plate and the loss of production. With colour printing, if the yellow is very light in one print on a quad demy sheet, it is difficult for a machine-minder to spot the damage caused by a coating lump; if he misses it, it will be discovered at the end of a day's work when the blocks are washed up. Recently, in our own factory, damage of this nature caused by the slackness of one overhauler in the supplying mill cost them over £100 and disorganised our production schedule for some time.

Wrinkles and cracks do not cause quite so much damage to the printing surface, although loose coating caused by the crack can delay production especially when printing heavier colours. The latter may occur in the handling of the paper after being wrapped. Without a doubt, the most satisfactory method of handling coated paper is to on- and off-load the lorry with a fork lift truck. This involves both the printer and papermaker in the provision of a large quantity of pallets, but eliminates cracking the coating.

5. *As smoothness is of paramount importance the coating should be evenly applied without streaks or patches. With two-sided paper any variation should be negligible. The caliper should not vary by more than ± 5 per cent., using your standard testing method. The surface should not be unduly hard or abrasive.*

The printer's fifth requirement is smoothness. In some ways, this is the hardest for the papermaker to produce, especially with machine-coated paper, though I was delighted to learn from Dr. Rose that, thanks to the development of double coating, we shall be able to purchase a machine-coated paper with a heavier amount of coating. I consider this one of the main challenges that the traditional coater has to face, because there are few types of branded traditionally coated art paper that are perfect, yet they sell in the region of 2*s*. per lb. If the surface of the paper is too hard or abrasive, it can cause excessive wear to the rubber blanket or blocks.

These observations apply to all coated stock papers, even if the printer purchases only one ream from the merchant. If the printer or publisher orders one ton or more of coated paper, the following information should appear on his order—

1. Size, whether coated one or two sides, colour.
2. Substance and number of sheets to the ream.
3. Grain (or machine-direction).
4. Pick resistance.
5. Surface oil absorption.
6. pH value.

If the papermaker has this information and incorporates with them all my observations for stock paper, the mill will receive no complaints from the printer!

Machine or traditionally coated paper?

In this happy position, it is now much easier to examine the future of machine-coated paper and traditionally coated paper. A few years ago, nobody would have acclaimed machine-coated paper as a substitute for traditionally coated paper; yet in the last 15 years, machine-coated paper has encroached into the traditional coated market. This has been achieved by much better quality control during manufacture and, once the machine coating mills reach completely automatic control of the papermaking machine and coating process, the traditional coating market will be largely conquered. Printers used to be frightened of machine-coated paper, because of the troubles they encountered with 'this temperamental material'. These troubles were ink drying and therefore greater possibility of set-off; variation in the surface of the paper; difficulty with static electricity; and greater impression required even to obtain a fair result. A few years ago, our company would not print a three- or four-colour illustration on machine-coated paper using over 120 screen. Today, screen 133 is normal and 150 can be achieved on a sheet size 20 in. × 30 in., if the machine runs at about 2 000 impressions per hr.

At the present time, the printer uses traditionally coated paper for illustrations for technical and educational books. It is also used for prestige advertising, including company annual reports, centenary books and brochures, framing prints and similar work when price is not of paramount importance.

Machine-coated paper is used for magazines, labels, fancy box wraps, house magazines, record sleeves, greetings cards and picture postcards. It is now being used for children's books and junior educational readers.

The public demands better design, quality and value for money. In my opinion, this is justifiable. Why should anybody accept inferior quality and yet pay a high price? It is this challenge that the traditional coaters are failing to meet, possibly partly due to their full order books. If general printers could obtain reasonable delivery of machine-coated papers, especially for making orders in an odd size, traditional coaters would not be in such a happy position. Mr. Hilton stated that anything a machine coater can do, a converter using modern methods can do better. If this is correct, the traditional coater will have to improve his quality and control in manufacture or reduce his price per ton to a level nearer the machine-coated paper containing esparto grass.

Conclusion

THE high cost of labour in the printing industry has forced companies to increase capital expenditure in modern, fast-running, automatic machines. This has increased the management's interest in fast production and highlighted the machine-minders troubles with paper and other materials, especially when production drops by half or quarter of the maximum number of impressions per hr. The demand for gloss inks also puts a greater strain on coated papers. These various difficulties have directed all levels of management to a closer inspection of the material used. Whether you like it or not, the motto of the printing company of the 1960s is *Never trust the paper or the ink.* Before either of these materials reaches the press, samples must be tested. It is only by this method that the printer can avoid trouble and loss of production at machine. This policy is bound to force mills to be stricter in their quality control and it may possibly result in the traditional coater widening the gap in quality between his product and that of his rival, machine-coated paper. If he fails to meet the machine coaters' challenge of price and equal quality (for these must be linked together), the length of time he can hope to remain in business will be in proportion to the productive capacity of the machine-coated mills and the amount of capital the papermaking industry invests in this type of machine.

general discussion

DR. R. C. ROSE: I have enjoyed Mr. Erskine's paper and no one can disagree with his stringent comments on curl, wavy edges, torn sheets, variations in size, off-square and the curse of one different sheet in four or five. I think multi-sheet cutters are an invention of the devil. Mr. Erskine has been complimentary to machine-coated papers and his strong objections are to poor workmanship.

MR. G. F. UNDERHAY: When Mr. Erskine tells us that one end of his printing house has one relative humidity and temperature and the other end has another, I wonder how the problem can be tackled. What are the conditions required?

MR. N. B. ERSKINE: First of all, the relative humidity of the press room in our factory is controlled. When printing fine colour work, we try to control the temperature. We like to keep the temperature about 70°F all the year round. This prevents the atmosphere getting too dry. We can never overcome the difficulty of our climate and one reason for the Swiss producing such beautiful printed work is that their climate is very much more stable than ours.

MR. UNDERHAY: Can you tell us the relative humidity at which you normally prefer to work?

MR. ERSKINE: The humidity is meant to be about 60 per cent.

QUESTIONER 1: Would it not save much time and trouble if Mr. Erskine invested a few thousand pounds in an air conditioning plant for his print house?

MR. ERSKINE: We do hang all our paper. On the jobbing side, we do not hang ordinary uncoated paper, but we do hang all our art paper before going to the machine.

MR. P. H. PRIOR: I think what the questioner means is can you not keep the wet weather out?

QUESTIONER 1: In some papermills, the packing room is air-conditioned. Would it not be possible for you to have the whole room at a constant temperature?

MR. ERSKINE: That would be the ideal condition, but then the paper has to travel from the mill to the printer and I have seen paper arriving in a dreadful condition through the container leaking.

MR. C. G. WALLACE: What is the point of a papermaker producing a paper at, say, 65 per cent. R.H.

and 60°F, if the printer has got his factory one day at 50 per cent. R.H. and 50°F and, at the end of the next month, it is going to be 70 per cent. R.H. and 70°F? What does it matter if the papermaker can wrap it in waterproof wrappers and send it in to the date, if the printer is not going to do his side of the business? Unless the printer holds conditions stable, there is not much the papermaker can do about it.

MR. ERSKINE: I would say our conditions are more or less stable. The paper that you saw on the slides had been hanging for two days in stable conditions. Even when you opened the ream, you could see the curl on it. In fact, we thought that the curl would come out after hanging, but in actual fact it got worse. Can you explain why some of it curled at both edges and some of it curled only at one edge, when it was all one making?

MR. C. G. WALLACE: I imagine that is uneven drying in the actual making, but, assuming that paper goes into your works right, if your conditions are not stable, there is no guarantee that it will stay right. Let us miss out the paper that is wrong at the start. Paper that is right at the start will still go wrong, if your conditions vary while it is there.

MR. ERSKINE: No doubt, but our conditions do not vary all that much.

MR. K. C. WEEDY: If I had known what Mr. Erskine was going to say, I would have brought up with me a report on work that our mobile laboratory carried out a short while ago into this very problem on paper behaviour. It was made on a large firm of printers making multiple stationery who should have known very much better. I may say that the bulk of the fine printings we produce go out in waterproof wrappers, having been overhauled and packed in an air-conditioned cell. The laboratory report showed that at one time there was a 20°F range in temperature between one end of the printing house and the other; moreover, there was a 14 per cent. range in relative humidity—which I would have thought to be virtually impossible. When the paper was brought in waterproof wrappers, having been produced under controlled conditions, some of it was left in its waterproof wrappers and some of it was taken out, stacked overnight and put with others of the right size and weight from a previous run, which might have been anything up to two months ago. You had then three lots of paper being put in the press.

There are two points I want to bring out on what Mr. Erskine said. The best of American offset lithography is as good as anything we can produce in this country, particularly on an all-wood or wood-free offset paper. It is my understanding that the Americans have now virtually cut out any reference to the pH value of the paper and are very rapidly abandoning the oil penetration test as a measure of the printability of paper.

Your figure of £1¾ m. as being invested (represented by the return made by your Scottish printers) is a very considerable sum, but it is only the price of one 40 in. papermachine. In any case, we have to find some better way of overhauling paper; because in a very few years we are not going to get women anywhere in the British Isles to do it. We have completely to rethink how to get rid of broken sheets (which, I must admit, are an appreciable problem for you), without the paper being overhauled.

MR. ERSKINE: I have girls who are overhauling coloured prints and not only have they to look out for misregister and similar faults, but they have got to withdraw any with colour variation and that is just as monotonous a job. I think that the papermills are more likely to find some mechanical method for overhauling. They should be able to obtain an electronic machine that can pick up lumps, etc., but I doubt if we will ever get a machine that can check colour variation.

I am interested in your view about the pH value. If this varies too much, we find that we may get trouble with ink drying. Have the American ink manufacturers devised some new chemical that British ink manufacturers have not got? I do not know, but I am very interested in it.

DR. ROSE: There are two differences between U.S.A. and British conditions that may account for these facts. Heat set inks are widely used in U.S.A. and with such inks oil absorption and pH value are of secondary importance. Secondly, their relative humidity is lower than ours and low relative humidity assists ink drying.

MR. ERSKINE: Regarding heat set ink, we have done a lot of experimental work with another printer using a Timson press for printing diaries and we are getting trouble with ink drying. The paper was tested and was reel-fed. On sending the ink to an independent chemist for analysis, it was found to contain a large quantity of shellac varnish.

QUESTIONER 2: If Mr. Erskine could get a paper with increased receptivity with the possibility of using high printing speeds, would he be interested in paying a high price for it?

MR. ERSKINE: If I could get a paper that was guaranteed perfect I should be prepared to pay anything up to 3*s*. a lb. for it. If we could get maximum production out of our presses, the extra money spent on paper would be well worthwhile.

MR. W. J. STEERS: If there is no air circulation under the hanging rack and if the number of sheets per clip is as high as 250, these could be contributory factors to paper curl.

MR. ERSKINE: There was air circulation underneath. On the question of the number of sheets in a clip, I am told it would be about 125.

DR. ROSE: Mr. Erskine referred to curl of label paper coated on one side. Could label paper not be coated on both sides to balance its composition? I think a coated surface would glue satisfactorily.

MR. ERSKINE: We have spent a lot of time on the question of curl. We even tried putting a very thin coating of clay on the reverse side, but it was not a success. We tried washing the back of the paper at the same time as it was coated on the front, but again that was unsuccessful. On the question of whether two-sided paper would adhere or not, the boxmakers demand a one-sided paper.

MR. P. H. PRIOR: Gentlemen, I am glad that tradition gives me, as Vice-Chairman, the task of proposing this vote of thanks to our speakers, as I think we have had an interesting and very valuable day. I was particularly struck by the way all speakers in turn were describing a progressive rather than static situation. Mr. Haven and Dr. Rose were obviously concerned with developments, while Mr. Hilton, having the task of dealing with the traditional process, showed that he was thinking of how the traditional can adapt itself again to a changing situation. Then Mr. Erskine, having put himself in the lion's den, brought home the ever increasing technical requirements of printers, some of whose machinery shows signs of outrunning the capabilities of present day papers.

We offer all these gentlemen our sincere thanks for what they have given us today.

The cleaning of paper stock
with particular reference to development of a new screen for sisal removal

W. ROBINSON and S. W. KINGSNORTH
The Bowater Research and Development Co. Ltd.

GIVEN AT A MEETING OF LONDON DIVISION: YORK HALL, CAXTON STREET, S.W.1
ON 14th APRIL 1960, Mr. G. THOMPSON IN THE CHAIR

Synopsis

An investigation of the performance of a number of commercial cyclone cleaners on groundwood stock is reported. High grit and dirt removal efficiencies were obtained, but shive removals, measured by the standard British method, were low. The difficulties caused in papermaking and printing by the presence of sisal and similar fibres are considerable, but no known devices remove these fibres effectively. This situation led to the development of a screen for the removal of such long fibres. This screen, which consists essentially of a large rotating drum faced with coarse wire, is self-cleaning and has a large volumetric capacity. It effectively rejects sisal fibres with a very small loss of paper stock.

Introduction

MUCH of the equipment at present used in newsprint mills for stock cleaning has become outdated. In many cases, only a single screening process is used to clean the prepared stock before passing it to the machine flow box. In direct contrast to this state of affairs, an increasing number of ancillary units is available to remove specific types of foreign material and it is possible to visualise a papermachine with several units installed in the system prior to the flow box, each unit designed to remove a specific impurity. Such a system would probably be too expensive to operate and maintain; consequently, managements are faced with the task of deciding on the number and type of cleaning units that their particular machines require. To assist in such decisions in the authors' organisation, a programme of investigation has been carried out during the last few years, in which attention has been paid to the removal of certain troublesome impurities.

Groundwood stock suspensions contain some grit particles from the grinding process, in addition to the proportion of the shives that has passed through the screening system in the groundwood mill. The removal of these unwanted materials has been accomplished in different ways in various mills. The simultaneous removal in one item of equipment has not proved entirely satisfactory, although several cleaning units are available, which will eliminate both grit and shive to varying degrees.

The investigations described in this paper have included a study of high pressure drop cyclone or centrifugal cleaners for shive and grit removal and a more specific investigation of the removal of sisal fibres from paper stock. The investigations started with preliminary laboratory work and quickly passed on to pilot plant scale, on which most of the experiments were carried out. To complete each part of the investigation, the final system was run continuously for sufficiently long periods under conditions closely approaching the estimated full-scale operating conditions.

Cyclone cleaners

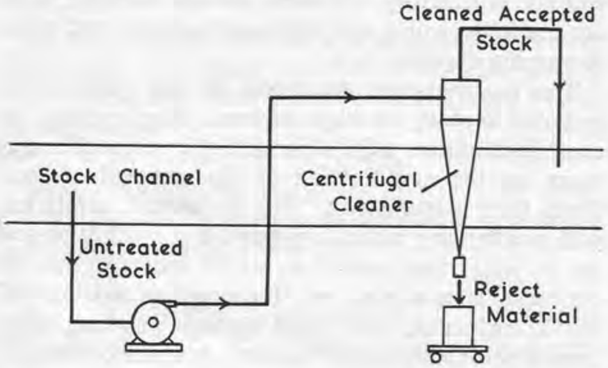
COMMERCIAL units of several different designs were operated on an experimental basis, cleaning freshly prepared groundwood pulp in an integrated mill. During the course of a lengthy period of investigation, a considerable amount of data was collected on the efficiencies of various types of cyclone under a variety of conditions.

Grit removal characteristics

Grit in groundwood is not found as a uniform dispersion, but as a fluctuating occurrence. Rather sharp peaks of greater concentration are superimposed on a background concentration that changes more gradually. These peaks of high grit content can be related to the burring operations carried out on the grindstones. Such local concentrations of grit are carried along with the stock, through the screening system and disperse throughout the stock only gradually.

In the experimental arrangement for the study of centrifugal cleaners, fully screened stock was drawn from the bottom of a long concrete channel by a centrifugal pump, passed through the cyclone and returned to the channel some distance downstream from the pump. This arrangement is shown diagrammatically in Fig. 1. The flow rate in the channel was slow and the pump intake was situated 20–30 ft. along the channel, but the smoothing out of peak grit concentrations in the channel was negligible. On the other hand, the background concentration of grit remained stable over periods of 10–15 min. to within a fraction of 1 per cent.

At first, attempts were made to measure the grit removal efficiency of the cyclones by adding a constant weight of grit continuously to the feed pump and sampling the rejected material over a set time interval.



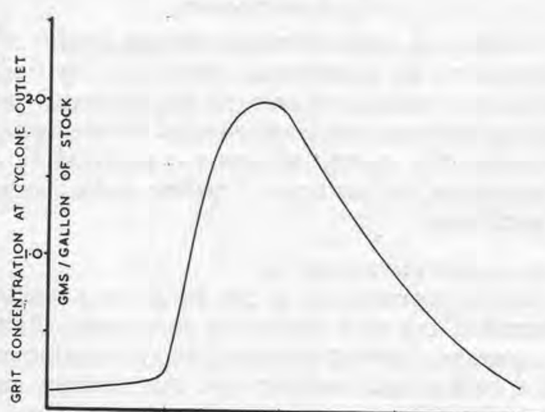


Fig. 1 (*above*)—Experimental arrangement for the study of cyclone cleaners in a groundwood mill

Fig. 2 (*below*)—Change of grit concentration during the addition of a shock dose of carborundum powder

It proved extremely difficult to meter size-graded carborundum with sufficient accuracy and continuous addition was discontinued. Experiments in which single shock doses of carborundum were added to the feed pump showed that the time of passage through the system was extremely small. Fig. 2 shows a typical intensity against time curve for grit added to the pump and measured at a cyclone outlet. The time interval between the addition of the carborundum and the return of the grit concentration to the previous steady value was measured. Rejects from a cyclone were collected over a period in excess of this time interval to provide a safety factor during experiments in which grit removal efficiencies were measured. A separate sampling of rejects immediately before and immediately after each experiment enabled the background grit to be distinguished from the added carborundum.

With each cyclone examined, a series of experiments was performed in which a range of size-graded carborundum powders was used, the average particle sizes being 210 μ (72 mesh), 152 μ (100 mesh), 100 μ (150 mesh), 70 μ (220 mesh), 50 μ (320 mesh) and in some cases 30 μ (500 mesh). Graphs showing the variation of grit rejection efficiency with particle size were drawn for six commercial units (Fig. 3).

From these curves, it can be seen that, while there is a considerable variation in performance with the finer particles, those of 100 μ or greater diameter are rejected with an efficiency as high as 97–99 per cent. by most cleaners. The particle size of the grit normally present in the pulp varies with the type of grindstone being used, but the amount of material with an average diameter of less than 100 μ is in all cases quite small. The better commercial units, it can be seen, will reject a very large proportion of any grit likely to be found in the system and their use should reduce the abrasive wear on various parts of the papermachine and the associated ancillary equipment.

The experimental technique employed in the analysis of the rejected material is of interest. Each experiment required that a volume of 2–20 gal. stock at 1–3 per cent. consistency should be examined for total grit content. This was quite a large sample to ash. The problem was simplified by the use of a small cyclone of 1½ in. diameter machined from aluminium and based broadly on one of the commercial units. Rejected material from the large cyclone was diluted and passed through the small cyclone, where most of the fibre was accepted and the grit and a little fibre were rejected. Usually, each sample was passed twice to reduce any loss of grit with the accepted material, the magnitude of the loss being determined

TABLE 1—SHIVE REMOVAL EFFICIENCIES OF SEVERAL CYCLONE CLEANERS OPERATING AT 0.5–0.6 PER CENT. CONSISTENCY

Cyclone	*No. of determinations*	*Inlet shive, percentage by weight*	*Standard deviation*	*Accept shive, percentage by weight*	*Standard deviation*	*Percentage improvement = (Average inlet — Average accept) / Average inlet*
A	18	0.69	0.20	0.69	0.22	nil
B	5	0.60	0.09	0.59	0.09	1.67
C	27	0.69	0.11	0.61	0.12	11.60
D	28	0.73	0.20	0.73	0.19	nil
E	27	0.64	0.09	0.47	0.08	26.60
F	31	0.72	0.10	0.71	0.09	1.39

in separate experiments for each size of grit used. These results (Fig. 4) indicate the very high efficiency of this small unit.

Shive removal characteristics

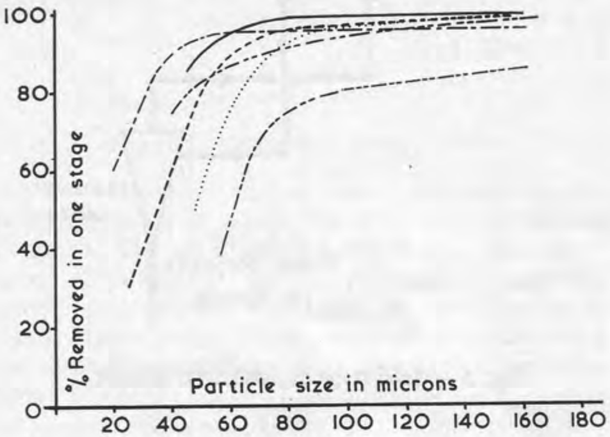
The measurement of shive removal was an easier task, but the improvements effected by cyclones did not reach the levels expected.

Samples of stock were drawn simultaneously from points in the inlet and discharge pipes of the cyclone under examination. These samples were examined for shive content by the standard British method. Improvement in quality was expressed as percentage improvement calculated as—

$$\frac{(\text{Percentage inlet shive} - \text{Percentage accept shive})}{\text{Percentage inlet shive}} \times 100.$$

Numerous determinations were performed on each cyclone and the average results are given in Table 1.

Most of these cyclone cleaners were developed in North America and have been reported to be good shive-removing appliances, therefore this poor shive removal efficiency was surprising. The discrepancy was explained when the interpretation of the term shive was examined. In North America, the shive content of a sheet is measured optically, either mechanically using an electronic counter or manually using a dirt count technique. It appears that results obtained in this fashion are not comparable with those obtained by the standard British method using the Somerville fractionator. Examination of sheets made from the accepted material from a cleaner, which by the standard British method showed little or no decrease in shive content relative to the feed material, showed a marked reduction in the number of surface specks. Attempts were made to measure this reduction in optical shive by a dirt counting technique (TAPPI Standard T213 m-43), but the results obtained



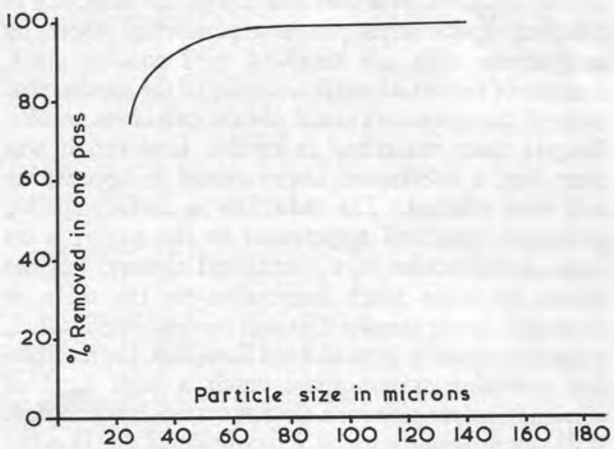


Fig. 4 (*above*)—Particle removal efficiency for six types of centrifugal cleaner

Fig. 3 (*below*)—Particle removal efficiency of 1½ in. diameter experimental cyclone

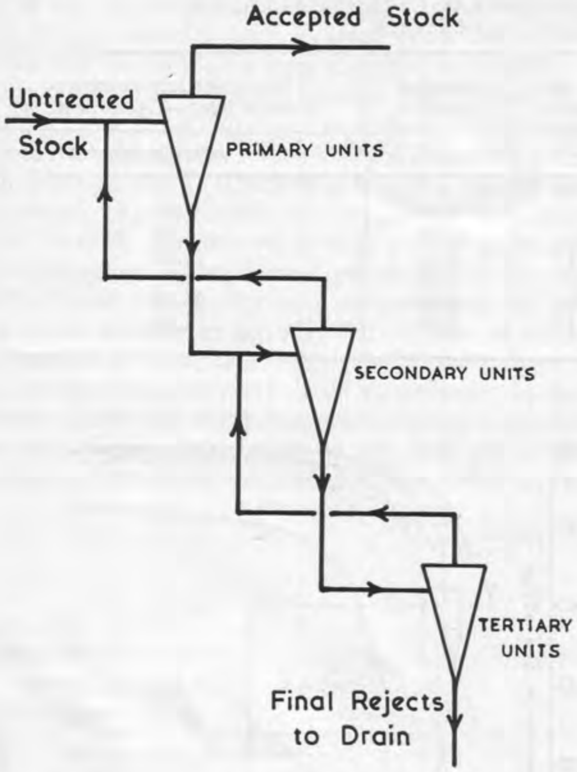


Fig. 5—Multi-stage cyclone arrangement

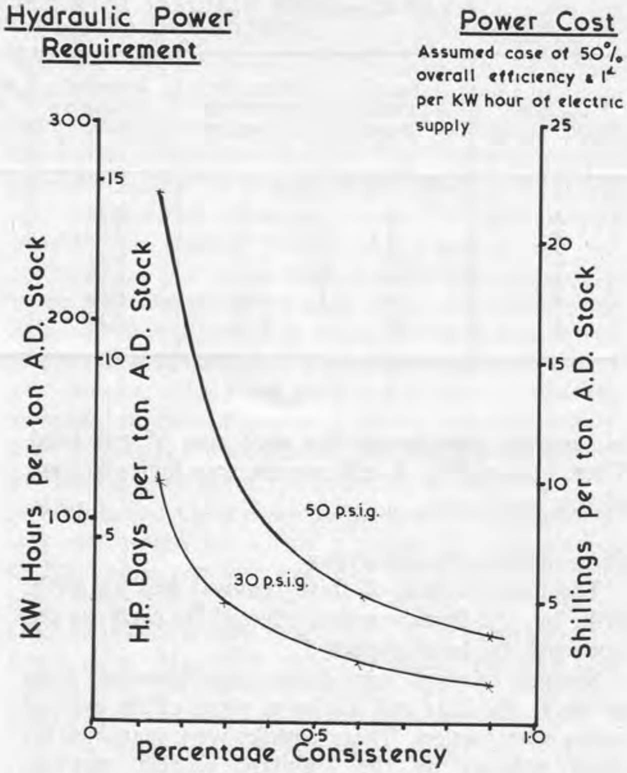


Fig. 6—Variation in power requirement with consistency at two pressures

were not reproducible. Although satisfactory results can be obtained with chemical pulps, the difficulty in counting speck areas on a groundwood sheet by comparison with the standard card was so great, because of the variations in intensity of the specks, that none of the operators could obtain consistent results. Despite these variations in results, however, it was clear that a substantial improvement in appearance had been effected. The reduction in surface specks, giving an improved appearance to the paper, is an important function of a centrifugal cleaner, but the failure to make much impression on the shive as measured by the standard British method implies that, for predominantly groundwood furnishes, the mechanical screening system must reach a high level of efficiency before a cyclone cleaner system is warranted. With this proviso, however, it is considered that in many cases the improvement in grit and dirt removal will be sufficient to justify the installation of these cleaners.

The importance of multi-stage operation of cyclone cleaners to minimise fibre loss has been stressed by users and manufacturers and a typical arrangement is shown in Fig. 5. The most economic arrangement depends on the degree of cleaning required, installation and running costs, etc. and the design of high efficiency cyclone systems is very well covered in a paper by Nuttall and Hendry[1] and will not be considered further here.

A major point to consider when studying the suitability of different types of cyclone for a particular job is that of operating costs. The greatest of these costs is that for electric power required to raise the pressure of the large volume of stock. It is obviously an advantage to use as high a stock consistency as possible, also to select a cleaner that gives the desired amount of cleaning at as low a pressure as possible. The variation in power requirements with consistency and with pressure drop is shown graphically in Fig. 6 for two different cleaners—one operating at 30 lb./sq. in. (gauge) and the other at 50 lb./sq. in. (gauge). The plotted power requirements correspond to the hydraulic pressure drops; therefore, in calculating the electric power consumption, allowances must be made for the pump and motor efficiencies.

The pump efficiencies particularly will vary quite widely according to the circumstances, but, as an example, the power costs have been included in Fig. 6 on the basis of 1*d.* per kWh. of electric supply and 50 per cent. combined pump and motor efficiency—that is, 2*d.* per kWh. of power consumed in the cyclones as hydraulic pressure drop.

Sisal screen development

In most papermills in Great Britain, the difficulties caused by the introduction of small quantities of sisal fibre into the stock system are well known; so much so that the introduction of sisal string into papermills is usually forbidden. Despite these precautions, periodic spells of dry end breaks directly attributable to sisal fibres occur. These outbreaks are often quite severe and much time is lost, both on the papermachines and the printing presses. Apart from these occasions of abnormally frequent breaks, it is found that quite a large proportion of the normal breaks on the papermachines are caused by isolated sisal fibres, hairs or similar long flexible fibres.

As this problem could not be overcome by the use of cyclone cleaners or other known devices, a programme of work was undertaken in the Research Division to devise a method for the removal of long flexible fibres from paper stock, particularly clay-loaded stock containing about two parts of groundwood pulp to one of chemical pulp as the fibrous furnish. Using individual sisal fibres 1 in. long as a representative guide, preliminary experiments were performed on suspensions of paper stock that were passed through stationary wire mesh screens by means of a gravity feed. Mesh size and stock consistency were varied in establishing a screening technique that allowed the long flexible fibres to be retained, while the papermaking fibres—being shorter—were allowed to pass. With these experiments in mind, an approach was made to a firm manufacturing large capacity water screening equipment. As a result of a meeting, the screen manufacturers arranged the loan of a rotary water screen of pilot plant size to enable the promising static method to be developed into a practical continuous process.

The rotary screen (Fig. 7) consisted of a short cylinder 2 ft. in length and 4 ft. 6 in. in diameter, mounted with its axis horizontal and rotated axially with a portion of the cylinder immersed in a collecting tank. The ends of the cylinder were flat steel plate and the walls were open panels supporting a wire mesh. The unscreened stock entered through a hole in the centre of one end and after screening left through

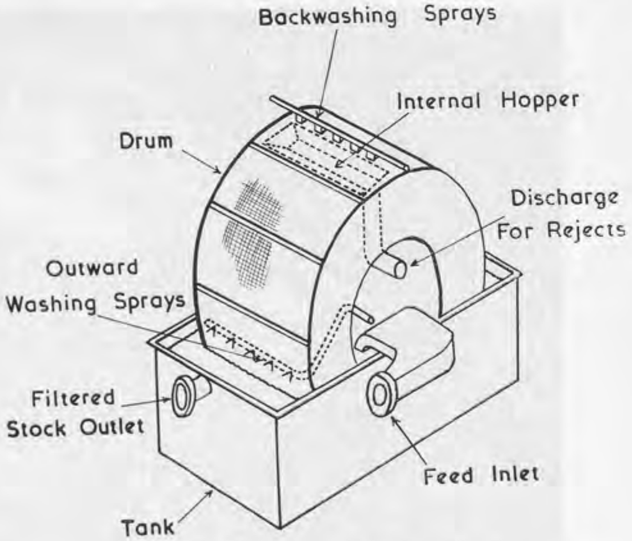


Fig. 7—Experimental rotary screen

the lower part of the cylinder immersed in the collecting tank, in which the level was maintained constant. The drum rotated slowly at a peripheral speed of 40 ft./min. Material retained by the screen adhered to the inside of the mesh and passed upwards to the highest point, where a series of sprays washing the mesh from vertically above dislodged these fibres into a stationary hopper, fixed inside the drum, thence to waste. As received, the mesh attached to the cylinder sides was made up in six panels on rigid frames; an internal elevator or flight was fixed at the join between each panel to lift large objects to the waste hopper. These flights proved to be a major source of fibre loss and were subsequently blanked off with sloping wooden formers.

The original side panels were fitted with woven-wire screens having six meshes to the inch and numerous experiments were carried out with the screen in this form.

The size of the pilot plant screen was large in relation to the ancillary equipment available for normal development work and introduced the difficulty of supplying sufficient stock for a reasonably long run. A recirculation system was arranged, with provision for short duration once-through experiments. In the initial experiments, stock was delivered to the screen at 5 000–6 000 gal./hr. and, during this period, many experiments were carried out to measure sisal fibre removal efficiency and the loss of good fibre with the rejected material. In the experiments measuring sisal fibre rejection efficiency, sisal fibres dyed for identification were added to the centre of the screen with the

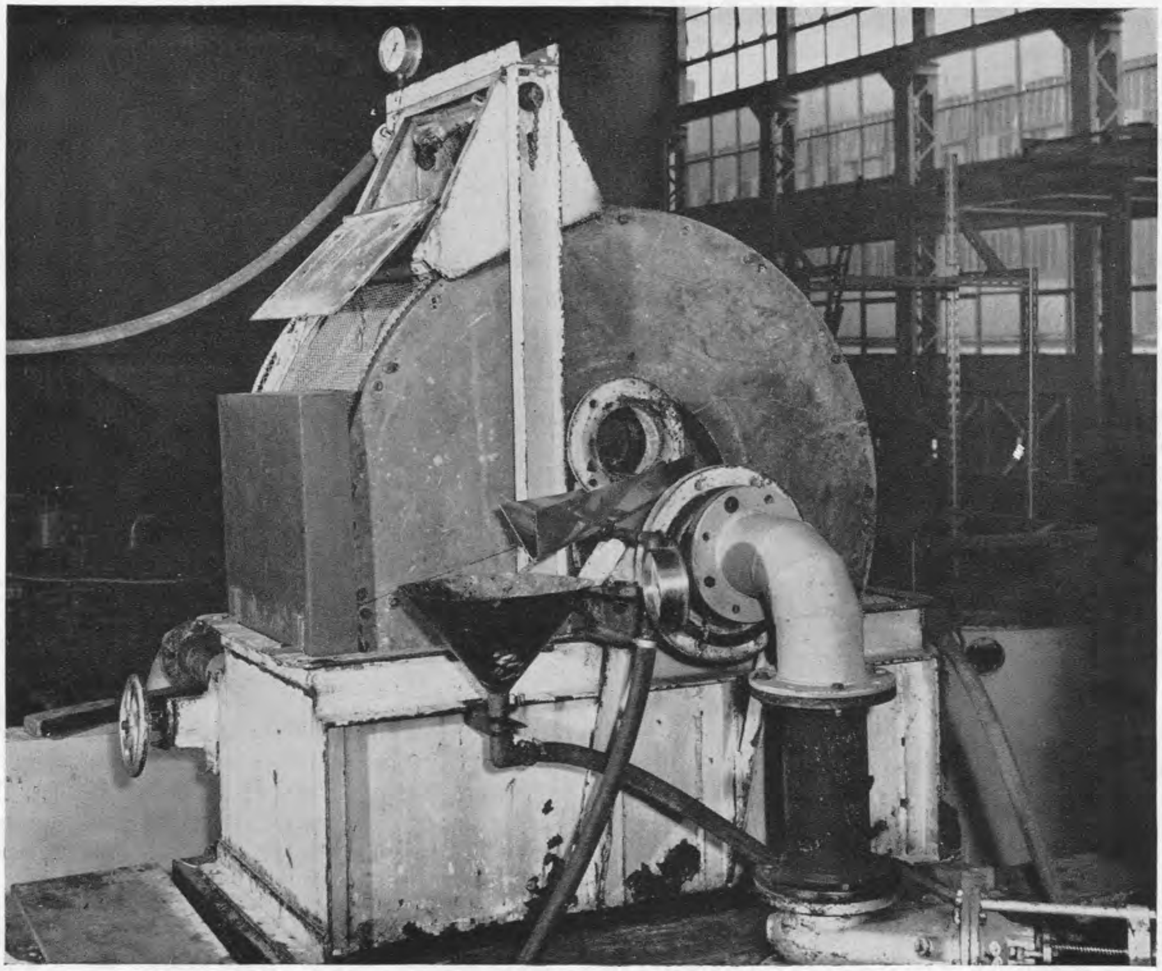
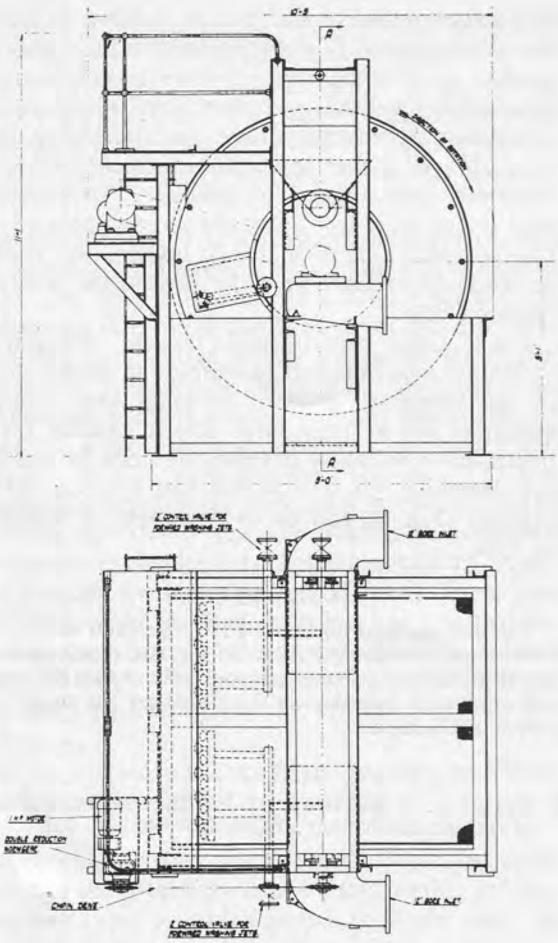


Fig. 8

incoming stock. The fibre from the rejection hopper was collected in a dustbin during the run and examined carefully afterwards for sisal fibres. Usually, twenty fibres were added, cut to a uniform length of either 1 in. or ½ in. An average of over 90 per cent. was recovered with the rejected material or found adhering to the screen caught up behind projections. Using the six mesh screens, the length of sisal fibres added did not appear important from the smallest size used (½ in. long) up to several inches.

At this stage, outward washing sprays were introduced to reduce the fibre loss. A system of sprays was arranged inside the drum to wash the surface of the mesh in an outward direction as it emerged from the tank. These sprays were very effective in reducing the amount of papermaking fibre carried up to the reject hopper. Operating continuously on a recirculation basis using a furnish with a freeness of approximately 100 ml. (Canadian standard), the loss of good fibre was measured at 15–20 lb. oven-dry per ton of oven-dry fibre passed. This was the best condition obtainable with the six mesh screen plates and the outward washing sprays.

Sufficient promise had been shown with the screen in this condition to indicate that the principle was practicable. The main disadvantages at this stage were low capacity and high loss of good fibre. The throughput of the pilot scale screen was limited by the amount of material that the pump could handle—5 000–6 000 gal./hr. at 0.8 per cent. consistency. The screen appeared to be approaching the capacity limit quite closely, however, as the liquid level inside the screen was several inches above that in the trough, indicating a considerable resistance to the flow through



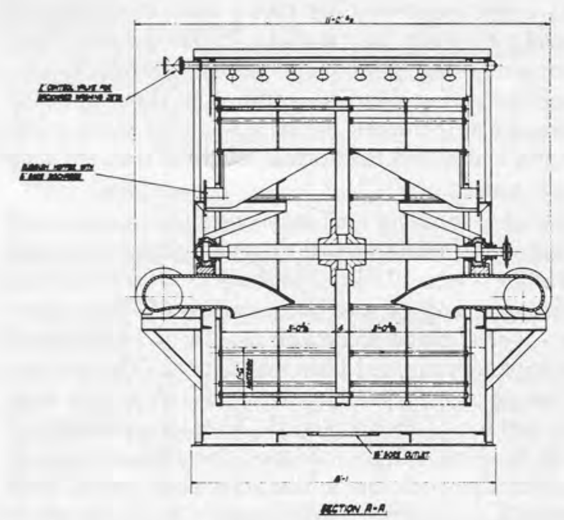


Fig. 9—Double-entry cup type sisal screen in tank—8 ft. diameter × 6 ft. effective width, capacity 250 000 gal./hr.

the mesh. Accordingly, screen panels with four meshes to the inch were fitted, the sprays washing outward were altered from a series of jets to a curtain-type discharge and the pumping capacity was increased to allow the screen to handle 10 000–12 000 gal./hr.

With these modifications, it was found that the sisal rejection efficiency was maintained, while the loss of good fibre was reduced considerably to about 2 lb. per ton oven-dry. When the screen was operated continuously at the maximum pumping capacity of about 12 000 gal./hr., it showed no tendency to accumulate fibre, nor did the very small differential head between the inside and the outside of the screen increase. It was estimated that, in order to be a practicable proposition when scaled up to handle all the dilute stock for a large papermachine, the pilot plant unit should be able to cope satisfactorily with about 25 000 gal./hr.

The screen was returned to the manufacturers for modifications based on the experience gained. The six panels consisting of wire mesh on stout backing wire were discarded and the flat struts joining the ends of the cylinder, to which the panels had been bolted, were replaced by round mild steel strengthening pieces joining the two ends. These steel bars were set back several inches from the circumference of the cylinder to leave the screening surface unobstructed. The six screening panels were replaced by a continuous strip of stout self-supporting wire mesh, three meshes to the inch being selected for these experiments. The outward washing sprays were improved by fitting a superior curtain type of spray system and provision was made for alternative speeds of drum rotation, peripheral speeds of 18, 30 and 42 ft./min. being obtainable.

On receiving the screen after these modifications, the experimental arrangement was altered considerably; larger stock-holding tanks were used and the pumping capacity increased to 25 000 gal./hr. when recirculating and to about 35 000–40 000 gal./hr. for a single pass (Fig. 8). The duration of the single pass experiment was limited by the amount of stock available and 1 min. was the normal length of time for such an experiment.

Sisal fibre recovery efficiency was measured on short single pass experiments and showed a slight drop over the earlier results. Using 1 in. long fibres, the average percentage recovery was in the region of 70 per cent. This was considered acceptable in view of the increased capacity and improved fibre loss figures. The amount of fibre passing to waste was measured at less than 0.5 lb. per ton of fibre screened. The stock consistency would be expected to influence the performance of the screen and therefore at this stage experiments were conducted at various consistencies. With regard to fibre loss, a consistency of 0.8 per cent. was considered to be the highest practicable, although the fibre lost at up to 1 per cent. consistency was not greater than 5 lb./ton. For the stocks examined, the volumetric throughput fell off and the fibre rejected increased at higher consistencies.

After a few more experiments, in which the above figures were confirmed, it was decided to install the screen in a papermill for a short trial. The screen was fitted into the stock delivery system to a papermachine and was arranged so that part of the flow to the flow box screens could be diverted through the rotary sisal screen. A V-notch weir in a smoothing box was attached to the discharge from the sisal screen in order to measure the throughput and the rejects were passed to drain via a fine mesh static screen, which was examined and emptied periodically. Throughout a trial period of a few days, the screen operated continuously at a rate of 30 000–35 000 gal./hr., showing no tendency to make up or to increase the good fibre rejection rate.

From these experimental results, sufficient information was obtained to enable the manufacturers of the screen to prepare drawings and submit a quotation for a single large screen suitable for the treatment of the whole of the dilute stock for one large papermachine. It is expected that a screen of this capacity (Fig. 9) will be in operation in the spring of 1960.

Acknowledgement

The authors wish to thank F. W. Brackett & Co. Ltd., Colchester, for co-operation during the development of this sisal-removing screen and to point out that the process and apparatus described in this paper are the subject of a patent application.

REFERENCE

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discussion

MR. P. H. PRIOR: How much sisal fibre is retained on a commercial screen?

DR. S. W. KINGSNORTH: The pilot plant equipment gave a measured efficiency of 70–80 per cent. retained for fibres of $\frac{3}{4}$ in. or longer.

MR. S. J. WRIGHT: Can you explain how sisal fibres pass through a screen slot 0.020 in. wide, yet are rejected by a wiremesh screen having three wires to the inch—that is, with holes approximately $\frac{5}{16}$ in. square?

MR. W. ROBINSON: This is explained by the different operating principles of the two types of screen. With a slotted screen, fibres that do not pass easily are retained on the slowly revolving screen plate and subjected to a vigorous spraying. Long fibres that are thin enough in cross-sectional area to pass through the slot are washed through, dragged by the flow of spray water into a favourable position with one end in the slot. The open mesh screen retains fibres held flat against the mesh by the pressure of stock flowing through it. Similarly, when passing the spray zone, the flow of spray water coupled with surface tension effects retains the captured fibres in the flat position.

DR. KINGSNORTH: The idea of the open mesh screen was to provide a minimum restriction to the flow of stock. Any fibre on the screen is not subjected to an accelerating drag from the fluid as in the case of a fibre lying on a slotted screen, where the velocity of fluid is very much greater through the small slot areas in the screen plate. Consequently, the fibres lying on a slotted screen are dragged through the small apertures by this increased fluid velocity. The low velocity flow through the open mesh screen, as well as providing this steady pressure holding the captured fibres in place, enables very long fibres passing lengthways through the screen to be captured. These pass with the body of the fluid at such a low rate that the rotating mesh cutting across the direction of flow strikes the long fibres, forcing them into a flat position, where they are held against the screen.

MR. N. C. UNDERWOOD: What quantity and what sort of water is used on the sprays?

MR. ROBINSON: The water is settled machine backwater and the total flow rate is about 10 000 gal./hr., some one third of which passes to drain with the rejected material.

MR. G. F. GLOVER: You mentioned earlier that the shive content of baled pulp tends to decrease—can you explain this?

DR. KINGSNORTH: In baled pulp, the shive content is generally less than in the stock from the head box of a lap-forming machine. This fact has been established repeatedly and the decrease is attributed to the separation during the pressing and subsequent reslushing of the pulp of fairly loosely formed fibre bundles.

MR. GLOVER: In referring to the difference in shive content found by the methods used in North America and those used here, you implied that some kinds of shive do not matter. This is not clear to me.

DR. KINGSNORTH: We believe that the optical methods used in North America measure dirt specks in addition to the woody type of shive, whereas the method used here measures mainly the latter type, which we think is the more serious form from the papermaking point of view. Both types, of course, detract from the appearance of the finished paper.

MR. PRIOR: What the customer sees in the sheet is as important as its roughness. Flat laminae can be seen in a half-tone block, because the ink stands up.

MR. A. G. WHALEY: Existing available cyclone screens have been investigated for the removal of shives and sisal fibres and a new type of screen developed for the removal of sisal fibres. Have commercially available screens that are established in the paper industry been evaluated for sisal removal qualities?

MR. ROBINSON: Both types of pressure screen have been considered, but we have not been able to carry out any practical work with this kind of screen.

DR. KINGSNORTH: These pressure screens are reported to reduce the shive content of the accepted stock in addition to removing heavy grit and trash. They do operate with a high reject volume, however, which requires treating by means of an auxiliary screen of some type. The general shive efficiency of any such system would therefore depend on the combined shive removal characteristics of both units.

MR. A. F. TOUT: One North American mill has said that Centriscreens will not remove sisal fibre.

MR. PRIOR: I appreciate that the information in this paper has been made available to the paper industry. I am interested in the pattern of thinking on the problem. How did the idea of low velocity flow through a large mesh screen develop?

DR. KINGSNORTH: A very senior member of our company recalled that barbed wire had been used in the past to entrain sisal fibres in stock and proposed that we should develop a self-cleaning screen on these lines.

MR. GLOVER: Have you done any work on the effect of size of cyclone and reject orifice on the efficiency of dirt removal?

MR. ROBINSON: A number of different sized units were included in the examinations carried out. These units varied in capacity 75–1 250 gal./min. In each case, the reject orifice size was varied in order to determine the best operating conditions.

MR. TOUT: No vortex cleaner will remove shives that are roughly cylindrical, because they have the same density and ratio of length to diameter as individual fibres: they are therefore inseparable by a gravitational field.

MR. GLOVER: We have found in my company that dirt content is difficult to measure even in chemical pulps, owing to the varying size, shape and density of the impurities.

MR. ROBINSON: A considerable amount of time was spent examining groundwood handsheets prepared from stock before and after passing through a cyclone. The TAPPI standard dirt counting technique and many variations of it were used. Whilst in most cases an improvement in appearance was obvious after passing through the cyclone, the magnitude of this improvement could not be reliably measured using dirt counting techniques.

MR. GLOVER: It is difficult to get different operators to agree on the dirt content of samples of pulp, but very much easier for consistent results to be obtained using a single operator, particularly if the viewing conditions are standardised.

MR. ROBINSON: This is exactly what was found in our laboratories. We noted, however, that even a single operator who produced reasonably consistent results at one session changed his level of assessment after a lapse of several days.

MR. WHALEY: If I understand you correctly, cyclone cleaners are not effective in removing shive from integrated mill pulp. Recently, there has been a large number of installations in groundwood mills in Scandinavia, through which all the production is passed to remove shive. Would you like to comment on this?

MR. ROBINSON: Apart from the high efficiency removal of heavy grit and dirt, the improvement in appearance of pulp after passing through a cyclone system is marked and sufficient to encourage the installation of these systems in mills producing groundwood. The performance of cyclones depends to some extent on the extent of screening that the stock has received. We have found instances of higher shive removal efficiencies when the screening has been less complete. This explanation is possibly applicable to some Scandinavian mills, where a higher proportion of coarser shives at the cyclone inlet would enable the cyclones to show a high efficiency.

MR. T. WALDMEYER: How long did it take to progress from the barbed wire flash of inspiration to the operation of a full-scale screen?

DR. KINGSNORTH: About 18 months.

MR. TOUT: The proportion of laminar shives is higher in an integrated mill pulp than in a non-integrated mill pulp, because there is more soft grit. The main function of a cyclone cleaner is to remove grit rather than shive, which is important in its own right. For instance, in one mill, it was found that on a machine without cyclone cleaners the calender rolls were dulled and needed regrinding after a few months, whereas on a similar machine, fed with the same stock but equipped with cyclone cleaners, the calender rolls were still bright after a year.

MR. PRIOR: What is the difference in operation between two small cyclone cleaners and one large cyclone cleaner of the same total capacity?

MR. ROBINSON: Generally, the smaller cyclones will reject particles of only a slightly higher density than the fluid vehicle with a higher efficiency than the larger cyclones for similar pressure drops across the units. It is, however, rather more expensive to buy and install two small units than one larger unit.

MR. WRIGHT: Has any work been done on the efficiency of cyclone cleaners at different pressures?

MR. ROBINSON: This aspect was covered during our experiments, from which graphs of grit removal efficiency drawn against pressure drop show a falling off in efficiency with reducing pressure drop. Usually, the efficiency decrease is small with only a small reduction in pressure drop, but can become quite marked for considerable pressure decreases.

Beating comparisons between Lampén mills

A. J. WATSON and A. E. CHITTENDEN

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Synopsis

A comparison has been made between two Lampén mills at the Division of Forest Products, C.S.I.R.O. Australia and a Lampén mill at the Tropical Products Institute, London. The T.P.I. mill had two balls and a separate comparison was made using each ball. All handsheet testing was carried out at the Division of Forest Products.

There were no significant differences in performance between the two D.F.P. mills. There were some significant differences between the two balls used in the T.P.I. mill, but these applied only to air resistance, drainage time, fold and freeness and not to the main strength properties.

The between-laboratory comparison showed significant differences in all properties except bulk and fold: however, as the unbeaten comparisons frequently showed significant differences, it was evident that factors other than beating had to be considered. In most cases, the agreement between the laboratories was satisfactory for practical purposes. The stability of performance of the D.F.P. mills is discussed.

The possibility that different types of pulp within the same fibre length group might have different effects on the mill beating surfaces, thus necessitating conditioning of the beating surfaces when changing from one pulp type to another, has been investigated. With a few minor exceptions, no residual beating effects were found when transferring from one pulp type to another.

Introduction

ALTHOUGH the Lampén mill is used widely for the evaluation of chemical pulps, comparatively little attention has been paid to comparing the performance of different mills. Ekstam[1,2] has included Lampén mills amongst the various beating units that have been examined in his extensive comparison of beating equipment, though the very broad coverage attempted in these investigations made it difficult to make a precise comparison between the different Lampén mills.

Comparisons have also been reported by Watson and Smith[3] for two Lampén mills made by the same manufacturer. These comparisons were made at different periods over a number of years and all showed very good agreement between the two mills. A new 10 kg. ball made according to the specifications was also used in one of these mills in place of the ball supplied by the manufacturer. It was found[3] that the use of this ball produced no significant changes in beating characteristics. This was an indication that different Lampén mills could be expected to have similar beating performances, provided close attention was paid to all manufacturing tolerances.

These investigations showed also that the beating performance of a Lampén mill remains stable over a number of years despite almost daily use for the evaluation of a wide range of pulps.

It has been shown[4] that the type of pulp being beaten could modify the beating surfaces of a Lampén mill and it has been found necessary to condition the beating surfaces of a mill that has been used for beating long-fibred pulp before using it for beating short-fibred pulp and vice versa. This is done by making several beatings using the appropriate type of pulp. This procedure has been detailed in the APPITA standard method P202 m–57. [5] In the present paper, a further comparison is described between the two Lampén mills at the Division of Forest Products, C.S.I.R.O. and this has been extended to include the Lampén mill at the Tropical Products Institute.

The possibility that different types of pulp within the same general fibre length group might have different effects on the beating surfaces, thus necessitating conditioning of the mill surfaces when changing from one pulp to another, has also been investigated.

Experimental

Lampén mill comparison

THE general comparison was to be made using the two Lampén mills at the Division of Forest Products (D.F.P.), C.S.I.R.O., Melbourne and a Lampén mill at the Tropical Products Institute (T.P.I.), London. All mills were manufactured in Finland by Ahlstrom.

Mr. Watson is at Division of Forest Products, C.S.I.R.O., Australia
Mr. Chittenden is at Tropical Products Institute, D.S.I.R., London

One of the D.F.P. mills (serial No. 56/1937) has been in general use since 1939 for the evaluation of all types of chemical and semi-chemical pulps. The second mill (serial No. 83/1939) was not used until 1950 and, since then, it has been retained as a reference mill for the beating of eucalypt pulps. The T.P.I. mill (serial No. 60/1937) has been used since 1939 for evaluating a wide range of pulps (mostly chemical). This mill was originally supplied with a 10 kg. ball in 1939, but another was acquired in 1941 from the research laboratory of a large papermaking concern. It is known with certainty that one of these balls (designated ball *A*) has been the only one in continuous use since 1947 at least. The other (designated ball *B*) has been kept solely as a spare during this time. A thorough examination of the records prior to 1947 has failed to yield sufficient evidence to be able to tell which ball was the one originally supplied with the mill. Both balls were used in this comparison.

All comparisons were made using matched samples of commercial eucalypt sulphate pulp. This pulp had been stored as dry lap at 65 per cent. R.H. and 20°C for two years prior to the comparison.

Experimental design and testing

The general plan consisted initially of a comparison between D.F.P. mills 56/1937 and 83/1939 at the Division of Forest Products and between ball *A* and ball *B* in the mill at the Tropical Products Institute. These comparisons were then combined to give a general comparison among the four mills.

All mills were run in with the eucalypt sulphate pulp to condition the surfaces of the ball and housing.[4,5] Beatings were made at 1 125, 4 500, 9 000 and 18 000 rev., using the conditions for the evaluation of eucalypt sulphate pulps given in APPITA standard method P202 m–57.[5]

Four separate evaluations were made with each mill, ball *A* and ball *B* of the T.P.I. mill each being considered as separate mills for this particular investigation. The beating order for each mill followed a Latin square arrangement to avoid bias in the results (*see* Table 1).

The same plan was followed for each mill. A full day was required for each set of beatings—that is, 1 125, 4 500, 9 000 and 18 000 rev. at the Division of Forest Products together with an unbeaten evaluation. Equipment and staff arrangements at the Tropical Products Institute necessitated this same arrangement being spread over two days.

The beating comparison was started on the same date at both laboratories. Handsheets were made according to the APPITA standard method P203 m–57.[6] Distilled water was used for all operations except sheetmaking to ensure a common water supply. Sheetmaking itself is not very sensitive to variations in the mineral content of the process water.[4,7,8] The handsheets were held in a conditioned room at each laboratory (65 per cent. R.H. and 20°C) until all series had been completed. They were then placed in desiccators, over concentrated sulphuric acid, for 24 hr., then placed in metal containers and sealed with moistureproof tape.

The sealed tins at the Tropical Products Institute were forwarded by air mail to the Division of Forest Products. These tins, together with those containing the hand sheets made at the Division, were placed in a conditioned room (65 per cent. R.H. and 20°C) for 24 hr. The containers were then opened and the handsheets tested after a conditioning period of at least 48 hr. Experience has shown that the above procedure ensures that any changes that might take place in the paper during transport and/or storage are common to all samples.

TABLE 1—ORDER OF BEATING USED FOR EACH QUADRUPLICATE SET OF EVALUATIONS FOR EACH LAMPÉN MILL

Day		*1*	*2*	*3*	*4*
Order of beating (Lampén rev.)	I	1 125	4 500	18 000	9 000
	II	9 000	18 000	4 500	1 125
	III	4 500	1 125	9 000	18 000
	IV	18 000	9 000	1 125	4 500

Note—An unbeaten evaluation was included in each daily series
At the T.P.I., each evaluation 'day' series extended over two days

Freeness (C.S.F.) and drainage time were measured at each laboratory following beating and sheet making. The handsheet properties—bulk, burst factor, breaking length, stretch, tear factor, air resistance and fold—were all measured at the Division of Forest Products. Tear factor was measured according to the APPITA standard method P400 M–55 and fold by means of a Köhler-Molin fold tester using an applied load of 800 g. All the other properties mentioned were measured according to the appropriate TAPPI standard method.

Influence of pulps on beating surfaces

This part of the investigation was undertaken at D.F.P. to examine whether any residual beating effects occurred when passing from (*a*) one type of short-fibred chemical pulp to another and (*b*) from one type of long-fibred pulp to another type. The two pulp types in each group were (*a*) unbleached and bleached eucalypt sulphate pulps and (*b*) a pine sulphate and a spruce sulphite pulp.

Experimental design

The first beatings were made using the unbleached and bleached eucalypt sulphate pulps. Both pulps were disintegrated in the British standard disintegrator for 75 000 rev. prior to beating or before sheet formation in the case of the unbeaten evaluations. Beatings were made for 4 500 and 18 000 rev. in the Lampén mill using the conditions set out in APPITA standard method P202 m–57[5] for short-fibred pulps. The same general procedure was used for the second series using the two long-fibred pulps.

The procedure adopted for each group of pulps at any one beating point is given in Table 2. The letters *X* and *Y* in the table refer to the unbleached and bleached sulphate pulps, respectively, for the short-fibred pulp group and to the spruce sulphite and the pine sulphate, respectively, for the long-fibred pulp group. The same procedure was used for both beating points.

The procedure outlined in Table 2 enables a comparison to be made between beatings performed after a similar or a dissimilar type of pulp—that is, beatings I and III on the first day were made with surfaces conditioned to this particular pulp type, whereas beating with II and IV was started on surfaces conditioned to a different type of pulp. Prior to beating I on the first day for each pulp group, the mill surfaces were conditioned by preliminary beatings with the appropriate type of pulp.

The above pattern was repeated for four days, an unbeaten set being included in each daily series. These unbeaten sheets acted as a control on any changes that might occur in sheetmaking and testing procedures.

Sheetmaking and testing procedures were similar to those used in Lampén mill comparison described earlier in this paper. All handsheets made on any one day were also tested within one day.

TABLE 2—ORDER OF BEATING FOR INVESTIGATING RESIDUAL BEATING EFFECTS

(*X and Y refer to the unbleached and bleached pulps, respectively, for the short-fibred pulp group and to spruce sulphite and pine sulphate, respectively, for the long-fibred group: the same procedures were used for the* 4 500 *and* 18 000 *rev. beatings*)

Day		*1*	*2*	*3*	*4*
	I	X	X	X	X
Order of beating	II	Y	Y	Y	Y
	III	Y	Y	Y	Y
	IV	X	X	X	X
		unbeaten	unbeaten	unbeaten	unbeaten
		X	Y	X	Y

Results

Lampén mill comparison

The results obtained from the Lampén mill comparison are given in Table 3, the test values reported being the mean of four individual determinations. The average values for the two D.F.P. mills and for balls *A* and *B* are also given to permit a general comparison between the Division of Forest Products and the Tropical Products Institute. Significant differences that may be used for individual comparisons when analyses showed significant interactions are also shown. When there were no significant interactions, no significant differences are shown; the significance of the main effects is summarised in Table 4 and explained in greater detail below.

Comparison between mills 56/1937 *and* 83/1939—The statistical examination of the results revealed that there were no significant differences between the performances of the two D.F.P. mills for any of the properties investigated over the full range of beating points.

Comparison between balls A and B—There were no significant differences with the T.P.I. mill used with either ball *A* or ball *B* for bulk, stretch, breaking length, burst factor and tear factor. Air resistance and drainage time both showed highly significant differences (1 per cent. level) between the two balls, however, the differences increasing with beating, ball *B* giving the higher values. Fold and freeness both show differences between balls significant at the 5 per cent. level, ball *A* giving the higher value for fold, while ball *B* gave the higher freeness. The statistical analyses of both air resistance and freeness were based on the logarithm of these values. Both the experimental results and $\log_{10}$ of these values are given in Table 3, though the means are restricted to the $\log_{10}$ values.

TABLE 3—COMPARISON BETWEEN D.F.P. LAMPÉN MILLS (56/1937 AND 83/1939) AND T.P.I. LAMPÉN MILL USING BOTH BALL A AND BALL B

(All values are the mean of four separate evaluations)

Property	*Laboratory*	*Mill*	*Beating, rev.*						*Significant difference between 2 means*			
									Between labs. at same beating point		*Between balls A & B at same beating point*	
			0	*1 125*	*4 500*	*9 000*	*18 000*	*Mean*	*5%*	*1%*	*5%*	*1%*
Bulk	D.F.P.	56/1937	1.942	1.738	1.560	1.482	1.392	1.623	0.029	0.038		
		83/1939	1.952	1.730	1.570	1.490	1.415	1.632				
		Mean	1.948	1.734	1.565	1.486	1.404	1.627				
	T.P.I.	A	1.912	1.745	1.590	1.512	1.450	1.642				
		B	1.920	1.732	1.612	1.498	1.425	1.638				
		Mean	1.916	1.739	1.601	1.505	1.438	1.640				
Burst factor	D.F.P.	56/1937	11.8	24.5	44.4	56.9	73.3	42.2				
		83/1939	11.1	25.2	44.5	55.4	74.2	42.1				
		Mean	11.5	24.8	44.4	56.2	73.7	42.1				
	T.P.I.	A	14.0	27.5	47.6	56.8	73.0	43.8				
		B	13.6	27.8	48.2	57.9	74.8	44.4				
		Mean	13.8	27.6	47.9	57.3	73.9	44.1				
Stretch, %	D.F.P.	56/1937	1.38	1.92	2.95	3.75	4.15	2.83	0.25	0.33		
		83/1939	1.30	1.75	2.72	3.45	4.18	2.68				
		Mean	1.34	1.84	2.84	3.60	4.16	2.76				
	T.P.I.	A	1.58	2.48	3.22	3.72	4.38	3.08				
		B	1.55	2.48	3.08	3.68	4.32	3.02				
		Mean	1.56	2.48	3.15	3.70	4.35	3.05				
Breaking length, km.	D.F.P.	56/1937	3.23	5.26	7.88	9.34	10.10	7.16				
		83/1939	3.07	5.18	7.80	8.76	10.31	7.02				
		Mean	3.15	5.22	7.84	9.05	10.20	7.09				
	T.P.I.	A	3.55	5.92	8.10	9.34	10.50	7.48				
		B	3.36	5.71	8.18	9.29	10.70	7.45				
		Mean	3.45	5.82	8.14	9.32	10.60	7.47				
Tear factor	D.F.P.	56/1937	39.4	73.2	95.0	97.6	91.5	79.3	3.8	5.0		
		83/1939	37.2	73.4	93.0	99.6	92.4	79.1				
		Mean	38.3	73.3	94.0	98.6	92.0	79.2				
	T.P.I.	A	45.0	75.4	92.4	96.2	95.9	81.0				
		B	46.0	75.3	94.3	98.4	94.1	81.6				
		Mean	45.5	75.4	93.3	97.3	95.0	81.3				

Comparison between laboratories—Except for fold, all properties showed some significant differences between pulps beaten at the two laboratories (*see* Table 4). Beatings at the Tropical Products Institute were significantly higher for breaking length (1 per cent. level) and burst factor (5 per cent. level) than the mean values for the Division of Forest Products. These differences were consistent for all beating points.

TABLE 3 (*continued*)

Property	Laboratory	Mill	Beating, rev.						Significant difference between 2 means			
									Between labs. at same beating point		*Between balls A & B at same beating point*	
			0	*1 125*	*4 500*	*9 000*	*18 000*	*Mean*	*5%*	*1%*	*5%*	*1%*
Air resistance	D.F.P.	56/1937	1.5	2.5	7.9	27.5	138					
(experimental results and $\log_{10}$ values)			0.18	0.40	0.90	1.44	2.14	1.01	0.09	0.12	0.13	0.18
		83/1939	1.4	2.8	7.8	24.0	158					
			0.15	0.45	0.89	1.38	2.20	1.02				
		Mean	0.16	0.42	0.90	1.41	2.17	1.01				
	T.P.I.	A	1.3	2.0	4.4	11.4	50					
			0.13	0.30	0.65	1.06	1.70	0.77				
		B	1.0	2.2	6.5	19.1	100					
			0.10	0.35	0.81	1.28	2.00	0.91				
		Mean	0.12	0.32	0.73	1.17	1.85	0.84				
Fold	D.F.P.	56/1937	2.6	10.0	79.4	302	1 000					
(experimental results and $\log_{10}$ values)			0.39	1.00	1.90	2.48	3.00	1.75				
		83/1939	2.2	10.5	70.8	316	1 002					
			0.34	1.02	1.85	2.50	3.01	1.74				
		Mean	0.37	1.01	1.87	2.49	3.01	1.75				
	T.P.I.	A	2.8	11.7	74.1	199	724					
			0.44	1.07	1.87	2.30	2.86	1.71				
		B	2.8	12.6	91.2	324	1 230					
			0.44	1.10	1.96	2.51	3.09	1.82				
		Mean	0.44	1.08	1.92	2.40	2.98	1.76				
C.S.F., ml.	D.F.P.	56/1937	386	371	296	206	89	270	25	34	36	48
		83/1939	398	358	301	220	102	276				
		Mean	392	365	299	213	96	273				
	T.P.I.	A	448	480	384	324	190	365				
		B	428	410	368	268	139	322				
		Mean	438	445	376	296	164	344				
Drainage time, sec.	D.F.P.	56/1937	6.0	6.2	6.9	8.6	15.6	8.7	0.8	1.0	1.1	1.4
		83/1939	6.0	6.3	6.8	8.2	14.4	8.4				
		Mean	6.0	6.2	6.9	8.4	15.0	8.5				
	T.P.I.	A	5.0	5.1	5.5	6.2	9.2	6.2				
		B	5.2	5.4	5.9	7.0	12.4	7.2				
		Mean	5.1	5.2	5.7	6.6	10.8	6.7				

Significant differences are shown only when the relevant interaction was found to be significant
The significance of other effects are shown in Table 4 and are discussed under *Results*

If bulk is averaged over all beating points, there are no significant differences between the two laboratories, but reference to Table 3 will show that the differences between means for the two laboratories varies with beating—for example, at the 1 125 and 18 000 rev. beating points, the differences are significant at the 5 per cent. level. The average value for stretch shows highly significant differences between the two lab-

TABLE 4—COMPARISON BETWEEN D.F.P. LAMPÉN MILLS (56/1937 AND 83/1939) AND T.P.I. LAMPÉN MILL USING BALL A AND BALL B

Difference significant at the 5 per cent. level *
Difference significant at the 1 per cent. level **
Difference not significant –

(*The asterisk marks the mill giving the higher value*)

<table>
<tr><th rowspan="3">Property</th><th colspan="4">Mill</th></tr>
<tr><th colspan="2">D.F.P.</th><th colspan="2">T.P.I.</th></tr>
<tr><th>56/1937</th><th>83/1939</th><th>Ball A</th><th>Ball B</th></tr>
<tr><td rowspan="2">Bulk</td><td>–[1]</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td colspan="2">–[2]</td><td colspan="2">–</td></tr>
<tr><td rowspan="2">Burst factor</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td colspan="2"></td><td colspan="2">*</td></tr>
<tr><td rowspan="2">Stretch, %</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td colspan="2"></td><td colspan="2">**</td></tr>
<tr><td rowspan="2">Breaking length, m.</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td colspan="2"></td><td colspan="2">**</td></tr>
<tr><td rowspan="2">Tear factor</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td colspan="2"></td><td colspan="2">*</td></tr>
<tr><td rowspan="2">Air resistance, sec.</td><td>–</td><td>–</td><td></td><td>**</td></tr>
<tr><td colspan="2">**</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Fold</td><td>–</td><td>–</td><td></td><td>*</td></tr>
<tr><td colspan="2">–</td><td colspan="2">–</td></tr>
<tr><td rowspan="2">Freeness, C.S.F.</td><td>–</td><td>–</td><td>*</td><td></td></tr>
<tr><td colspan="2"></td><td colspan="2">**</td></tr>
<tr><td rowspan="2">Drainage time, sec.</td><td>–</td><td>–</td><td></td><td>**</td></tr>
<tr><td colspan="2">**</td><td colspan="2"></td></tr>
</table>

[1] The upper line for each property refers to the within-laboratory comparison—that is, between D.F.P. mills 56/1937 and 83/1939 and between balls *A* and *B* used in the T.P.I. mill

[2] The lower line for each property refers to the between-laboratory comparison

oratories, but this does not hold for all beating points. The position is similar for air resistance, freeness and drainage time. It should be noted that the mean unbeaten values for the two laboratories frequently have significantly different results. This aspect will be discussed in a later section.

Residual beating effects

The results obtained in these investigations at D.F.P. are given in Table 5. A statistical examination of these results does not show any statistically significant differences for the comparison of unbleached eucalypt sulphate and bleached eucalypt sulphate pulps.

The long-fibred pulps did show some statistically significant residual beating effects for the 18 000 rev. beating. Freeness showed highly significant differences (1 per cent. level) for the spruce sulphite pulp when beaten in a mill with the beating surfaces in either the conditioned or unconditioned state. The pine sulphate pulp showed differences, significant at the 5 per cent. level, for both freeness and drainage time. Examination of these results will reveal, however, that these differences are of little practical significance.

Discussion

Comparison between Lampén mills

An examination of the results obtained in the general comparison reveals a number of rather interesting aspects. The two D.F.P. mills gave identical beating performances. This is in keeping with other comparisons made between these two mills in 1950, 1951, 1952 and 1954.[3] The result also substantiated earlier conclusions on the stability of the beating performance of the Lampén mill.[3] Mill 83/1939 has been used only for chemical eucalypt pulp since used in the first comparison in 1950. Mill 56/1937 has been used since 1939 for long- and short-fibred chemical and semi-chemical pulps and has always been used much more extensively than mill 83/1939. Despite these different opportunities for wear, they have shown comparable beating properties in the comparisons made over the past nine years.

Ball *A* and ball *B* showed some differences in beating characteristics, although only air resistance and drainage time showed differences significant at the 1 per cent. level. Examination of the individual air resistance results showed some very low values when using ball *A*. It was observed also that some handsheets contained thin patches; these could have contributed to the low test results. It should be noted that there was no statistically significant difference between the balls for any of the main strength properties.

The comparison between the two laboratories showed significant differences for most of the properties examined. In many cases, however, these differences are at a maximum for the unbeaten test

TABLE 5—EFFECT OF CONDITIONED OR UNCONDITIONED BEATING SURFACES IN A LAMPÉN MILL

on the beating effect of (a) Unbleached eucalypt sulphate pulp and (b) Pine sulphate and spruce sulphite pulps

(All values are the mean of four separate evaluations)

Pulp	*Beating, rev.*	*Condition of surface*	*Bulk*	*Burst factor*	*Stretch, %*	*Breaking length, km.*	*Tear factor*	*Air resistance, sec.*	*Fold, Köhler-Molin*	*Freeness, C.S.F.*	*Drainage time, sec.*
	(a) Unbleached eucalypt and bleached eucalypt sulphate pulps										
Unbleached eucalypt sulphate	4 500	C	1.55	54	3.3	8.5	102	17.8	129	305	6.7
		U	1.54	55	3.1	8.6	104	19.7	141	308	6.4
	18 000	C	1.40	75	4.4	10.9	106	357	1 349	100	16.2
		U	1.40	76	4.4	11.1	101	380	1 584	100	16.0
Bleached eucalypt sulphate	4 500	C	1.51	39	3.3	6.4	73	6.4	32	409	6.0
		U	1.51	38	3.4	6.4	75	6.8	28	410	6.0
	18 000	C	1.33	48	3.6	7.8	65	127	113	130	14.0
		U	1.32	49	3.6	8.1	63	133	144	120	14.6
	(b) Pine sulphate and spruce sulphite pulps										
Pine sulphate	4 500	C	1.64	48	3.6	6.9	159	3.8	1 479	684	5.4
		U	1.66	48	3.4	6.9	162	3.2	1 412	688	5.4
	18 000	C	1.43	68	3.4	9.0	111	214	1 697	252*	8.4*
		U	1.43	69	3.4	9.1	110	192	1 778	266	7.9
Spruce sulphite	4 500	C	1.39	64	3.5	9.2	85	61	977	532	6.2
		U	1.39	63	3.5	9.1	88	59	1 047	538	6.2
	18 000	C	1.22	81	3.7	10.2	68	>20 min.	2 042	91**	33.1
		U	1.22	82	3.8	10.3	67	>20 min.	2 290	79	37.6

C = conditioned mill surface U = unconditioned mill surface

* Differences between conditioned and unconditioned surfaces significant at the 5 per cent. level

** Differences between conditioned and unconditioned surfaces significant at the 1 per cent. level

and it is evident that factors other than the beating characteristics of the mills at each laboratory must be considered. All measurements, with the exception of freeness and drainage time, were made in the one laboratory (D.F.P.) by the same operators using the same equipment; the same standardised procedures were used by both laboratories for beating and sheet formation. The differences in the unbeaten tests can be attributed only to minor variations in equipment and technique during sheetmaking.

It is not possible to separate differences due to these factors from those that might have been associated with the beating equipment. If the differences between the unbeaten values for the various determinations are considered as typical of the variations that occur in sheetmaking and testing between the two laboratories, however, it is evident that most of the differences that could be attributed to differences in the beating equipment are of minor importance. A general examination of the results shows that the agreement between laboratories is satisfactory, for practical purposes, for all strength properties.

The differences in drainage time and freeness between the two laboratories call for comment. As these determinations were made at each of the laboratories when the pulps were beaten, they are not subject to the same control as all the other tests. Both laboratories used the same equipment for these two measurements and every attempt was made to standardise the operating procedure. Even under these conditions, there were highly significant differences in both freeness and drainage time between the two laboratories.

Freeness is sometimes used as a basis for comparison of the performance of different pieces of beating equipment, results being compared either at a common freeness value or by graphical presentation using freeness as one of the ordinates. In the present investigation, in spite of the standardisation of the operating conditions between the two laboratories, there were substantial differences between the freeness values for both the beaten and unbeaten pulps for the two laboratories. It is apparent therefore that the practice of reporting test results using freeness as a reference basis may give rise to misleading results.

Residual beating effects

It is clear from the results that there is no necessity to condition a Lampén mill when changing from an unbleached to a bleached eucalypt pulp and vice versa. As these two very different pulp types had no residual beating effects, it would appear in general that there is no need to condition the beating surfaces of the Lampén mill when changing from one hardwood pulp to another. If a hardwood pulp has any unusual properties, however, it would be advisable to condition the mill prior to evaluation, unless investigation has shown that this action is not required.

A similar picture was obtained with the long-fibred pulps, spruce sulphite and pine sulphate, the few cases when the residual beating effect had any significant influence on the pulp and paper properties being of little practical importance. It would appear that there is little danger of appreciable residual beating effects when changing from one type to another type of long-fibred pulp.

The residual beating effect experienced when changing from long-fibred to short-fibred pulps and vice versa,[4] was demonstrated using pulps with an average fibre length of 1 mm. (hardwood) and 3–4 mm. (softwood). There are no experimental data for pulps with other average fibre length such as bamboo pulps (2 mm.). If evaluation results are required to a high order of accuracy, it would be desirable to condition the Lampén mill surfaces when changing from a pulp in one fibre length range to a pulp of different fibre length, unless experimental work has shown this to be unnecessary.

Acknowledgements

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The use of a large model to study the flow pattern of an open flow box

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Synopsis

Whilst it is generally agreed that tests are not possible on existing flow boxes because of production requirements, work on small scale models is open to criticism because of the lack of knowledge of the necessary scaling factors for flow boxes. This paper describes work carried out on a model that is full scale in every dimension but width. The techniques used are described and the flow patterns and dead spots found are compared with those of a smaller model The use of simple formulae to calculate the drag at evener plates is verified experimentally and the slice is pinpointed as the vital part of the flow box.

Introduction

MANY workers in the paper industry have pointed out that the study of hydraulic models could materially advance our knowledge of papermachine flow boxes. Two papers[1,2] have discussed the physical laws governing the design and operation of models and it is generally accepted that two dimensionless groupings of variables must have identical values for model and prototype. These are respectively—

Reynolds number, $$R = \frac{VL\rho}{\mu} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Froude number, $$F = \frac{V}{gL} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where V = mean velocity of flow,
L = characteristic length,
g = acceleration due to gravity,
ρ = density of fluid,
μ = viscosity of fluid.

Thus, only with a full scale model can the Reynolds and Froude numbers be kept constant and, if smaller models are to be built, one at least of these must vary. Mardon[2] and Shoumatoff[3] have calculated typical Reynolds numbers for particular flow boxes using the concept of hydraulic radius. In this case, Reynolds number is defined as

$$R = V4m\rho/\mu,$$

where m, the hydraulic radius =

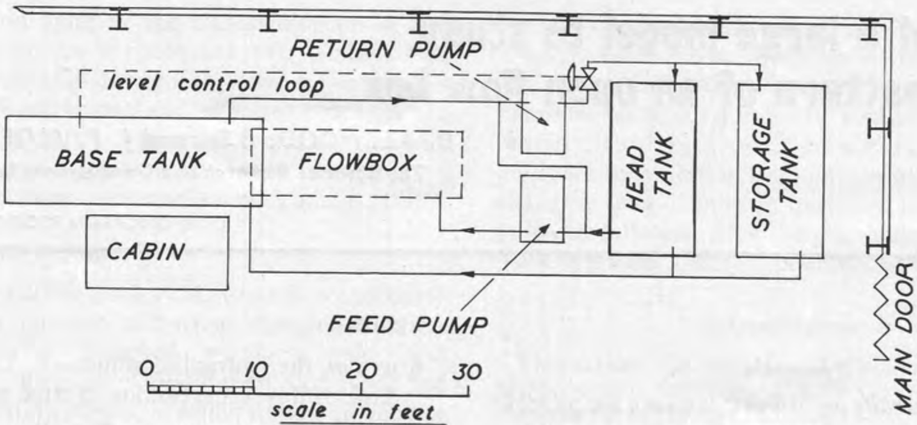
Area of flow cross-section/Wetted perimeter.

[For a circular pipe, $m = \pi D^2/4\pi D = D/4$ and so $R = VD\mu/\pi$.]

Whilst this concept is of great value, it is doubtful whether it needs to be applied to flow boxes. The greater part of the work described in this paper was carried out on a model built full scale in every dimension but width. The width was chosen to be 6 ft. (that is, a scale of $\frac{1}{4}$). Using this concept of hydraulic radius, the model will not maintain Reynolds number constant, excepting if the change in cross-sectional area is proportional to the change in the wetted perimeter (say, at the slice). By definition, the Froude number will be unchanged, because the characteristic length used to calculate the Froude number is the depth of the channel and this was the same as the full scale flow box. From experience gained with models of many sizes, however, cross flows and edge effects do not appear to be serious and it is possible to calculate a Reynolds number for the box from the characteristic length used for the Froude number. It should be noted that the usefulness of this Reynolds number is limited to the particular application and may not be used as a criterion for turbulence until it has been experimentally determined.

Fig. 1 shows the layout of that part of the Development Laboratory at the Research Division of Bowaters at Northfleet set aside for flow box investigations, which was designed and constructed under the supervision of N. C. Underwood, M.Sc. by D. P. Read, Grad. I. Mech. E. The base tank, the header and storage tanks and the associated pumps are regarded as permanent. The space shown between the pumps and base tank is for the model flow boxes and, whilst models of such a size are fairly major items, they are regarded as expendable items.

The layout is so arranged that it may be run on a continuous circulation with the base tank level controlled or by a direct feed from the header tank or by



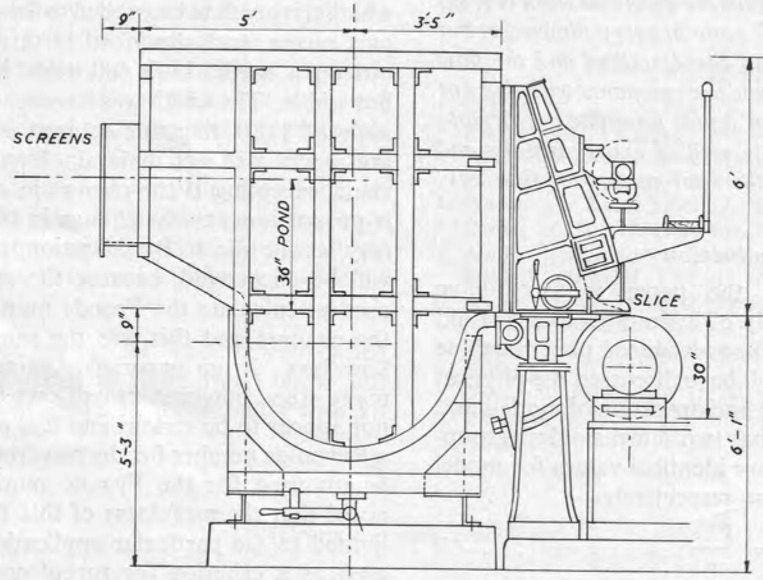


Fig. 1 (*above*) and **Fig. 2** (*below*)

circulation from the base tank. The last two provisions are made for use with stock, when it is desired either to refine the stock no further or to use only a small quantity.

The test rig is adequately instrumented, the instruments being mounted in the control cabin. Flow to the flow box, levels in the flow box and the tanks and the temperature of the fluid are all recorded.

Fig. 2 shows a drawing of the conventional box chosen for the initial study and Fig. 3 shows the model flow box in operation.

Measurement of flow through the model using a propeller

THE speed of flow through even the faster regions inside the model is measured in only inches per second. Since a pitot tube gives less than 0.2 in. head for a flow of 12 in./sec., a more sensitive method of measuring the flow was required and it was decided to use a propeller type flowmeter.[5] The propeller was milled out from a 1 in. diameter methyl methacrylate rod and was mounted in jewelled bearings. A circuit for counting the passage of propeller blades by a non-

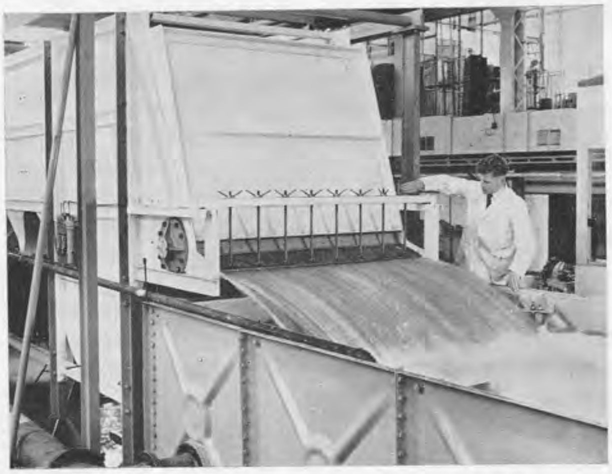


Fig. 3 (*above*) and *Fig. 5* (*below*)

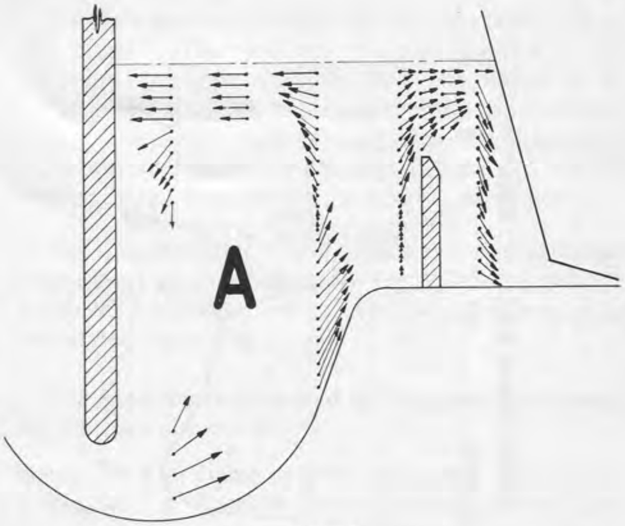


Fig. 4

contact method and followed by a commercial rate meter gave measurements of the flow rate. The propeller was calibrated in a flow channel and the relationship between flow rate and counts was found to be linear for speeds above the lower limit set by bearing friction of 0.5 in./sec. This propeller can be used only in water, but commercial instruments with sealed bearings are now obtainable that will work satisfactorily in stock. The lower limit set by bearing friction is higher, however, than the 0.5 in./sec. obtained with simple bearings.

Plots of the rates of flow through the model, chiefly on the slice side of the midfeather, were made by measuring the flow rates in the horizontal and vertical directions and obtaining the resultant.

Fig. 4 shows the result of a plot taken in a plane drawn through the centre of the model and is typical of the results obtained. The arrows indicate the magnitude and the direction of the flow in the plane of the diagram. Similar plots were taken of the flows across the model, but these were found to be quite small by comparison with the flows through the model and the cross flows are considered to be more characteristic of the type of input used in the model than a fundamental property of this kind of flow box. Similar plots taken through planes closer to the walls of the flow box allowed a complete picture of the flow throughout the model to be built up and an estimation to be made of the edge effects caused by the sides of the model. Even with the cross flow present, edge effects did not extend 1 ft. into the model and thus more than 4 ft. of clear working space was available.

Fig. 4 shows there to be a large dead area just in front of the midfeather and denoted by *A* in the figure. The flow in this region was in fact rotating anti-clockwise. Fig. 5 shows the effect visualised on a small scale model using aluminium powder. This technique[4] has been found most useful. A wooden model of the flow box 1 in. wide and otherwise one sixth scale is cut out and fitted with a clear plastic front. Water is passed through it and, when a stream of aluminium powder in a solution of wetting agent is fed in, the flow pattern can be seen.

In Fig. 5, the exposure was 0.1 sec. and the faster moving areas show up clearly from the dead areas.

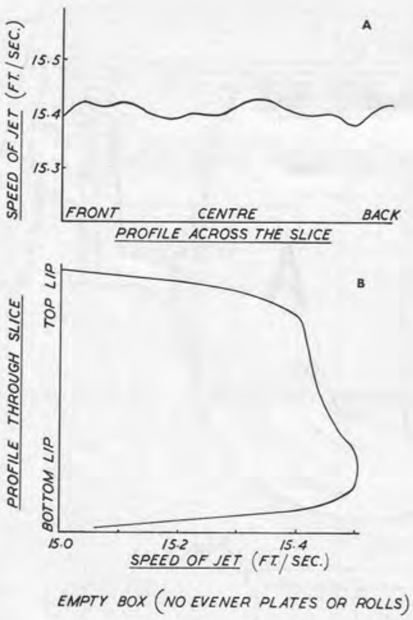


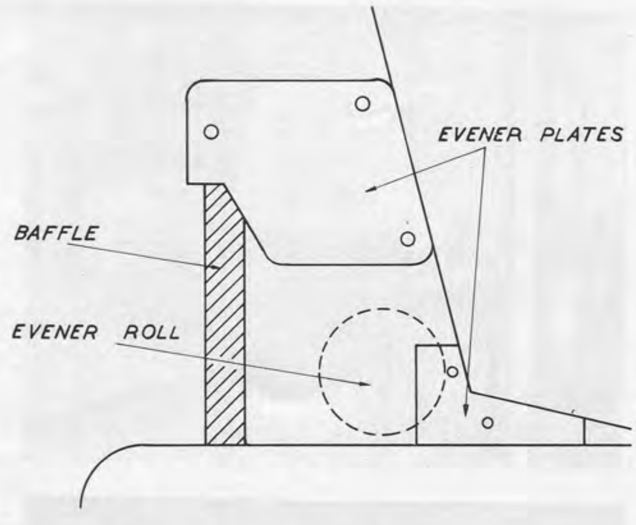
Fig. 6 — (A) and (B)

A very close agreement is found with the propeller plot obtained in the full scale model. This agreement persists with widely varying flow velocities through the small model showing that the Reynolds number used in this work is not critical at least for regions away from the slice. The absence of any spurious effects from the very small width of these models also shows that the concept of the hydraulic radius is not vital in this particular work.

Once this close agreement that justifies the use of these small models has been established, modifications to the baffles, etc. can be tried out easily and quickly on the small model, also a reasonable prediction of the effect of similar changes on a large model can be made.

Measurements of flow from the slice using a pitot tube

To obtain a uniform sheet of paper from a particular flow box, stock must leave the slice in a uniform manner. Measurements were therefore made on the slice jet to find how evenly the water was leaving the slice and whether, for instance, it was flowing faster out of one side than the other. Theory, as expressed by Bernoullis equation, states that the velocity out of the slice will be dependent only on the head above the slice, the input velocity to the region of the slice and



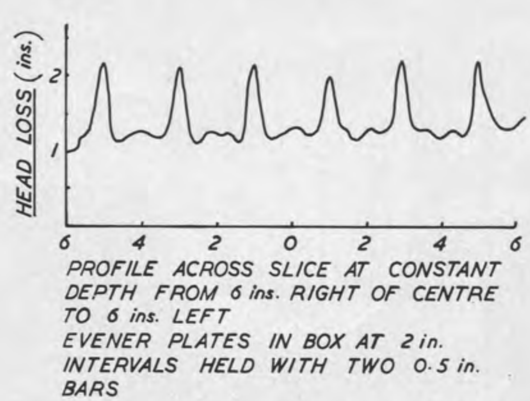


Fig. 7 (*above*) and **Fig. 9** (*below*)

the drag caused by any obstacles in the direction of the flow. This may be written in the form—

$$V_S^2 - V_B^2 = 2gH - f(D)$$

where V_S = velocity of flow from the slice,
V_B = velocity of flow in the box,
H = head in the box,
$f(D)$ = head loss due to frictional drag on sides of the box, evener plates, etc.

Now, $V_S = 15$ ft./sec. and $V_B < 1$ ft./sec., so $V_S^2 \gg V_B^2$ and the equation reduces to $V_S^2 = 2gh - f(D)$.

The measurements showed Bernoullis equation to hold in that the input velocity did not add a measurable component to the speed of flow. The speed at different points across the slice was substantially constant—*see* Fig. 6(A), which is a plot of the speed changes across the slice when the pitot tube was traversed at a constant depth. The velocity was found to increase towards the bottom of the slice, chiefly owing to the increased head, but partly because of the lower friction drag of the bottom lip—*see* Fig. 6(*B*). The head loss from the friction at the slice was approximately 0.5 in. in a total head of 45 in. Thus, the velocity discharge coefficient of the slice is almost unity and, if water is assumed to be incompressible, the volume discharge coefficient must also be unity. It is most certainly not the 1.2 or 1.3 necessary to account for the weight of the sheet actually made on a newsprint machine. The solution to this anomaly, which has given rise to the idea that to some appreciable extent the input speed to the flow box adds to the speed out of the slice, seems to be due to the fact that when the box is filled and running the slice opens out by as much as 50 per cent. Although the opening of the slice was set at 0.5 in. along its length with the box empty, when the box was filled, this was in places nearer 0.75 in., the larger open area permitting the greater flow without the need for a greater speed.

It is possible to calculate the drag expected from evener plates and their connecting bars shown in Fig. 7—*see* Appendix. The next step therefore was to see how accurately these idealised calculations agreed with drag measured on the model and various arrangements of evener plates and support bars were tried with this in view.

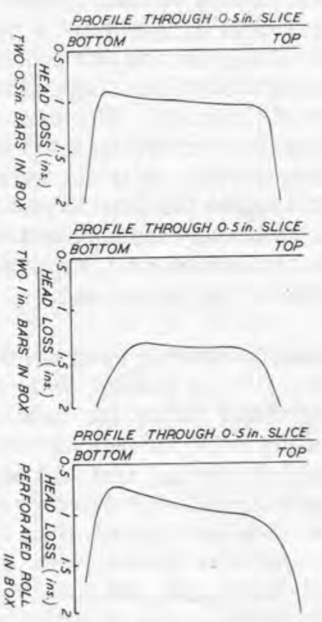


Fig. 8

The experimental results are shown graphically in Fig. 8 and 9. The head loss (at a mean head of 45 in.) with no obstructions in the box was found to be 0.5 in. The drag of the evener plates is obviously compounded from that of the plates and supporting bars and so not only were tests carried out on the evener plates, but also on the support bars alone.

The drag from one evener plate was found to extend over about 0.3 in. of slice (*see* Fig. 9) and an average value of 2 in. was obtained for the head loss. The calculated value was 2.3 in.

The head losses measured by the pitot tube caused by the bars alone were—

0.9 in. for ½ in. diameter bars—calculated value 0.8 in.
1.4 in. for 1 in. diameter bars—calculated value 1.5 in.

Considering the approximations made in the calculations, the experimental results are in reasonable agreement with the theoretical results and justify the use of simple calculations to determine the effects of obstructions in a flow box. It will be noticed that the losses in the pitot head are still very small and the velocity discharge coefficient is still nearly unity.

No calculation has been attempted for an evener roll because of the very large number of unknown variables associated with it. Measurements using a pitot tube have been made of the head loss caused by a stationary evener roll just behind the slice (*see* Fig. 8) and once again, as might be expected, the total head loss remained quite small and amounted to 0.4 in. in the 45 in. head.

Using a differential pressure recorder capable of measuring extremely small differences, attempts have been made to detect the positions of the holes in the evener roll by the change in speed of the jet at the slice when the roll was moved. Owing to minute fluctuations in the head lasting for a few seconds, it was necessary to record the pressure between the static head in the model and the pitot head for about 20 min., then to rotate the evener roll slightly whilst disturbing nothing else and to record for a further 20 min. No significant difference between the means of such measurements was ever found and, since a change of less than 0.05 in. could have been detected by this technique, the effect of the individual holes of a stationary evener roll in the jet must be exceedingly small. The effect of rotating the evener roll remains to be studied.

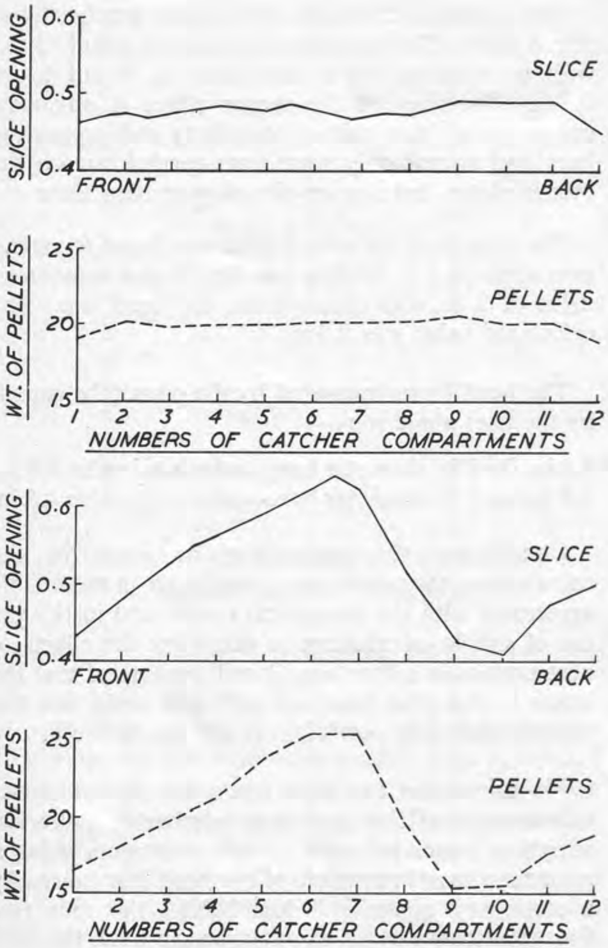


Fig. **10** — (*a*) and (*b*)

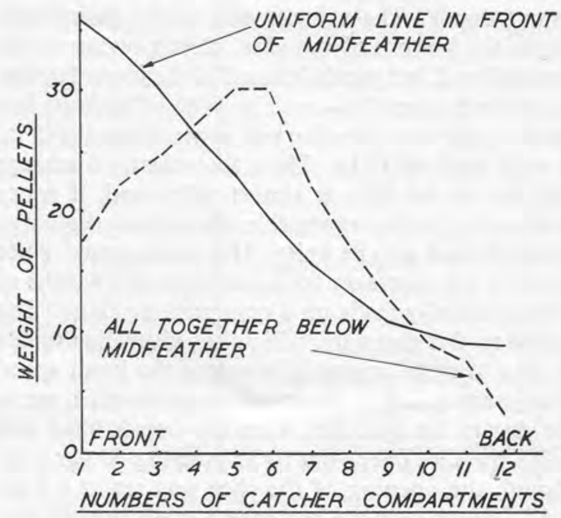


Fig. 11

The use of polystyrene pellets for volume measurements

THE pitot tube measurements show that the speed of flow out of the slice is virtually constant across the length and through the depth of the slice. Therefore, if the slice is opened to a uniform width, one would expect equal quantities of water to flow out of equal sections of the slice. By using polystyrene pellets as tracers, it is possible to check whether or not this is so. A check is considered essential, because of the large changes in the basis weight profile of the sheet, measured with a beta-gauge, for the disproportionately small changes made in the slice opening. A photographic technique using polystyrene pellets as flow tracers has been used in other industries for some time.[6] The properties of the pellets (which are roughly spherical, 1 mm. diameter and which have a density almost equal to unity owing to the minute air bubbles present in the polystyrene) lend themselves readily to flow tracing work. In our case, we were less interested in the path of any particular pellet than in the general motion of many pellets. Pellets were put into the inlet to the pump for a period of about 20 sec., some 250 g. (or 250 000 pellets) being used. They were collected again in a special catcher as they left the slice of the model. This catcher, which was fastened to the slice, was divided into twelve 6 in. wide compartments, two sides of which were covered with machine wire to allow the water to pass through. The pellets collected in every compartment were dried and weighed, the total loss in every experiment being less than 5 per cent. of the pellets used.

Initially, the slice opening was made 0.5 in. along its length as accurately as possible whilst the water was flowing. Fig. 10(*a*) shows the quantity of pellets collected. In Fig. 10(*b*), the slice has been deliberately distorted and it can be seen that a 10 per cent. change in the pellets collected is produced by a 10 per cent. change in the slice opening and, since the pellets had a uniform input distribution, with the pitot tube results, these results are particularly important and show that the accurate control of the slice opening is vital for good control of the basis weight profile.

Polystyrene pellets have also been added at different points through the model with a view to measuring the cross flows: Fig. 11 gives two examples of this. One graph shows that pellets put in uniformly across the box just in front of the midfeather tend to move towards the front side of the box as was expected from the work with the propeller flowmeter. The other graph shows that pellets put in together below the centre of the midfeather follow a similar distribution with less accumulation towards the front side, because of the central input. As mentioned previously, these cross flows are believed to be peculiar to this particular model with this particular input. In this connection, by collecting only the pellets leaving the slice during a chosen period, information has been obtained about the different hold-up times in the box for water emerging from different points of the slice.

Conclusion

ALL these experiments show that the velocity of the jet at the slice is adequately explained by the hydrostatic head behind the slice and that with a perfectly parallel slice opening a uniform sheet of paper should be produced. Naturally, turbulence will affect small scale variations and formation and these effects remain to be investigated.

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(*Appendix overleaf*

Appendix

THE head loss from a bar in the flow can be calculated as follows.

The energy per second to overcome the drag force on a round bar of unit length is given by the formula*—

$$E_D = \tfrac{1}{2}\rho V_B^3 d C_D \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where ρ = density of fluid,
V_B = speed of fluid past the bar,
d = diameter of bar,
C_D = drag coefficient
[0.9 in the cases considered]

The energy loss per second at the slice per unit length caused by the bar can be found from the change in speed at the slice, so that—

$$E = \tfrac{1}{2} M_1 V_1^2 - \tfrac{1}{2} M_2 V_2^2,$$

where V_2 and V_1 are the speeds with and without bars and M_2 and M_1 the masses of liquid flowing with and without bars.

Take $M_1 = \rho t V_1$, where t = slice opening

and $V_1^2 = 2gh$ for the pitot tube,

then
$$E = \tfrac{1}{2}\rho t V_1^3 - \tfrac{1}{2}\rho t V_2^3$$
$$= \tfrac{1}{2}\rho t [(2g h_1)^{3/2} - (2g h_2)^{3/2}] \quad . \quad (2)$$

Equating (*1*) and (*2*)—

$$\tfrac{1}{2}\rho V_B^3 d C_D = \tfrac{1}{2}\rho t [(2g h_1)^{3/2} - (2g h_2)^{3/2}]$$

Therefore, $h_1^{3/2} - h_2^{3/2} = V_B^3 d C_D / 2\sqrt{2}\, t g^{3/2}$.

Let $h_1 = h_2 + \delta h$, where δh is small,

then $\tfrac{3}{2}\delta h\, h_2^{1/2} = V_B^3 d C_D / 2\sqrt{2}\, t g^{3/2}$

Therefore, $\delta h = V_B^3 d C_D / 3\sqrt{2}\, t \sqrt{h_2}\, g^{3/2}$

and $V_2 = \sqrt{2g h_2}$

so that $\delta h = V_B^3 d C_D / 3 V_2 t g$

[FOR A ROUND BAR]

The head loss from an evener plate can be calculated as follows. The energy per second to overcome the drag force on an evener plate is given by the formula*—

$$E_D = \tfrac{1}{2}\rho V_P^3 (2A) C_D,$$

where V_P = the speed of flow past the plate,
A = the area of plate,
C_D = drag coefficient = $0.74\, Re^{-1/5}$
(calculation of *Re* given below)

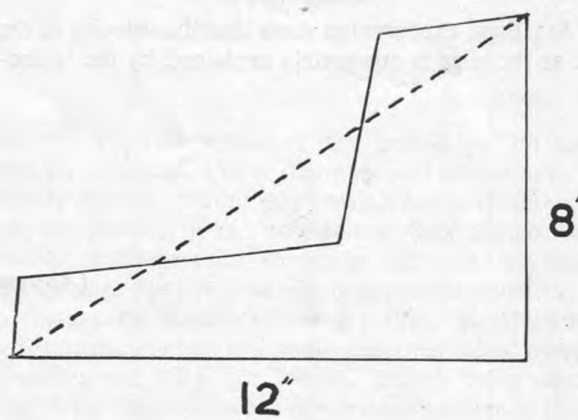
Equating the loss in energy as previously, we get—

$$\delta h = \tfrac{2}{3} . V_P^3 A C_D / V_2 t g P$$

[FOR AN EVENER PLATE]

Here, P is the distance across the slice over which the effect of the evener plate extends.

CALCULATION OF C_D FOR A SMALL EVENER PLATE



Consider the plate approximated to by the triangle. Take 12 in. as the characteristic length and the mean speed past the plate V_P as that two thirds of the way along the plate.

Then $Re = V L \rho/\mu = 2.03 \times 10^5$

and $C_D = 0.74\, Re^{-1/5} = 0.064$.

* These formulae are found in *Modern Developments in Fluid Dynamics*, Goldstein

D. Borruso

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

Pulp and Paper Research Institute
(Stazione Sperimentale Cellulosa e Carta), Milan, Italy

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

Summary

Seven different strawpulps (four prepared in the laboratory from Italian wheat straw and three received from Dutch pulpmills) were used to investigate the influence of the non-fibrous fraction on beating rate and physical and mechanical properties. Since no large differences were found within the two groups, two extra pulps were prepared from straw in the laboratory. In one case, monosulphite buffered with caustic soda was used as cooking liquor; in the other, a soda cook followed a mild aqueous prehydrolysis.

The two pulps and their fibrous fractions (65 per cent.) were examined for—

- (*a*) *Fibre length distribution, drainage characteristics and initial wet strength against beating time.*
- (*b*) *Breaking length, tear, folding endurance, opacity, density and permeability against drainage characteristics.*

From the results obtained in this investigation, it is possible to draw the following conclusions—

1. *The drainage characteristics of the strawpulp are adversely affected by the non-fibrous fraction.*
2. *The presence of the non-fibrous fraction is favourable, at the beginning of the beating, to the formation of a drier wet web with better initial wet strength.*
3. *The strength properties of strawpulp are adversely affected by the presence of the non-fibrous fraction.*
4. *Density and opacity of the sheet are not affected by the non-fibrous fraction.*
5. *For strawpulp, the freeness test does not represent a significant measure of the beating of the pulp.*

Introduction

DURING the last ten years, some work has been done on the characteristics of European wheat straw pulps obtained by monosulphite, sulphate and chlorine gas pulping processes. This work showed that strawpulps, which are particularly rich in hemicelluloses, wet up very rapidly in the beater and, generally speaking, can also produce papers with good physical and mechanical properties. Therefore, it is to be hoped that they may find a broader use in papermaking.

Discussions relating to various aspects of the papermaking properties of strawpulps are found in papers by van Nederveen and his co-workers,[1,2] Brecht,[3,4] Marton and others,[5] Vámos,[6] Schönberg,[7] Ivanov.[8]

During this period, the characteristics of wheat strawpulps, produced in our country, were thoroughly evaluated at our Institute. Actually, we did not try to stress the importance of physical and mechanical properties as much as to investigate the aspects arising from the fibrous composition of strawpulps. In fact, this material may contain even as much as 40 per cent. of non-fibrous particles and very short fibres, with 60 per cent. of bast fibres.

We deemed it advisable that a more careful and accurate study of the strawpulps from this point of view would have led us to a better understanding of this material and consequently to an improvement of its final use.

Fig. 1 shows some results obtained during our first experiments with wheat straw pulps produced in the Italian mills. In each graph, the curves show the behaviour of the whole pulp related to its fibrous fractions. If we examine the influence of beating on the drainage factor, we see that for the fibrous fraction the specific surface development is similar to that of strong woodpulp, but for the whole pulp, which before beating displays poorer drainage characteristics, the

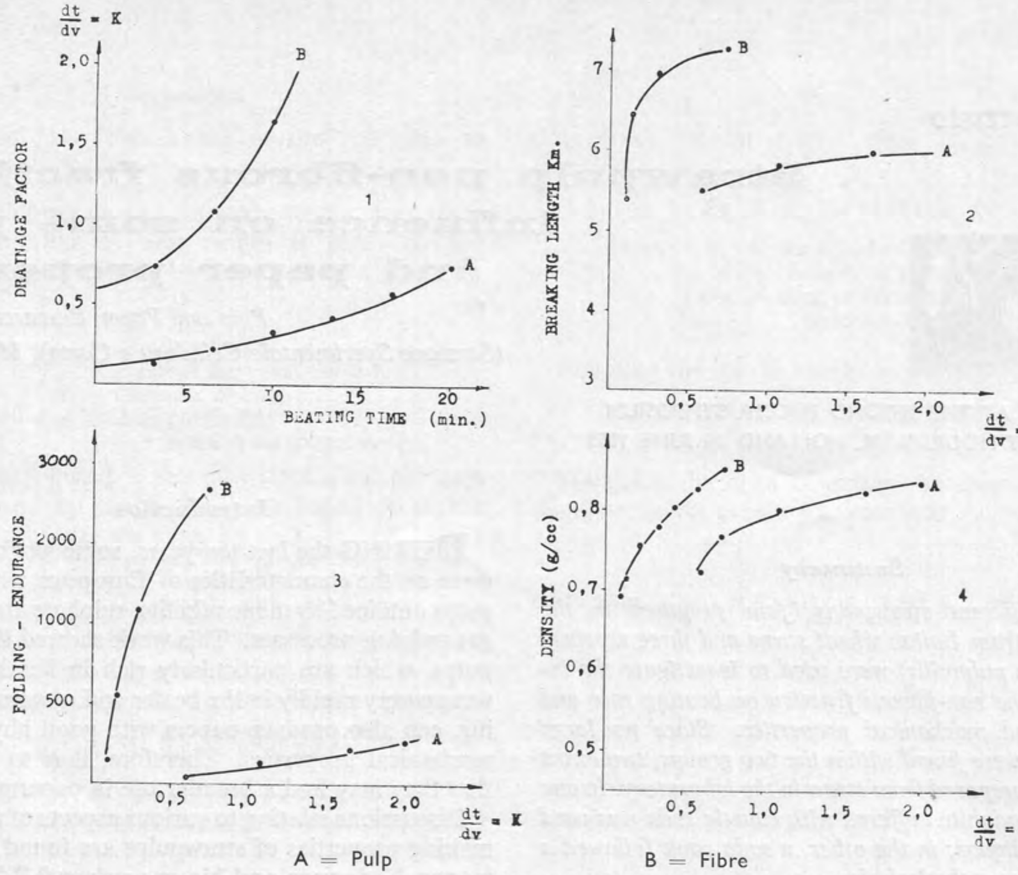


Fig. 1 — Italian (chlorine) strawpulp—drainage factor plotted against beating time; breaking length, fold endurance and density plotted against drainage factor

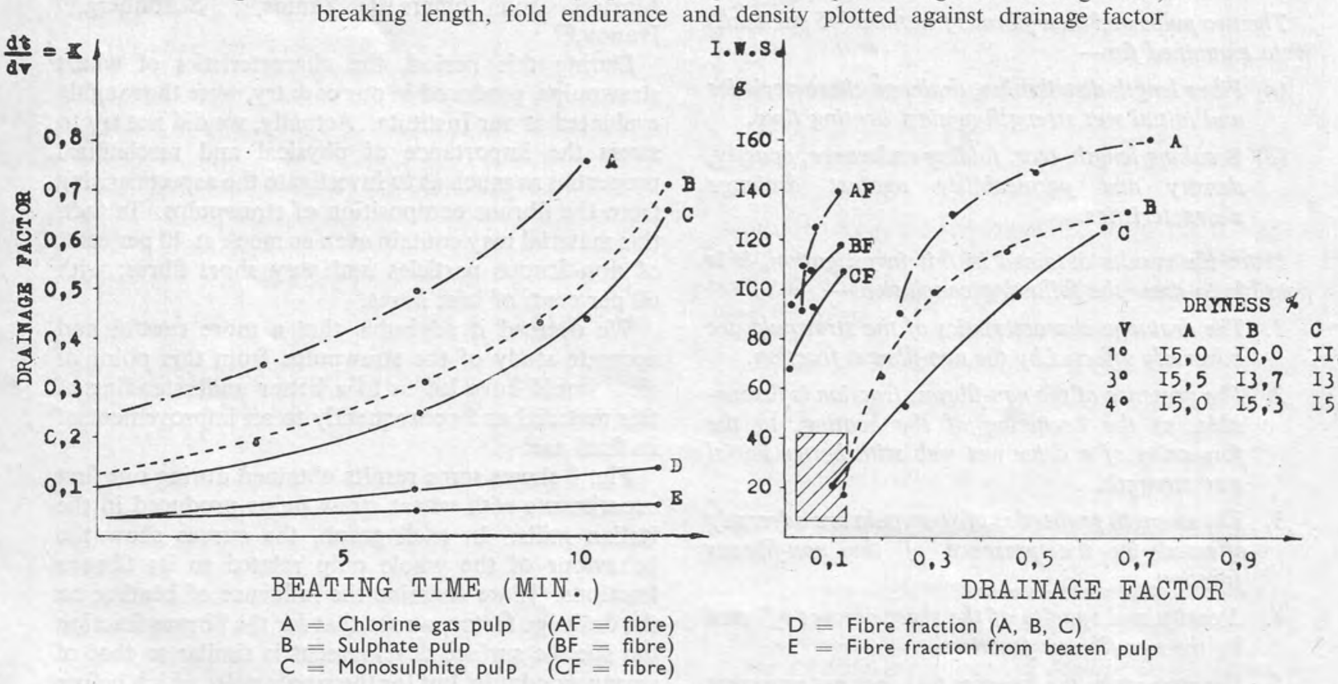


Fig. 2 — Dutch strawpulp—drainage factor plotted against beating time; initial wet strength plotted against drainage factor

specific surface development is very fast, that is, it wets up very rapidly. By plotting some physical properties of the sheets against the drainage factor, we find that tensile strength and folding endurance are adversely affected by the non-fibrous fraction, whilst density is chiefly determined by the fibrous fraction.

From these results, it would appear that it is possible to gain useful information by studying wheat straw pulps along these lines. We have consequently examined some strawpulps with reference to their behaviour in the wet and dry condition.

Analytical methods

A. Chemical analysis

The fraction insoluble in 17.5 per cent. sodium hydroxide (Merkblatt IV/29-Proc. B) and the amount of pentosans (Merkblatt 9) were determined on the whole pulps and on their fibrous and non-fibrous fractions. The alkali-resistant pentosans and ash were determined only on the whole pulps.

The object of these analyses was to stress some aspects of the chemical composition that could have been helpful in explaining the behaviour of these pulps. The relationships existing between chemical composition and pulp behaviour are being examined in another paper by Centola and Borruso.* The importance that is here attributed to the results of the chemical analysis is therefore rather limited.

B. Physical analysis

The different pulp samples were tested before and after beating in a Jokro mill.

Drainage characteristics—The drainage factor was determined by the Ivarsson & Johansson apparatus.[9,10]

The specific drainage resistance, determined by the rate of the flow through the area, the pressure causing the flow, the viscosity of the liquid and the mass per unit area, depends essentially upon two factors—specific surface of the pulp and compactness of the pulp in the fibrous mat. The specific surface is a pulp property. Compactness is not a pulp property, since it is determined by two components—compressibility of the pulp and pressure to which the pulp is subjected. However, if the pressure maintained is constant, the principal factor affecting compactness is the compressibility of the pulp. Since this is the case with the instrument we used, the measurements of the specific drainage resistance reported in this work result from the specific surface and compressibility characteristics of the pulp examined.

* *Paper Tech.*, 1961, **1** (2), 157

Fibre classification—The classification was performed in a Bauer-McNett classifier (30, 50, 250 mesh). The flow of water was 1.5 litres/min. and the duration was that required for 60 litres of water to flow through. Each 10 g. (oven-dry) sample of pulp was divided as follows—(*a*) long fibres (on 30 mesh); (*b*) short fibres (on 50 mesh); (*c*) non-fibrous particles and very short fibrous elements (on 250 mesh + material in the 60 litres of outflow water). Under such conditions, this procedure allowed not only a study of fibre length distribution, but also collection of the amounts of fibrous fraction necessary for beating tests (long and short fibres). In this case, however, 20 g. of pulp were used each time—that is, twice the quantity normally fractionated in the analytical method.

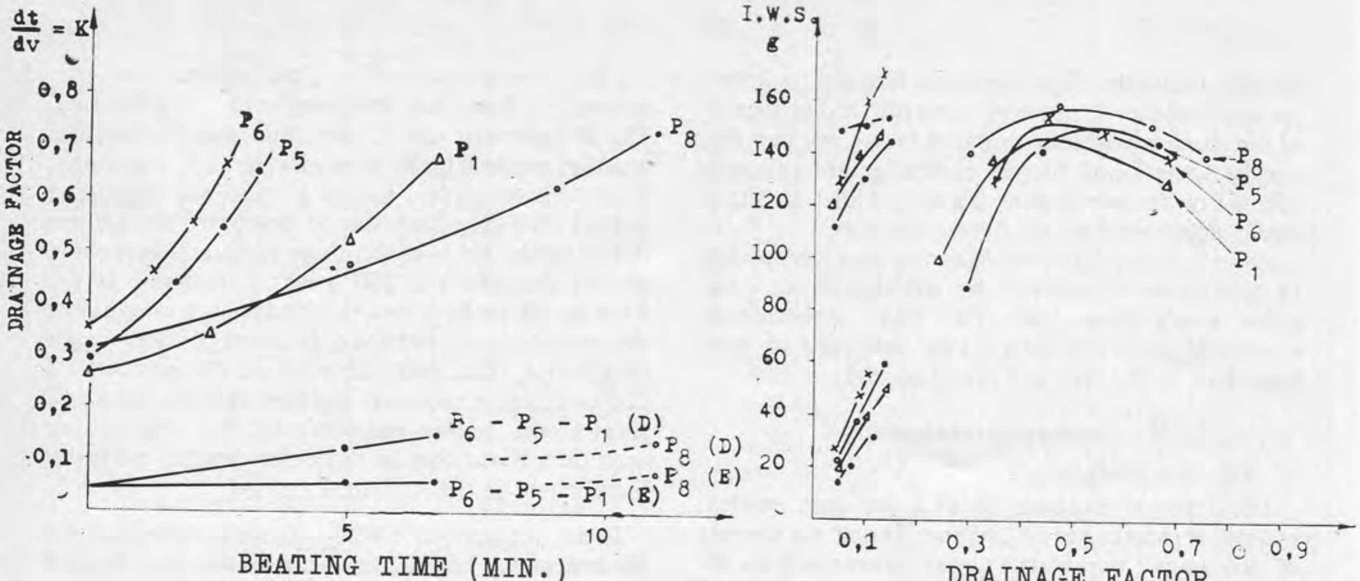
Initial wet strength (*IWS*)—Given the simplicity of the instrument and the testing procedure, we decided to use the Brecht IWS tester.[11,12] A 100 g./sq. m. sheet was formed on a Rapid-Köthen sheetmachine under standard conditions by the following procedure—

(*1*) Volume of suspension	4 litres
(*2*) Duration of aeration for mixing ..	10 sec.
(*3*) Time left standing after (*2*) ..	5 sec.
(*4*) Duration of suction after the water surface film of water has disappeared from the sheet	5 sec.

Three strips (30 mm. × 90 mm.) were taken from each sheet. Two were used to determine the IWS and the other to determine the dry solids content. The results were obtained either from three sheets or from five sheets. The aim of these tests was to observe the influence of the non-fibrous particles on the initial wet strength and to see the IWS changes brought about by beating as a result of the variation in the fibre length distribution, both on the whole pulps and on their fibrous fraction.

Sheet preparation—The sheets (80 g./sq. m.) were formed on a Rapid-Köthen sheetmachine to German standard specifications. They were submitted to mechanical tests after conditioning for 48 hr. at 20°C and 65 per cent. R.H. They were prepared—(*a*) from the whole pulp; (*b*) from the fibrous fraction; (*c*) from the fibrous fraction obtained from beaten whole pulps.

Physico-mechanical properties—The handsheets made from the different pulp samples, before and after beating, were tested for—breaking length (m.); tearing strength (g.); folding endurance (number of double folds); density (g./c.c.); brightness (per cent.); TAPPI opacity (per cent.); scattering power (from TAPPI opacity and reflectivity); air resistance (sec./100 c.c.).



P1 = Soda
P5 = Monosulphite
P6 = Chlorine gas
P8 = Sulphate
D = Fibre fraction
E = Fibre fraction from beaten pulp

Fig. 3 — Italian laboratory strawpulp—drainage factor plotted against beating time; initial wet strength plotted against drainage factor

Results

In preliminary work, seven different strawpulps, four prepared in our laboratory from Italian wheat straw and three received from Dutch pulpmills, were used. We did not use strawpulps produced in the Italian mills, since we already knew their behaviour (*see* Fig. 1), but we wanted to be able to experiment with some pulps from Italian straw, which might produce totally different results in wet and dry conditions.

Table 1 gives some data about the cooking processes, the fibre length distribution, the pentosans and ash contents of these seven pulps. Only slight differences were found in the amount of pentosans within the two groups. The same can be said about the whole pulps and the corresponding fibrous fraction. Among the four laboratory pulps, the sulphate pulp (P 8) has higher pentosans and alkali-resistant pentosans at lower yield level. This corresponds to the explanation recently given on the fate of xylan during the sulphate cook.[13,14] Rather large amounts of ash are also present in the monosulphite pulp (P 6).

In Fig. 2, the drainage versus beating time and the

TABLE 1—STRAWPULPS

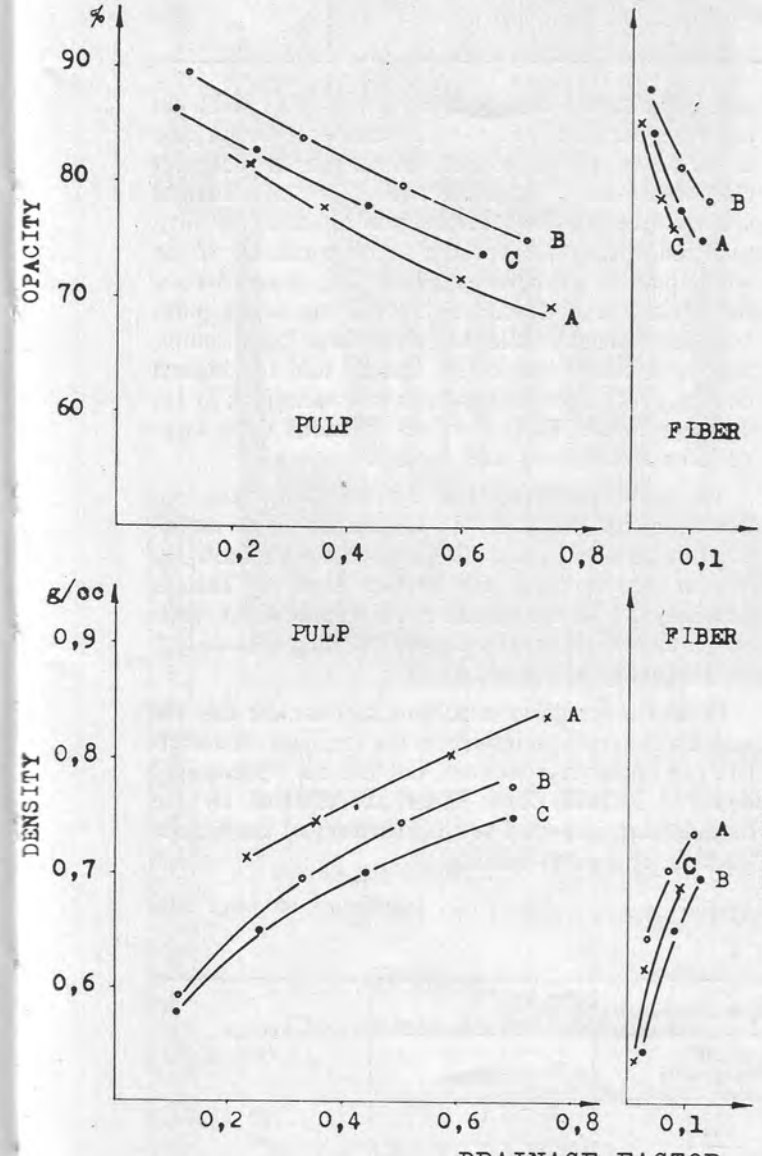
Pulps	*Yields (bleached) pulp, %*	*Fibre length distribution, %*			*Pentosans, %*			*Ash, % (on pulp)*
		30 mesh wire	*50 mesh wire*	*Outflow + 250 wire*	*Pulp*	*Non-fibrous fraction*	*Insoluble in 18% NaOH*	
Dutch chlorine gas	—	52	26	22	30.0	30.0	7.8	0.40
Dutch sulphate	—	56	21	23	27.0	26.5	5.0	0.70
Dutch monosulphite	—	59	16	25	27.0	25.5	5.5	4.50
Lab. P 1 soda.. .. .. (10% caustic, 165°c, 3 hr.)	46	49	19	32	33.5	30.0	7.0	1.60
Lab. P 5 monosulphite .. (Prehyd. 120°c, 1 hr.; 12% sodium sulphite, 165°c, 3 hr.)	53	46	22	32	32.0	27.0	6.5	7.50
Lab. P 6 Pomilio process ..	54	45	22	33	34.5	33.0	7.5	2.50
Lab. P 8 sulphate .. .. (18% total alkali, 165°c, 2½ hr.)	42	44	25	31	35.0	32.0	10.0	1.00

IWS versus the drainage factor are given for the three Dutch pulps.

The initial differences in the water permeability remain unchanged during the beating process. If we beat the fibrous fractions or obtain them from the beaten pulps by classification, we have fibrous material with a very high permeability. The fact that the fibrous fractions resulting from the beaten pulps by fractionation have a higher permeability is certainly due to the washing effect, which removes fibre debris.

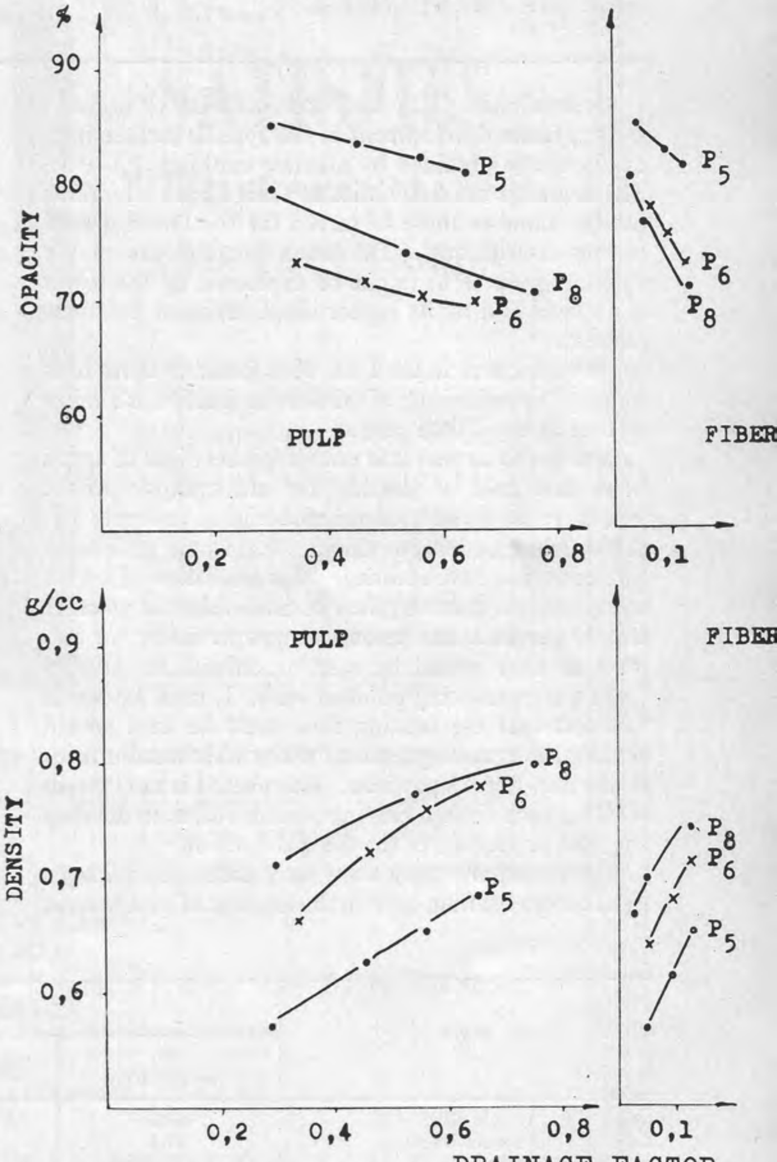
At the same drainage factor, pulp *A* shows better IWS. This is true also at the same wet web dry solids content. In consequence of the low drainage factor, the fibrous fractions give low dry solids content (10 per cent.) and low initial wet strength when the normal beating times for strawpulps are applied; however, if blotting paper is used to increase the dryness of the wet webs to 13.5 per cent., we obtain the same IWS figures as for whole pulps.

Fig. 3 gives the beating time, drainage properties and wet web strength for the four pulps prepared in our laboratory.



A, B, C = Fibre fractions (as for Fig. 2)

Fig. 4 — Dutch strawpulp—opacity and density plotted against drainage factor



P5, P6, P8 = Laboratory pulps (as for Fig. 3)

Fig. 5 — Italian laboratory strawpulps—opacity and density plotted against drainage factor

TABLE 2

Pulps	Yields (bleached), %	Fraction insoluble in 18% NaOH, %	Pentosans, %		Ash, %
			Whole pulp	Insoluble in 18% NaOH	
Lab. P 9 .. .. (10% sodium sulphite, 4% caustic soda, 3 hr., 155°C)	46	73	30.5	5.5	7.6
Lab. P 10 .. .. (Prehyd. 160°C, 1 hr., 18% caustic soda, 165°C, 3 hr.)	34	78	28.0	10.5	0.6

Monosulphite (P 5) and soda/chlorine (P 6) pulps show a faster development of the specific surface than do the pulps obtained by alkaline cooking (P 1–P 8). The drainage characteristics of their fibrous fractions are the same as those observed for the Dutch pulps' fibrous constituents. The lower beating rate of the sulphate pulp (P 8) might be explained by the lower yield level and by its higher alkali-resistant pentosan content.

No differences in the IWS were found in these four pulps. The behaviour of the fibrous fraction is similar to that of the Dutch pulps.

It seems to us that it is not altogether right to speak of a fast rate of beating for strawpulps. About 70 per cent., indeed, of the material in the pulp has certainly not undergone changes that would noticeably influence its own drainage characteristics. One of the problems that requires consideration is whether this 70 per cent. has favourable properties or not and whether they would be easy or difficult to develop from a papermaking point of view. It must be borne in mind that the beating time must be kept within modest limits, owing to the quantity and characteristics of the non-fibrous particles. However, it is not certain whether such limited beating periods suffice to develop the best properties of the fibrous fraction.

The strawpulps may show very different drainages even before beating, both in the amount of non-fibrous particles and the kind of cooking and pulp yield. In any case, the fibrous fraction, no matter to which pulp it belongs, shows rather advantageous drainage characteristics. The fibrous fraction of different strawpulps might, however, show a different flexibility, thus influencing the packing or compression of the whole pulp in a different manner. Fig. 4 and 5 show the opacity and density figures of the seven pulps and their fibrous fractions. Of the three Dutch pulps, sample *A* shows the lowest opacity and the highest density. Notwithstanding the small variations in the drainage factor, all the fibrous fractions show large variations in opacity and density.

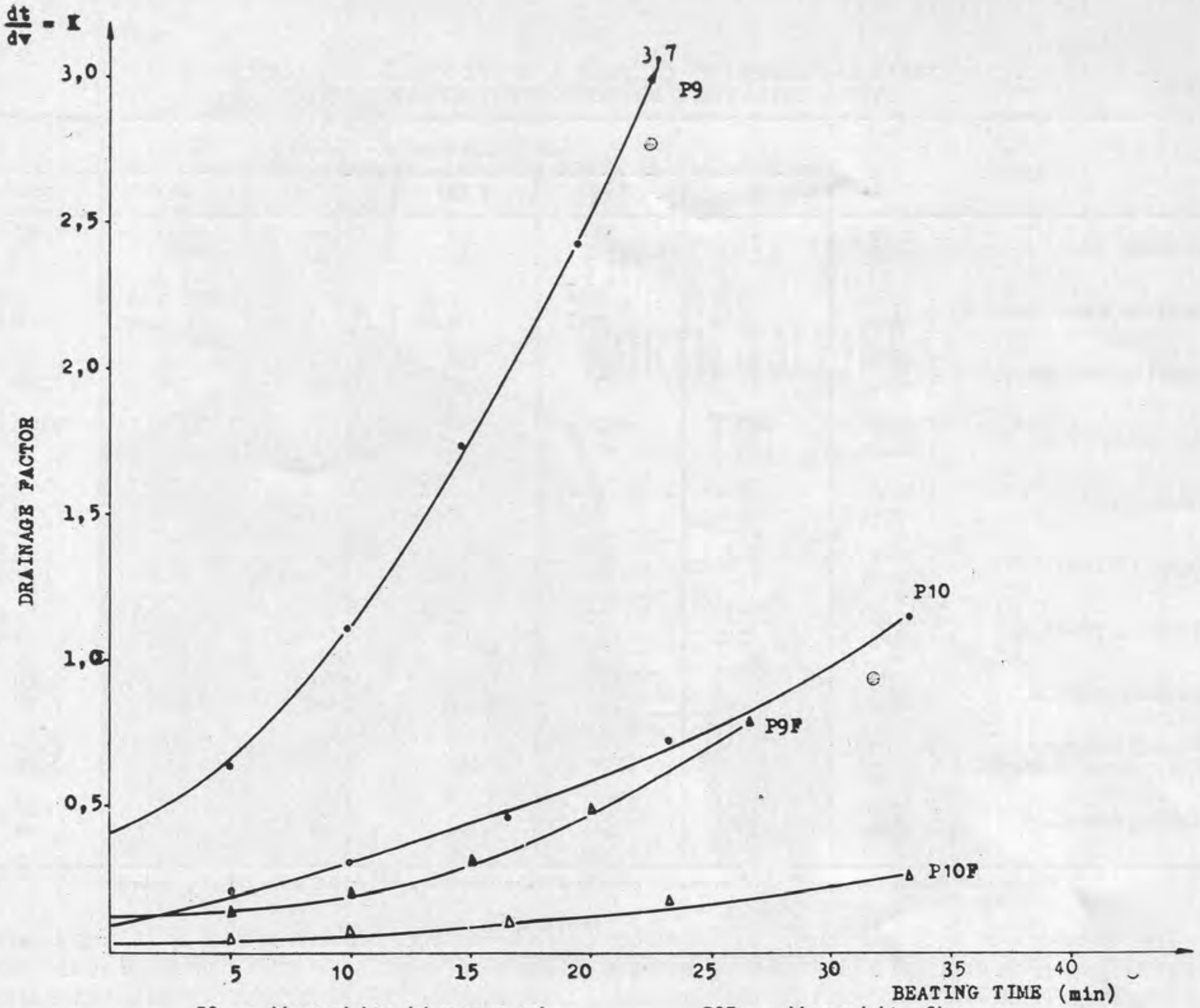
The same conclusions may be made about the four strawpulps prepared in the laboratory. The monosulphite pulp (P 5) and its fibrous fraction show the highest opacity and the lowest density. This is probably due to the special cooking conditions—that is, an unbuffered monosulphite cooking following a mild aqueous hydrolysis.

From the foregoing conclusions, it is clear that the non-fibrous fraction influences the drainage characteristics in an adverse manner, but not the opacity and density. Instead, these latter are affected by the modification imparted to the structure of the fibrous fraction by a short beating.

(*continued on page 669*)

TABLE 3

Pulps		Fibre length distribution (%)			Fibrous fraction, %
		30 mesh wire	50 mesh wire	Outflow + 250 wire	
P 9	Whole pulp	49.6	17.4	33	67
	Fibrous fraction ..	67.5	22.5	10	90
P 10	Whole pulp	52.5	14.5	33	67
	Fibrous fraction ..	73.5	20.0	6.5	93.5



P9 = Monosulphite laboratory pulp
P10 = Soda laboratory pulp
P9F = Monosulphite fibre
P10F = Soda fibre

Fig. 6 — Italian laboratory strawpulps—drainage factor plotted against beating time

Strawpulps with entirely different beating behaviour

SINCE no great differences were discovered among these seven pulps, two further pulps were prepared in the laboratory. Obtained by different cooking processes, they showed a great difference in their drainage characteristics.

In Tables 2 and 3, some results of the cooking conditions, the pentosans, the ash content and the fibre length distributions are given. As we can see, the monosulphite pulp has a high ash content and the soda pulp a high percentage of alkali-resistant pentosan. Both pulps and their fibrous fractions show almost the same fibrous composition.

In Fig. 6, we observe that after a beating period of 35 min. the soda pulp (P 10) has a water permeability nearly four times higher than that of the monosulphite pulp (P 9) and reacts in almost the same way as the fibrous fraction of this latter. The fibrous fraction of the soda pulp is exceptionally slow in developing its specific surface.

In proportion, the influence of the non-fibrous fractions is similar on both pulps. The changes caused in the fibre length of whole pulp and its fibrous fraction by beating are shown in Fig. 7 and 8. In Fig. 7, they are plotted against the drainage factor and, in Fig. 8, against the beating time. The percentages of long fibres, short fibres and non-fibrous fractions are shown in each graph. Both in the presence and absence of the non-fibrous particles, the fibrous fraction undergoes the same beating action. The beating, therefore, seems to have no special effect on either of the components, once they are mixed together in the pulp. We can assume therefore that, whether beaten alone or in the whole pulp, the fibrous fraction assumes the same characteristics, provided the beating time is the same.

TABLE 4—PROPERTIES OF PULP AND ITS FIBROUS FRACTION FOR LABORATORY MONOSULPHITE STRAWPULP (P 9)

Properties		*Jokro mill revolutions*					
		0	*750*	*1 500*	*2 250*	*3 000*	*4 000*
Freeness, °S.R.	pulp	42	54	64	71	79	83
	fibres	23	25	34	43	51	62
Drainage factor ($dt/dv=K$)	pulp	0.39	0.64	1.10	1.80	2.40	3.70
	fibres	0.10	0.12	0.20	0.33	0.49	0.80
Initial wet strength, g.	pulp	96	150	150	100	98	92
	fibres	35	43	88	168	200	205
Air resistance, sec./100 c.c.	pulp	180	400	750	1 800	2 700	8 000
	fibres	30	40	60	140	250	700
Density, g./c.c.	pulp	0.60	0.65	0.68	0.73	0.75	0.77
	fibres	0.56	0.63	0.68	0.72	0.73	0.76
Opacity (TAPPI)	pulp	80.8	78.2	76.7	73.7	74.5	73.2
	fibres	81.7	78.8	75.6	73.7	72.5	71.0
Scattering power, S_X*	pulp	2.42	2.13	2.00	1.78	1.75	1.61
	fibres	2.76	2.32	2.08	1.91	1.76	1.64
Breaking length, m.	pulp	4 900	6 000	6 300	6 500	6 600	6 300
	fibres	4 500	5 200	6 800	7 400	7 600	7 700
Folding endurance (number of double folds)	pulp	250	350	500	700	850	1 150
	fibres	350	750	1 000	1 700	1 900	2 150
Tearing strength, g.	pulp	39	38	37	36	33	27
	fibres	50	50	49	47	46	44

* From TAPPI opacity and reflectance of a compactly packed number of sheets with zero transmittance (80 g./sq. m. sheets)

The variations in the fibre length of the monosulphite pulp (P 9) obtained after 10 min. of beating, at a drainage value of 1.0 (65° S.R.) are not excessive. Its fibrous fraction shows a wetness of 33° S.R. and a drainage value of 0.3. The variations in the fibre length of the fibrous fraction only become apparent after 25 min. beating—that is, when it has reached 60° S.R. wetness and 0.8 drainage value. Its pulp gives a wetness of 85° S.R. and a drainage value of 3.0. For the soda pulp, the same conclusions may be deduced.

We now pass to an investigation of the properties of the handsheets. It must always be borne in mind that, whether beaten alone or in the whole pulp, the fibrous fraction assumes the same characteristics, provided the beating time is the same. As the six values (as shown in the graphs) relative to each pulp and to its fibrous fraction are obtained with the same beating time, we are able to deduce the effects the fibrous fraction exercises on the whole pulp (Tables 4 and 5).

The brightness (Fig. 9) seems to be adversely influenced by the non-fibrous fractions. In fact, the fibrous fractions are brighter than the whole pulps. This difference becomes greater as beating proceeds. The small variation in colour observed in the monosulphite pulp (P 9) at the same drainage factor are due to the fact that its fibrous fraction has been beaten for a longer period to reach the same drainage value.

The opacity (Fig. 9) is determined by the fibrous fractions. Non-fibrous constituents bring about decrease in opacity in soda pulp (P 10) at the highest drainage factors.

At the same drainage, the whole monosulphite pulp and its fibrous fraction are more opaque than the corresponding soda pulps. This behaviour could be accounted for by the fact that the monosulphite pulp has a higher ash content and that the soda pulp needs a longer beating period to reach the same drainage values.

Similar behaviour is noticed with the density (Fig. 9). It seems that a correlation exists between opacity and density. While the non-fibrous components increase the density of unbeaten pulps, that of beaten pulps may be affected by the fibrous fraction (monosulphite pulp) or by the non-fibrous fraction (soda pulp).

(*continued on page 675*)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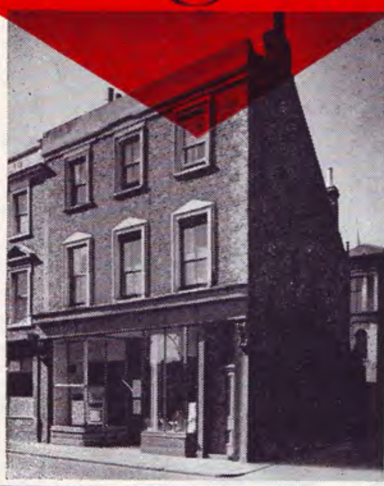

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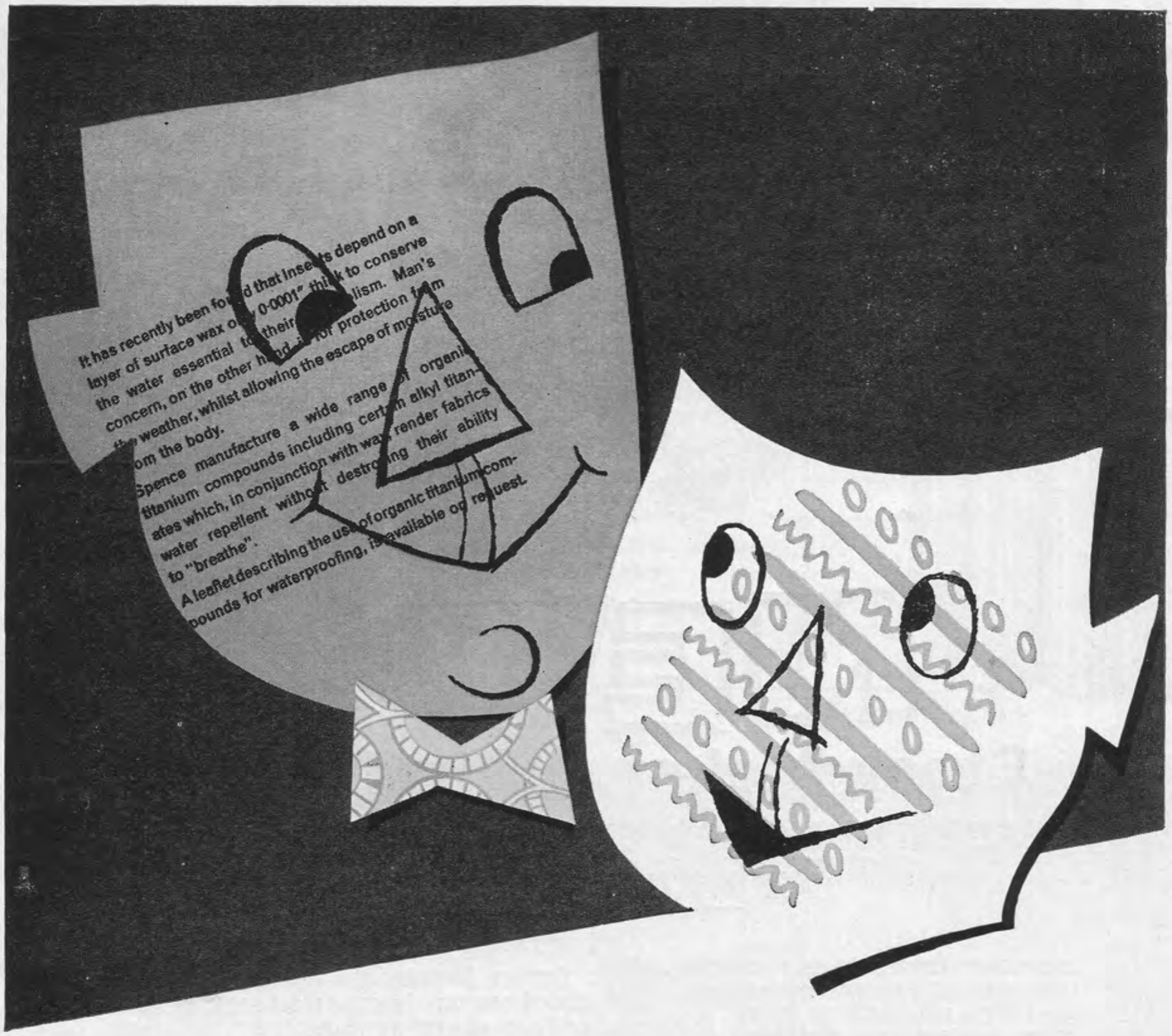


TABLE 5—PROPERTIES OF PULP AND ITS FIBROUS FRACTION FOR LABORATORY SODA STRAWPULP (P 10)

Properties		Jokro mill revolutions					
		0	*750*	*1 500*	*2 500*	*3 500*	*5 000*
Freeness, °S.R.	pulp	25	33	40	49	61	68
	fibres	17	20	24	27	34	40
Drainage factor ($dt/dv=K$)	pulp	0.10	0.26	0.31	0.46	0.75	1.14
	fibres	0.036	0.054	0.080	0.11	0.17	0.25
Initial wet strength, g.	pulp	48	104	130	154	190	176
	fibres	20	30	40	48	74	100
Air resistance, sec./100 c.c.	pulp	38	130	180	330	740	1 100
	fibres	5	10	18	30	50	85
Density, g./c.c.	pulp	0.65	0.71	0.74	0.76	0.80	0.83
	fibres	0.56	0.65	0.67	0.69	0.72	0.74
Opacity (TAPPI)	pulp	83.7	78.7	76.6	72.8	69.3	67.1
	fibres	84.2	79.3	78.0	75.5	75.1	73.0
Scattering power, S_x*	pulp	2.83	2.21	2.01	1.76	1.53	1.41
	fibres	2.94	2.32	2.19	1.97	1.93	1.78
Breaking length, m.	pulp	3 400	5 000	6 200	6 500	6 500	6 400
	fibres	2 600	4 500	5 300	5 700	6 000	6 300
Folding endurance (number of double folds)	pulp	75	500	650	1 000	1 350	1 700
	fibres	30	300	850	1 400	2 050	2 600
Tearing strength, g.	pulp	65	60	58	54	52	50
	fibres	90	83	79	68	65	61

* From TAPPI opacity and reflectance of a compactly packed number of sheets with zero transmittance (80 g./sq. m. sheets)

If the scattering power (Fig. 10) is plotted against the density, we still observe the prevailing influence of the fibrous fraction of the monosulphite pulp and the prevailing influence of the non-fibrous fraction of the soda pulp. At the lower density figures, the soda pulp shows the higher values of the two, the smaller differences being between the two fibrous fractions.

Regarding the IWS (Fig. 11), the lowest and highest values are those belonging to the whole pulp and the fibrous fraction of the monosulphite pulp, respectively. Whereas in the monosulphite pulp the adverse effect resulting from the non-fibrous particles is evident as the beating proceeds, we cannot say the same for the soda pulp. The IWS is determined by the dry solids content that the wet web can reach. Besides certain variations in the fibre length caused by the beating, the mixture gives a poorer result than the IWS of the monosulphite pulp. In the breaking length, too (Fig. 11), the lowest and highest values are those belonging to the pulp and to the fibrous fraction of the monosulphite pulp, respectively. Instead, generally speaking, the non-fibrous fraction of the soda pulp influences the tensile strength favourably.

The tearing strength (Fig. 12) of the strawpulps is rather low, that of the soda pulp being the highest. Beating does not appreciably reduce the strength of the monosulphite pulp, but it reduces that of the soda pulp, which, on the other hand, shows the highest values. The adverse effect of the non-fibrous fraction on both pulps is evident.

Non-fibrous particles decrease the folding endurance (Fig. 12). The highest folding value is shown by the fibrous fraction of the soda pulp, followed by the fibrous fraction of the monosulphite pulp, then the soda pulp and lastly the monosulphite pulp.

All these observations seem to indicate that the mechanical properties of strawpulps are essentially determined by the fibre material.

At the same drainage values, both the whole pulps and the fibrous fractions show the same permeability figures (Fig. 13). It is evident from the results that the non-fibrous particles are a major factor in determining the drainage and permeability characteristics.

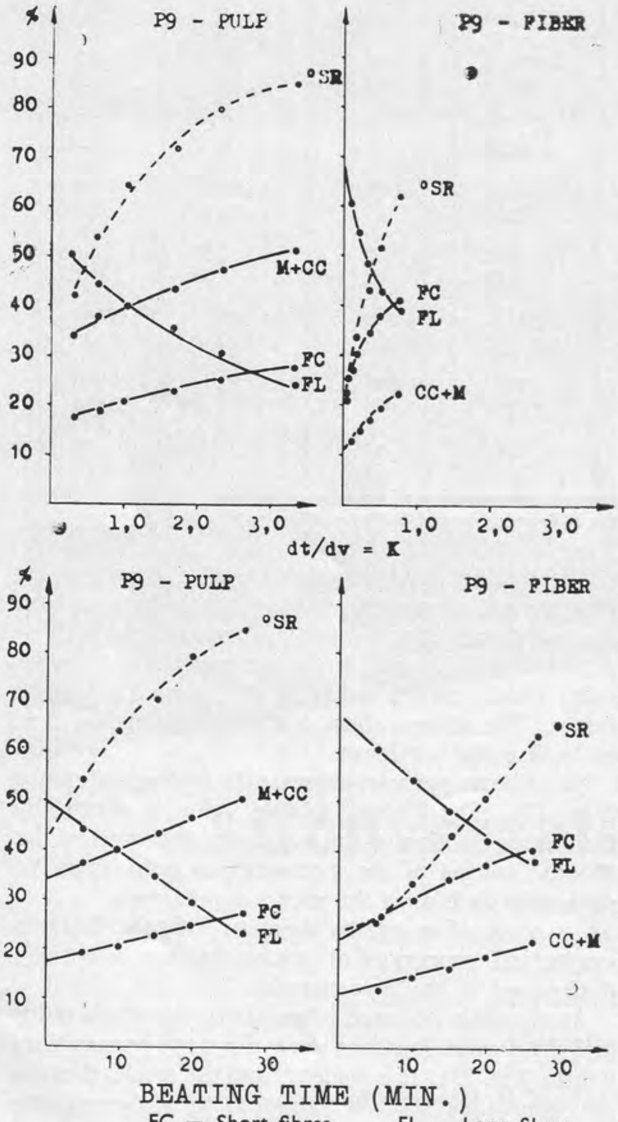
Notwithstanding their almost equal pentosan content and fibre length distribution, we can—in the light of our examination of the behaviour of these two strawpulps and on the basis of recent investigation[15,16] —confirm what we stated some years ago.

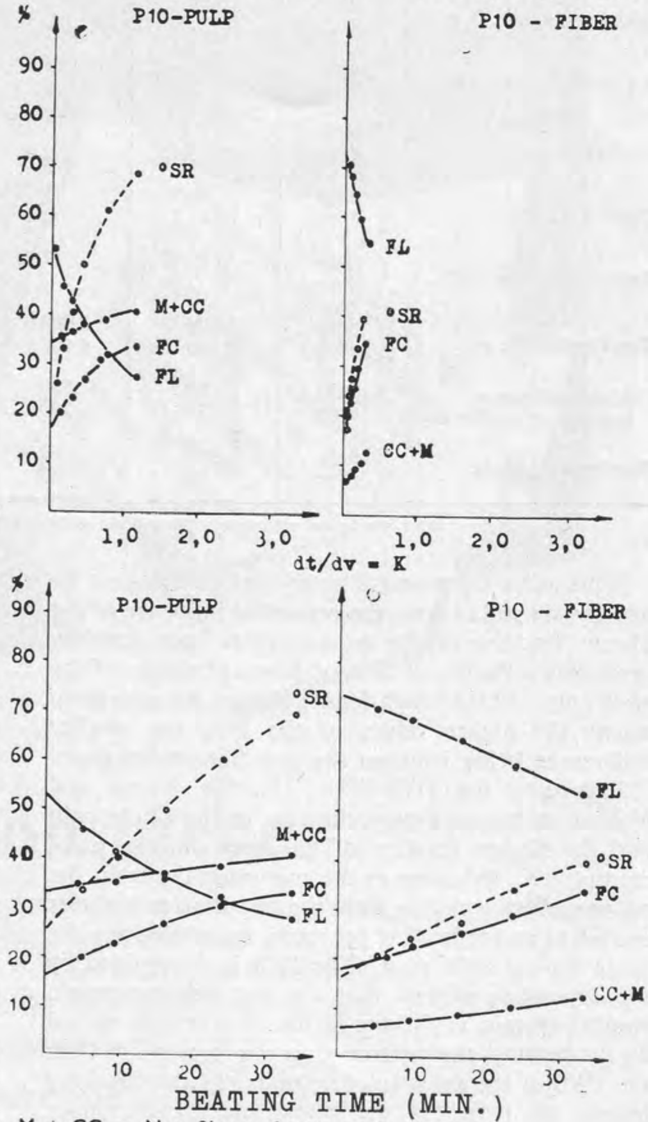
The determining factors for the papermaking properties of a fibre are not to be found exclusively in the amount and composition of the hemicellulose. The predominant action of the reagents and of the conditions employed in the pulping and bleaching processes lies in the modifications imparted to the structure of the fibres and particularly to that of the surface.

Conclusions

THE wheat straw pulps show a percentage of non-fibrous material including very short fibres varying from 40 per cent. to 25 per cent. It is essential, therefore, that this material be examined with due regard to the effect of the non-fibrous fraction on the properties of the pulp.

Considering the mixture components of the straw-pulps, the physico-chemical condition in which the fundamental constituents of the fibre may be associated





FC = Short fibres FL = Long fibres M + CC = Non fibrous fraction minus particles

Fig. 7 — Laboratory pulp P9 — fibre length distribution before and during beating plotted against drainage factor and beating time

Fig. 8 — Laboratory pulp P10—fibre length distribution before and during beating plotted against drainage factor and beating time

(*continued on page 679*)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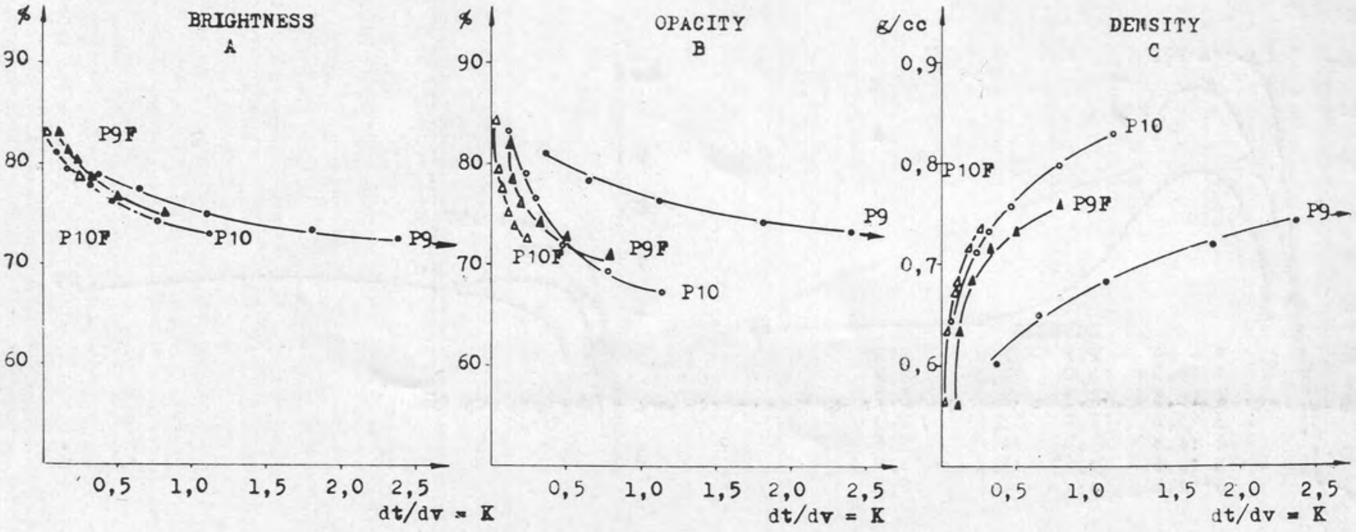


P9 = Monosulphite laboratory pulp
P10 = Soda laboratory pulp
P9F = Monosulphite fibre
P10F = Soda fibre

Fig. 9 — Italian laboratory strawpulps—brightness (A), opacity (B), density (C) plotted against drainage factor

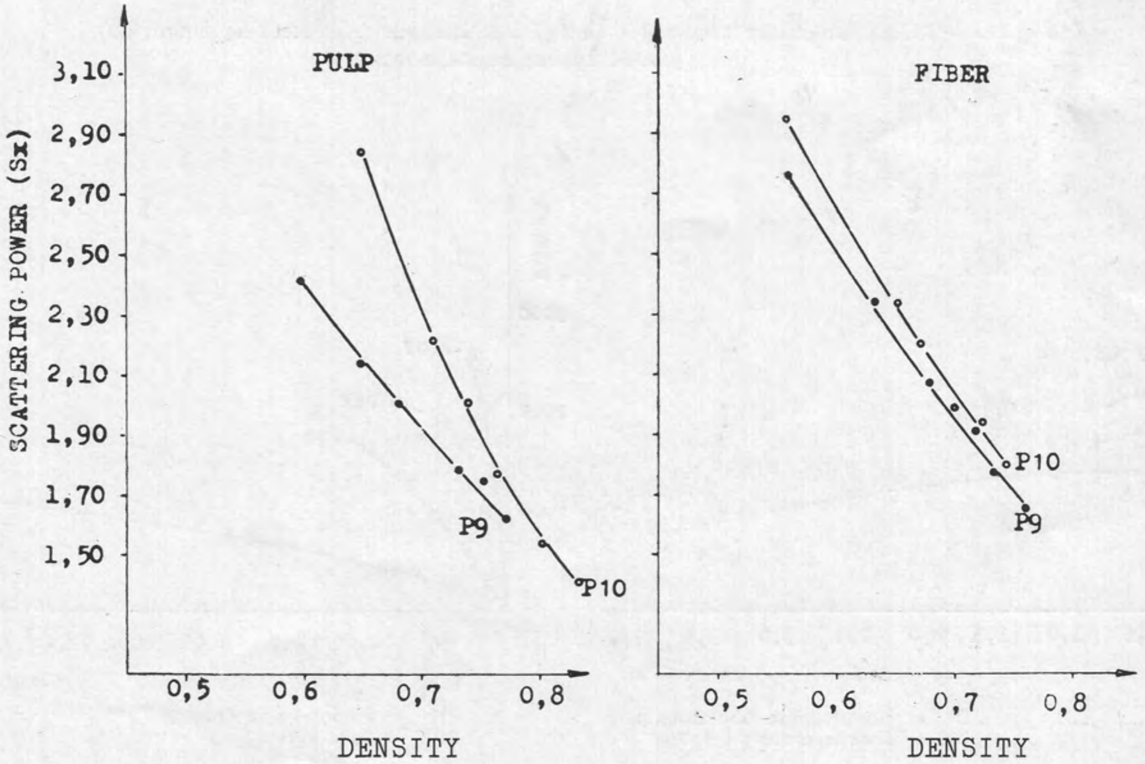
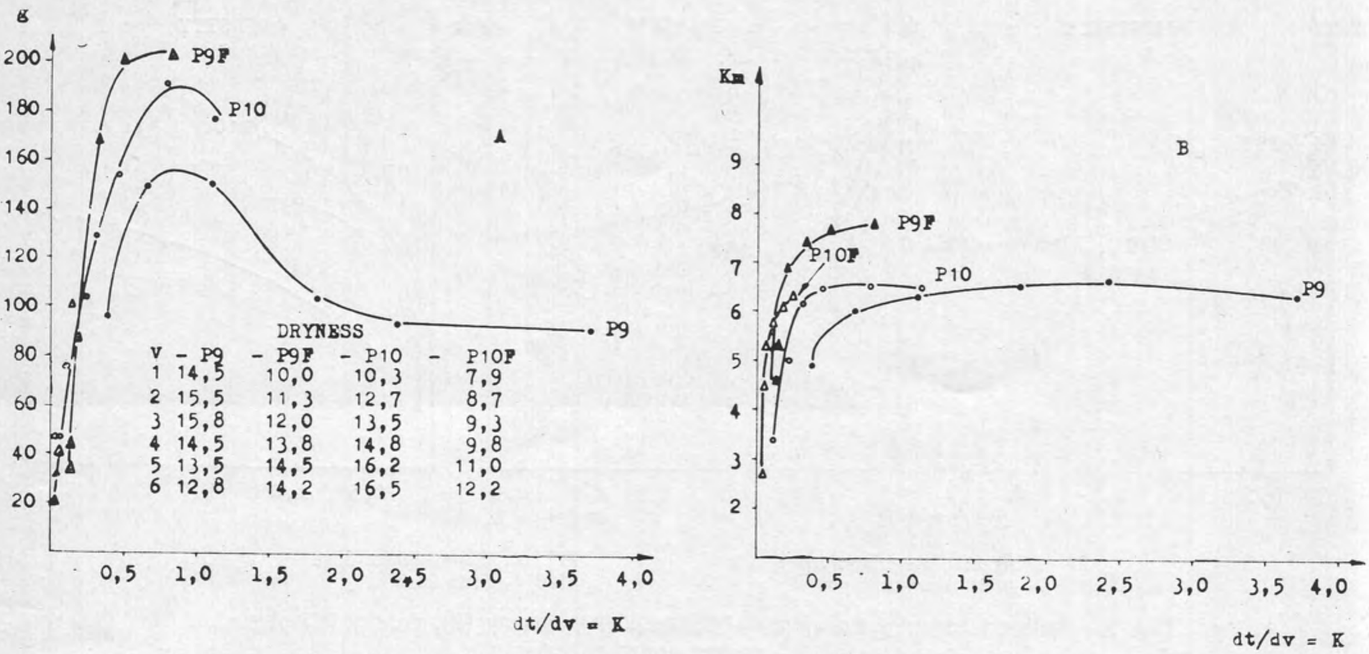


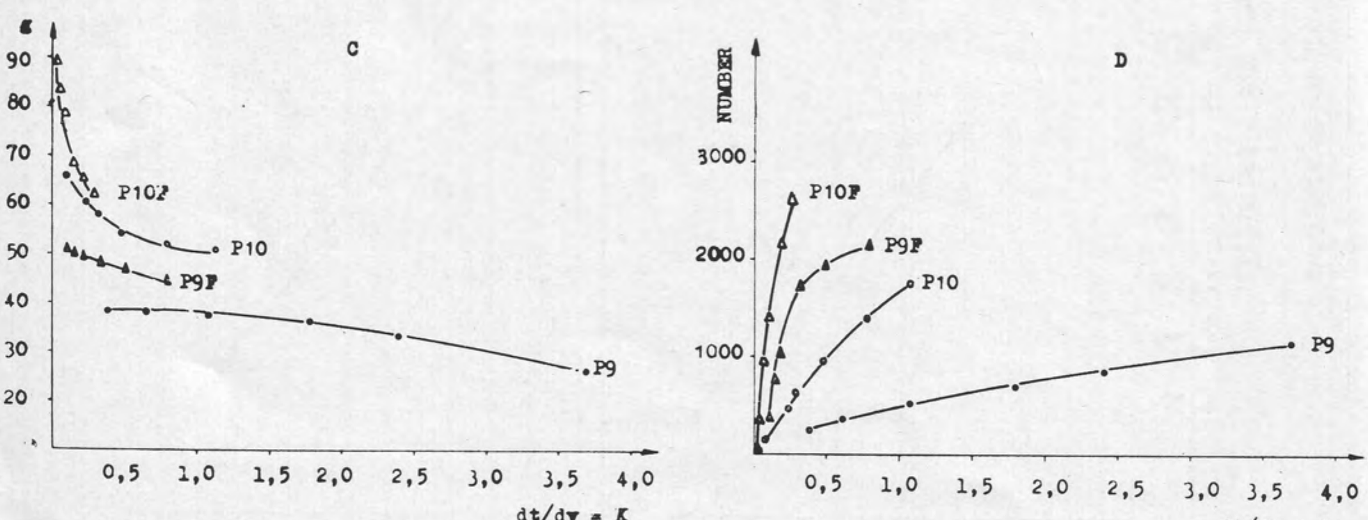
Fig. 10 — Laboratory pulps P9, P10—scattering power plotted against density



P9 = Monosulphite laboratory pulp
P10 = Soda laboratory pulp

P9F = Monosulphite fibre
P10F = Soda fibre

Fig. 11 — Italian laboratory strawpulps—initial wet strength (A), breaking length (B) plotted against drainage factor

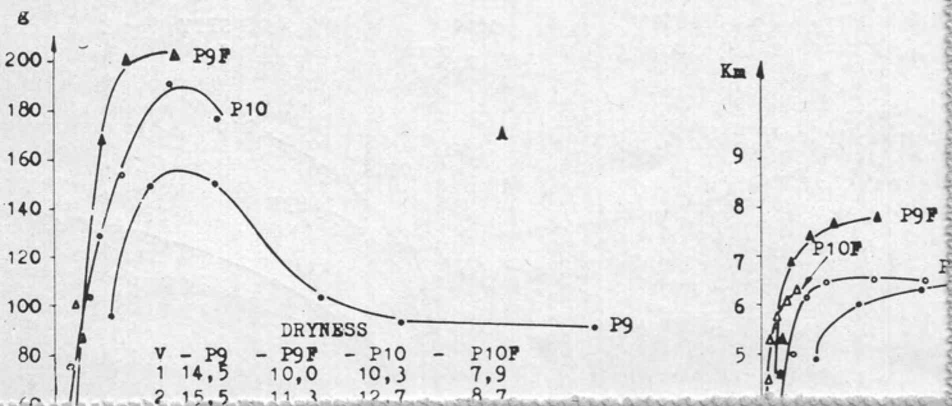


P9 = Monosulphite laboratory pulp
P10 = Soda laboratory pulp

P9F = Monosulphite fibre
P10F = Soda fibre

Fig. 12 — Italian laboratory strawpulps—tearing strength (C), folding endurance (D) plotted against drainage factor

[*p.t.o.*



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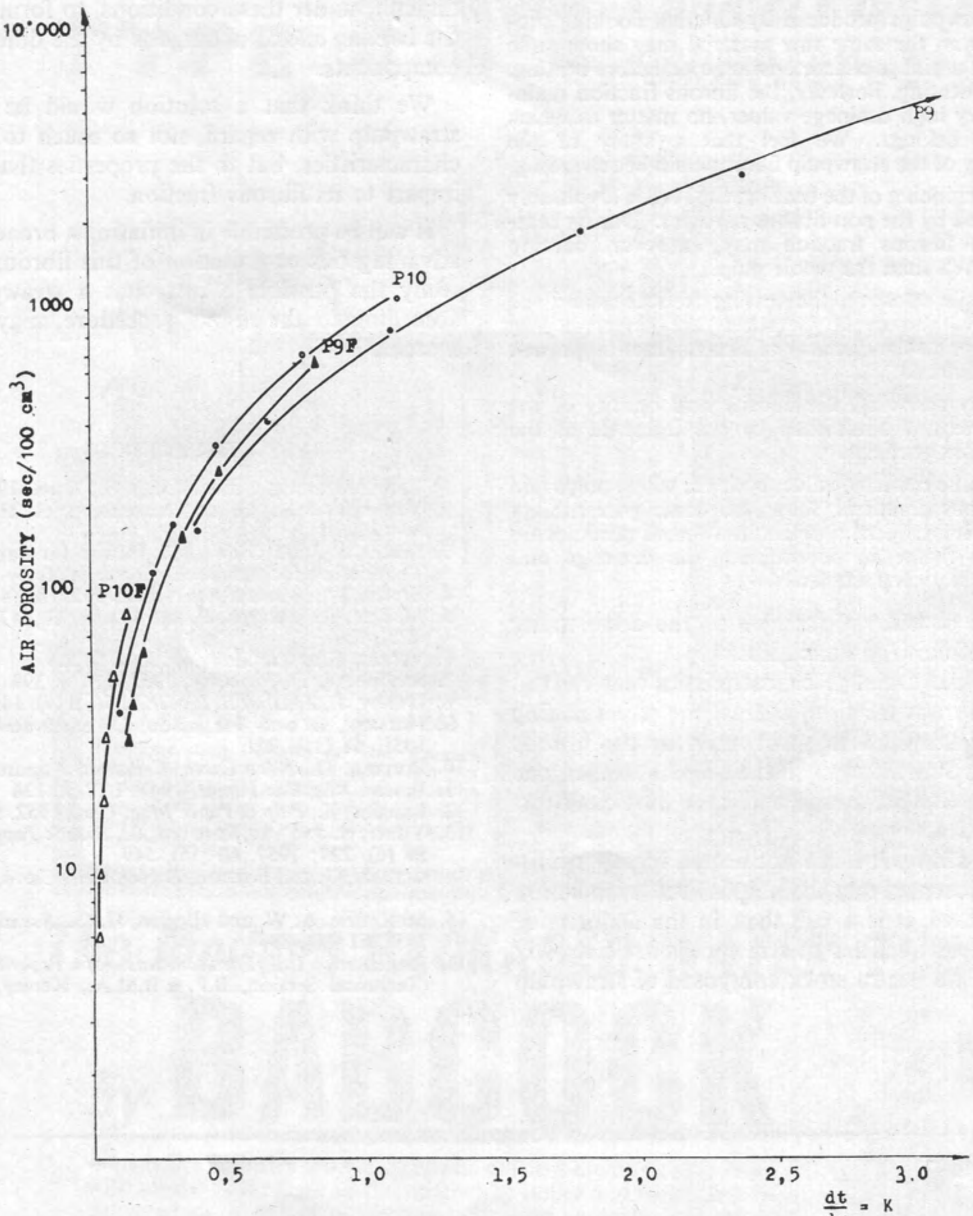

P9 = Monosulphite laboratory pulp
P10 = Soda laboratory pulp
P9F = Monosulphite fibre
P10F = Soda fibre

Fig. 13 — Italian laboratory strawpulps—air permeability plotted against drainage factor

after cooking and bleaching processes and the factors governing the papermaking properties of pulp, we have in our researches been able to establish that—

1. Two strawpulps produced by different cooking processes from the same raw material may show quite different drainage characteristics, even before beating. During beating, however, the fibrous fraction maintains very high drainage values, no matter to which pulp it belongs. We feel that a study of the flexibility of the strawpulp fibres would be rewarding.

2. At the beginning of the beating, the IWS is favourably influenced by the non-fibrous particles. During beating, the fibrous fraction may, however, develop higher IWS than the whole pulp.

3. The tensile strength, the tearing resistance and the folding endurance of the sheets are determined in proportion to the quantity of fibrous fraction present in the mixture.

4. Generally speaking, the density and opacity of the sheets are not diminished by the influence of the non-fibrous particles.

5. At the same drainage value, both the whole pulps and the fibrous fractions show the same permeability figures. It is evident that the non-fibrous particles are a major factor in determining the drainage and permeability characteristics.

The above considerations give us the opportunity to draw the following conclusions.

If we plot the drainage characteristics (determined by the non-fibrous fraction) against the papermaking properties (determined in most cases by the fibrous fraction), it is difficult to say if the pulp has undergone beating to the best advantage and if the fibre can show its best qualities.

Normally, strawpulps are not beaten in papermills. It is usually accepted that the pulp is 'wet' even before beating. Instead, it is a fact that, in the majority of cases, the latent qualities of strawpulps are not fully exploited. If we beat a stock composed of strawpulp and another fibrous pulp together, the resulting wetness will be different, owing to the lower percentage of the strawpulp non-fibrous particles. It is even more difficult, under these conditions, to form opinions on the beating effects undergone by the different mixture components.

We think that a solution would be to beat the strawpulp with regard, not so much to its drainage characteristics, but to the properties that we wish to impart to its fibrous fraction.

It will be profitable in initiating a broader and more advantageous exploitation of this fibrous material to study the possible effects that a strawpulp, beaten according to the above procedure, may produce in a stock.[7]

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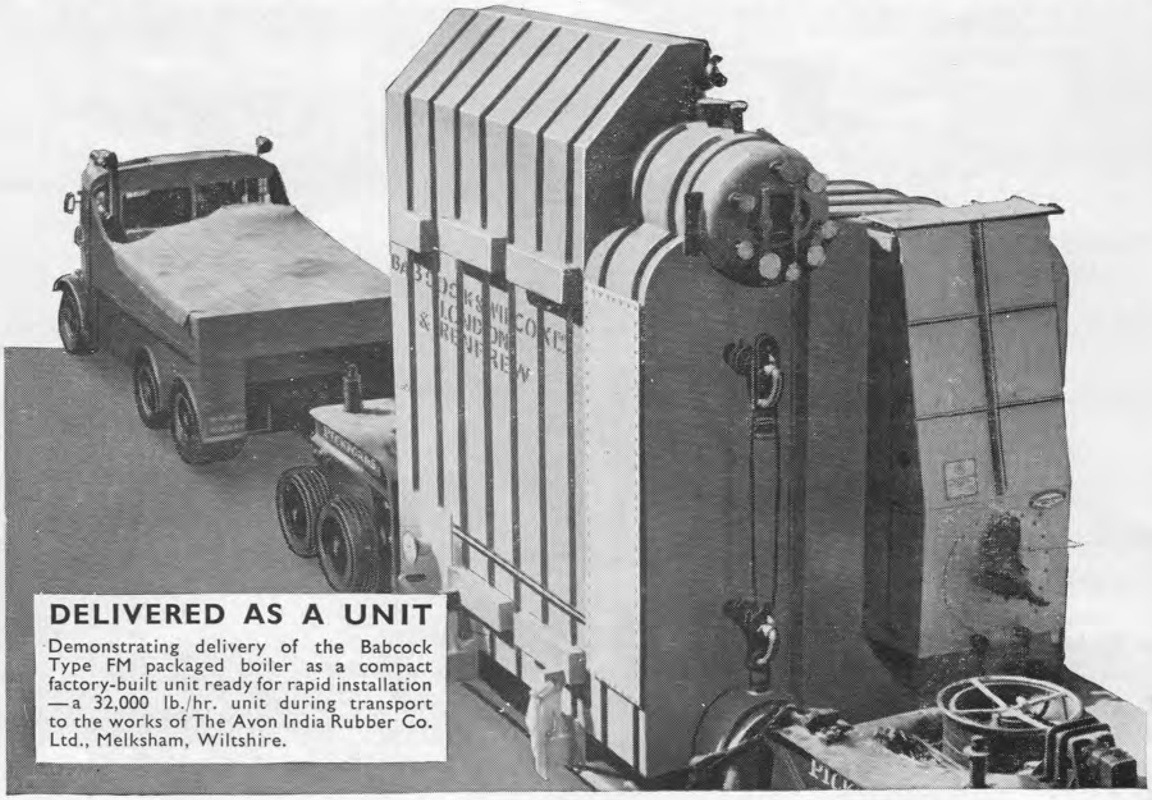

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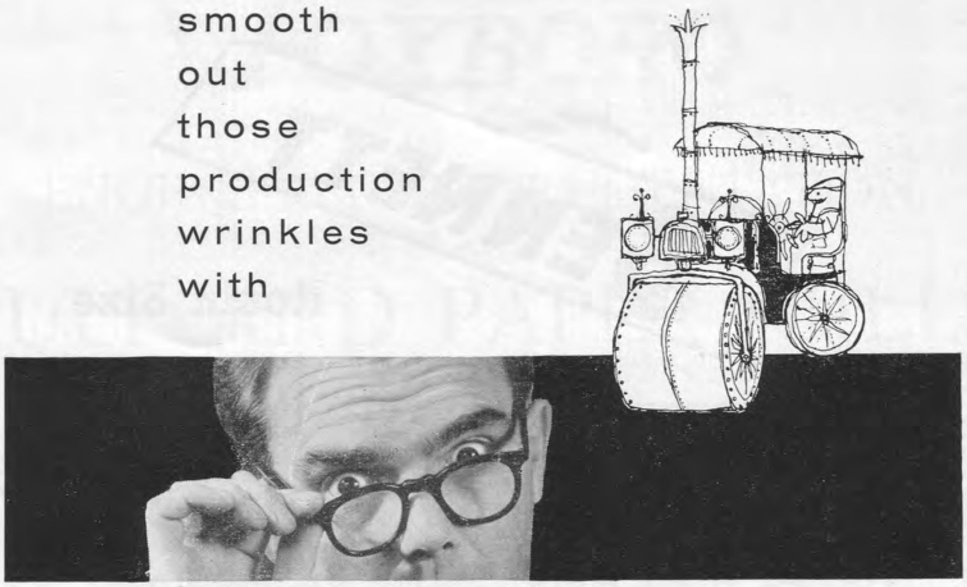

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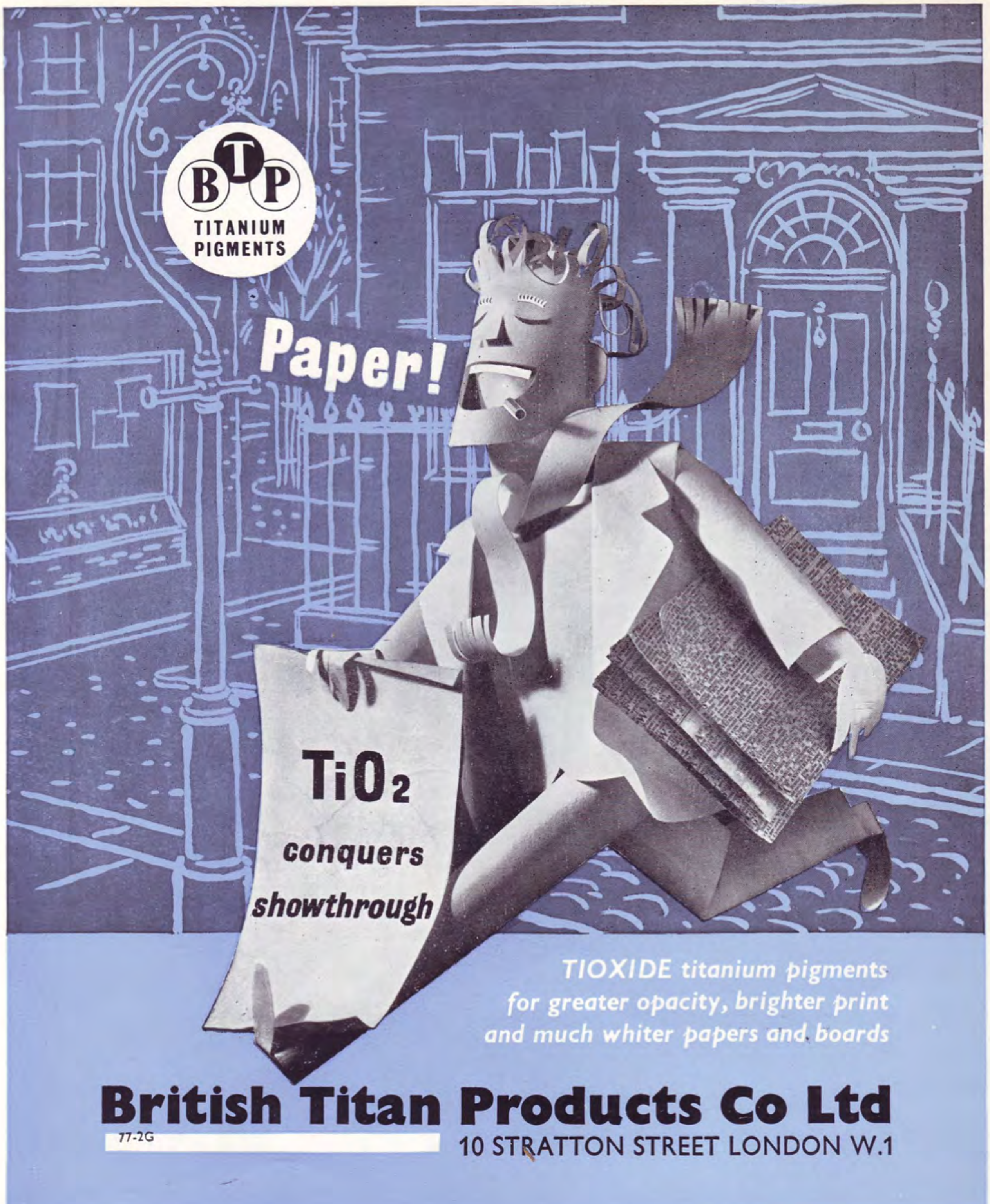

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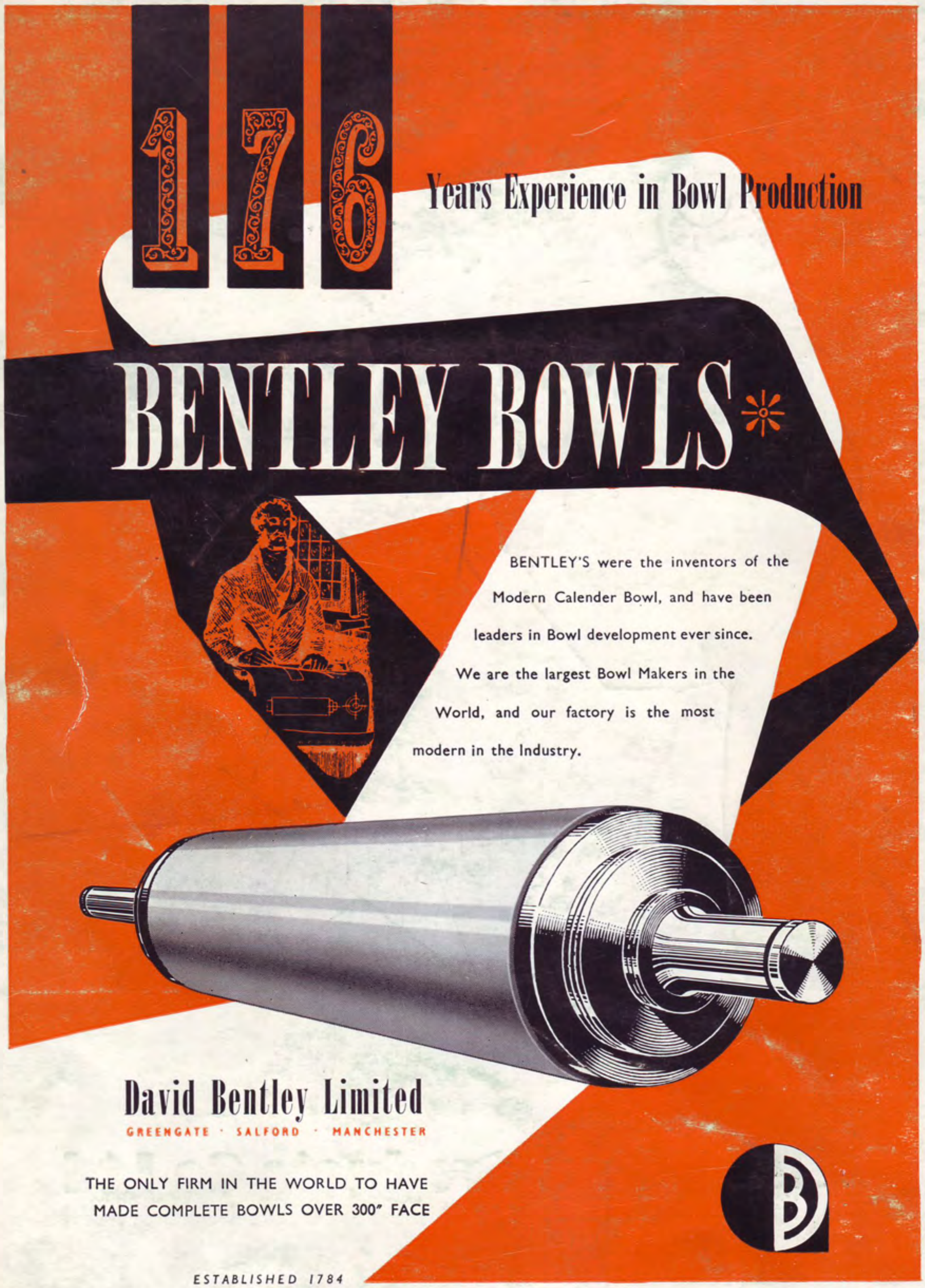
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