paper technology

pt

No 1

PUBLISHED BY THE TECHNICAL SECTION
BRITISH PAPER AND BOARD MAKERS ASSOCIATION
KENLEY SURREY ENGLAND

Paper Tech., Vol. 1, No. 1, pages 1 - 100: London, Feb. 1960

PAPER TECHNOLOGY

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

INCORPORATING TECHNICAL BULLETIN AND *
PROCEEDINGS OF THE TECHNICAL SECTION

February 1960 Vol. 1 No. 1

CONTENTS

Proceedings papers

* IMPORTANT NOTICE ON PAGES **17** & **18** *

Bulletin

Secretary and Editor —
F. M. Bolam, B.Sc., A.R.I.C.
Assistant Editor —
W. J. Abercrombie, B.Sc.

Published by the Technical Section of the British Paper and Board Makers' Association (Incorporated) at St. Winifred's, Welcomes Road, Kenley, Surrey

Telephone—Uplands 4956
Telegrams—Tecsec, Purley

PAPER TECHNOLOGY is issued every two months to all Technical Section members
Each year's six issues form a volume
Subscription rates per annum —
Members' extra copies 4 gn.; Non-members 5 gn.; *pro rata* for single issues

Printed at Old Trafford, Manchester 16, by Jesse Broad & Co. Ltd.

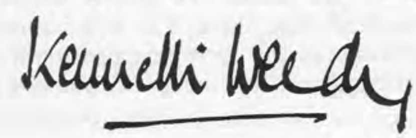
Chairman's introduction

THIS is both a requiem and a greeting, for, in introducing this first issue of the Technical Section's new publication PAPER TECHNOLOGY, we simultaneously mark the end of our former journal *Proceedings*, of which no less than forty volumes have appeared in the years since our foundation. There was always something rather friendly about that familiar terra cotta cover and the overcoat-pocket sized format that seemed so admirably adapted to reading in the train, even if there was a faint residual whiff of the broad gauge in its unpretentious solidity. There must be many men now occupying advanced positions in our industry who can think back to their early days when by hook or by crook they would beg, borrow or steal those precious volumes—then not so widely circulated—from their seniors, so that they could pursue their studies of the technical problems of the day after work was done. The auld acquaintance so formed will not easily be forgot.

BUT times change and tastes with them, with the consequence that the Publications and Library Committee realised some time ago that a new approach to the production of our journal was needed and began to work towards that end. Sizes, thicknesses, frequency of publication, cover designs and typefaces . . . these and many other problems came under scrutiny, criticism and rescrutiny, until as the result of two years of appraisal, final ideas were formulated and approved which resulted in the production of PAPER TECHNOLOGY. I should like to pay tribute to all the members of the Committee who have worked so hard and so willingly on this project and also to recognise the valuable assistance we have received from Mr. J. R. Prest and other members of the Publicity Design Unit of Wiggins, Teape and Co. Ltd. I should like also to thank our advertisers for the support they have given us and for the ready way in which they have adapted their matter to the change of format.

WHAT does this change mark? Not merely change for its own sake, but a genuine step in the development of the Technical Section as it moves forward from its start in the minds of a few farsighted enthusiasts to its eventual status as an industrial learned society. It has been repeated *ad nauseum* that we live in an age of technology, when precept may stealthily outrun practice almost overnight, but a truism loses only its impact and not its verity with repetition. In industry, technology is the lifestream itself and the harder the road that we have to travel, the more it is essential for survival in a competitive world that the stream should be adequate in both quantity and quality to sustain the whole.

OUR greatest hope lies in the sparking of ideas from contacts of restless inquiring minds, from the analysis of tenets (cherished though they may be) and the ruthless rejection of what is found to be false. Our future lies in the firm belief that there must always be a better way or a more accurate appreciation and it is my hope that the Technical Section will continue, through the medium of this issue and those that will follow, substantially to help all those who seek this grail.



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—

Testing the suitability of base paper for corrugating

W. Brecht and W. Berthold
Wochbl. Papierfabr., 1959, **87** (11/12), 467

THE equipment used to test the flat crushing strength of corrugated board was a Concora medium fluter made by the Container Corpn. of America and a crush pressure tester made by Paper Testing Machines of New York.

Experiments on papers made from different furnishes and of different basis weights confirmed that there was a close relationship between the crushing pressure found for commercial corrugated board and that for the test strip, made on the Concora fluter, from the same base paper. There was also good correlation between results found using sheets made on a laboratory sheetmachine and corrugated in the Concora fluter and the results from tests on commercial corrugated board made from the same stock. It is thus possible to obtain an idea of the suitability of a base paper for corrugating in the laboratory without recourse to either a papermachine or to a corrugating boardmachine.

Experiments carried out using an unbleached spruce sulphite pulp and a spruce semi-chemical pulp showed that the type of pulp had an important effect on crushing strength, which could be increased by beating the pulp. Other conditions remaining the same, the crushing strength increased sharply with increased basis weight and, if the pulp wetness and the paper basis weight were the same, the crushing strength was higher the lower the paper's apparent specific gravity, that is, the thicker it is.

The stiffness of the paper increased with thickness and so does the force necessary to press the corrugations out of the sheet. A special series of experiments showed that there was a relationship between the stiffness of the corrugating medium and the crushing strength of the corrugated board made from it.

Investigations on the yellowing of chemical pulps and paper

A. Roudier and A. Saulquin-Bisson
ATIP Bull., 1959, (3), 109

THE causes of the yellowing of pulps and paper have been the subject of many investigations; although many different theories have been advanced, very little positive information on this phenomenon has been obtained. It is well known that reducing sugars, especially those formed by the hydrolysis of cellulose and the hemicelluloses, readily form decomposition products containing carbonyl and carboxyl groups and double bonds. These products, in turn, are readily condensed and oxidised to give strongly brown substances. The aim of the present investigation was —

1. To elucidate the probable role of the degradation products of cellulose and hemicellulose in the yellowing of pulps and papers.

2. To study certain aspects of yellowing.

3. To formulate a method of examining the effect of certain substances on yellowing.

It was found from the experiments that, during the process of ageing, coloured materials could be formed by the glucides (cellulose and hemicelluloses) of the paper and that these materials could produce a strong yellow colouration of the sheet. These materials are probably formed by way of intermediate leuco-derivatives. When pulps are naturally or artificially aged and extracted with 95 per cent. alcohol, examination of the ultra-violet absorption spectrum of the extract shows that there is an absorption peak at a wavelength of approximately 2 580 Å, which it is suggested may be caused by one of the leuco-derivatives. The degradation of cellulose or hemicelluloses in the sheet may be initiated by a chemical reaction (for example, the effect of acid) and can then continue spontaneously even in darkness, with the ultimate yellowing of the paper. Most of the coloured materials so formed can easily be extracted by water and seem to have comparatively low molecular weights.

Small amounts of free reducing sugars caused considerable yellowing when sheets made from bleached cotton linters were artificially aged. The presence of small quantities of alkalis (sodium carbonate or disodium phosphate) or acids (sulphuric or oxalic) degraded cellulose with simultaneous formation of substances that coloured the cellulose yellow-brown.

(*continued on page 11*)

In a series of experiments with amino acids, it was found that glycine, proline, α-alanine and especially the sulphur-containing amino acid cysteine reacted with the leuco-derivatives such as furfural to give strongly coloured complexes. In addition, glycine degraded the cellulose during artificial ageing and formed highly coloured substances.

Much work remains to be done on the phenomenon of yellowing, but this investigation has provided several pointers for future studies.

Studies on the slice of a newsprint machine

W. Müller-Rid and G. Pausch
Wochbl. Papierfabr., 1959, **87** (11/12), 478

THE machine used in the investigation was an old type of newsprint machine that had been modernised by reconstruction of the breast box and the wire and press parts. The trim width was 3 600 mm. (142 in.) and the maximum speed of 400 m. (1 312 ft.)/min. was fixed by the limitations of the drive and the dryer part.

The breast box was of the closed, pressure type and in these experiments three different types of slice were tested—

1. Baffle slice
2. Projection slice
3. Combined projection and baffle slice

All three types were fitted to the breast box so that the impingement angle, the flow length and the point of impingement were kept approximately the same.

In the simple baffle slice, the flow of stock was controlled by a vertically adjustable strip, fixed to the lower edge of the front side of the box. On the other hand, in the projection slice, the flow was regulated by adjusting the lip itself and, in the combined baffle and projection slice, the sheet profile was controlled by a strip, corresponding to that in the simple baffle arrangement, fixed at the end of the projection part. In contrast to the simple projection slice, the upper lip of the projection part does not move.

The finished sheet was used as the main criterion for a comparison of the three slice systems. The main part of the experiment was concerned with investigating the sheet profile and, for this purpose, test strips were taken daily for several months. In a special experiment, profile measurements were made during a 4 hr. test period, in which no adjustments were allowed on any part of the machine. The investigation also included smoothness measurements across the machine, measurements on sheet formation and pressure head readings. During the course of the experiments, the most important stock properties—temperature, freeness, consistency, pH and ash content—were closely controlled and hence did not affect the results.

It was interesting to find that there was agreement between the experimental results and the evaluations made by the machine crew from their experience of operating the three types of slice. It was found that uniformity of basis weight could be controlled most quickly and accurately with a combined projection and baffle slice. The simple projection slice gave the greatest difficulties in controlling the basis weight. The baffle slice occupied an intermediate position.

It was, thus, conclusively found that adjustment of basis weight across the machine (that is, the fine adjustment of slice aperture) is most rapidly and accurately done with a baffle strip. It should be emphasised, however, that these experimental results were obtained from a limited number of operating conditions and when making newsprint at 400 m. (1 312 ft.)/min. More fundamental information can be obtained only from further studies on different types of paper.

Experiments on the use of plant gums in papermaking

E. Hochauz
Zellstoff u. Papier, 1959, **7** (8), 256

THE work showed that the addition of galactomannans to the stock was advantageous both economically and from the technical point of view. In every case, it was found that there were improvements in paper quality (strength, smoothness, transparency and look-through) and in operation of the papermachine. This included an increase in speed of 10 - 13 per cent. and considerable steam economies in the dryer part as a result of improved stuff drainage.

For the purpose of the investigation, the plant gums were classified as either 'retention type' or 'strength type', Daicol DG being taken as an example of the former type and Polygal 142 BS as an example of the latter. The addition of the strength-type gum reduced beating time by 20—30 per cent. without reducing any of the strength properties.

Besides the other advantages quoted above, the addition of retention-type gum improved fines and filler retention by 20—40 per cent. and correspondingly reduced the work to be done by the savealls and recovery equipment.

The use of galactomannans results in increased porosity of the paper, along with increased air and grease permeability, which can be disadvantageous for many grades.

The choice of the type of gum (retention or strength) to be used must be made with a clear idea of what effect is desired. The point of addition must be decided similarly and, in the case of the retention-type, allowance must be made for equipment for preparing and adding the gum solution.

The economic advantages must be decided in each case, for it involves not only the price of the added gum and that of the finished paper, but also the reduced power consumption in beating, the full use of beating capacity, the increased running speed and the steam economies in the dryer part of the paper-machine and, finally, a reduced need for fibre recovery equipment against an improvement in paper quality.

The use of cyclones for cleaning papermaking stock immediately before the head box

A. Gregerson
Norsk Skogind., 1959, **13** (8), 256

TRIAL runs that were made with different sizes of cyclones are described. It was found, by fractionating the fibres of inlet stock and reject for each run, that units bigger than a certain size tend to reject long fibres rather than short ones, whereas smaller units tend to reject short fibres. However, with increased beating of the pulp, there was a tendency to more pronounced rejection of short fibres. For cyclones over a certain size, the thickening factor (reject consistency/inlet consistency) and the fibre losses were found to decrease with increased beating. For smaller cyclones, the thickening factor seems to increase with increased beating.

Experiences in the use of a new kind of wire

G. S. Shapiro
Bumazh. Prom., 1959, **34** (6), 21

HAVING had difficulty in finding suitable wire for use on a high-speed newsprint machine, a new type of semi-twill weave wire was made with the following characteristics —

Number of warp wires per cm.	24
Number of weft wires per cm.	20
Diameter of warp wire	0.22 mm.
Diameter of weft wire	0.24 mm.
Size of mesh aperture in warp direction	0.260 mm.
Size of mesh aperture in weft direction	0.197 mm.
Area of mesh	0.051 sq.mm.
Number of meshes per sq. cm.	480
Effective open are per sq. cm.	24.54 sq. mm.

The difference between the new wire and the one normally used was that both the warp and weft wires were finer, the number of weft wires was increased from 15 to 20 per cm., the mesh number was increased from 372 to 480 per sq. cm., the mesh area was reduced from 0.0606 to 0.051 sq. mm., but the total effective area is increased by 2 per cent.

In spite of the fact that the total effective area was increased, it was found that the drainage rate was slower, but the wet web strength was increased, so that the speed between the couch roll and first press could be increased by 0.5—0.6 per cent. without causing the usual trouble with breaks and sticking to the couch roll. The improvements in production can be seen in Table 1.

TABLE 1

Machine No.	*Working life of wire in days*	*Paper production with normal wires (tons)*		*Paper production with experimental wires (tons)*		*Increase in hourly production, %*
		Total	*Hourly average*	*Total*	*Hourly average*	
2	8	655.0	4.43	—	—	
	17	—	—	1699.2	4.65	
	14	—	—	1366.6	4.67	
	13	1156.8	4.40	—	—	
	12	1158,7	4.16	—	—	
	18	—	—	1689.3	4.44	
	Average	—	*4.33*	—	*4.59*	*5*
3	11	618.2	3.47	—	—	
	14	—	—	1000.4	3.49	
	8	494.3	3.86	—	—	
	7	—	—	494.6	4.09	
	11	1016.5	4.42	—	—	
	13	—	—	1153.8	4.37	
	10	—	—	996.9	4.57	
	12	—	—	1040.1	4.38	
	9	711.2	4.00	—	—	
	Average	—	*3.94*	—	*4.18*	*7*
7	13	1094.7	4.00	—	—	
	15	—	—	1275.8	4.12	
	15	—	—	1229.8	4.21	
	Average	—	*4.00*	—	*4.17*	*4*
8	13	1101.8	4.16	—	—	
	15	—	—	1342.0	4.23	
	Average	—	*4.16*	—	*4.23*	*2*

The quality of the paper produced on the new type of wire was considerably higher, particularly in smoothness, formation, bulk and breaking length. The average working life of the wire was increased from 247.5 hr. to 322.2 hr.

(*Continued on page 79*)

RUSSIAN PAPER INDUSTRY

Book review

Paper: The fifth wonder— J. H. Ainsworth

(*Thomas Publishing Co., Kaukauna, Wisconsin,* 1958; 180 *pages*, $4.00)

THIS amusing little book presents the story of papermaking from the forest to converting processes in a racy and easily assimilable form. The subject is divided into twelve topics, each dealt with in the space of a fifteen page booklet and it is stated that the booklets can be obtained either separately or as a bound volume.

The text is illustrated by a large number of line drawings and, though the humour of these, as also of the text, may strike many as fatuous, there can be no doubt that they would serve a useful purpose in retaining the interest of someone wanting a general idea of papermaking, but not prepared to expend much mental effort. The value of the book, from the British point of view, is reduced by the fact that so much space is devoted to pulping methods; nevertheless, this could prove of value in providing a general picture of the pulp and paper industry and so provide a firm basis for an educational programme.

wja

(For your reading continued from page 69)

Electrokinetic streaming, viscous flow and electrical conduction in interfibre networks G. J. Biefer and S. G. Mason

Trans. Faraday Soc., 1959, **55** (7), 1239

The pore orientation factor—In treating (*a*) viscous flow, (*b*) electrokinetic phenomena and (*c*) electrical conductivity of liquids contained in porous materials, the pore system is often represented by an equivalent capillary network in which the pore-orientation (or tortuosity) factor is considered to be identical for the three. Measurements over a wide range of void fractions ϵ on pads of both non-swelling and swelling fibres have shown instead that the pore-orientation factor is proportional to $\epsilon^{1\cdot5}$ for electrokinetic movement and to ϵ for ionic conduction, but is constant for permeation. These differences account for discrepancies previously observed between the swollen specific volume determined by permeability and stream current measurement. They also serve to demonstrate that the conventionally used Briggs method of evaluating the zeta-potential is invalid and that the absolute values of all zeta-potential measurements based on streaming and electro-osmotic measurements reported in the literature, except those for single circular capillaries, are probably in error.

ATTENTION

This is the first 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 page T1 with each volume.

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

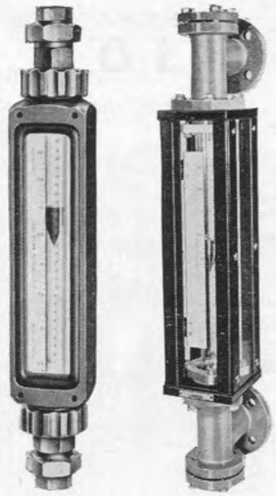
● Six issues of PAPER TECHNOLOGY will be published each year —

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 before 30th September 1960.

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

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



Rate of Flow

Glass tube Rotameters from stock for water, alum, size.

Ask for leaflet PA. 2020/19

Pneumatic Transmitting Rotameters for clay, dyes, size, alum, titanium dioxide.

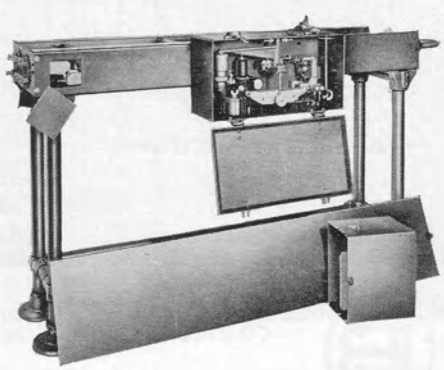
Ask for leaflet PA.2007/19

Instruments for the Paper Maker

Density

Continuous-weighing density meter to measure and control the density of clay slurry.

Ask for leaflet PA. 2042/19



ROTAMETER

FLUID MEASUREMENT AND CONTROL
FLOW-DENSITY-LEVEL

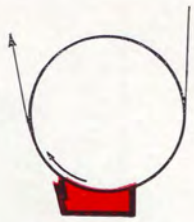
ROTAMETER MANUFACTURING CO. LTD.
PURLEY WAY, CROYDON, SURREY **Telephone: CROydon 3816**

THE BLACK-CLAWSON

FLEXIBLADE*

A UNIQUE HIGH SOLIDS BLADE COATER

★ Enclosed coating chamber
★ Coat weight can be varied and controlled while machine is running
★ Uniform coating



Coater up and coating

Black-Clawson's patented blade type coating machine for on and off-the-machine coating. Utilises an inverted flexible steel blade to deliver a smooth, pattern-free coating. It handles high solids coating which requires less adhesive, results in higher brightness and cuts down drying time.

The Flexiblade features an enclosed fountain and positive feed of coating without cascading of coating from the blade.

★ Coating does not spill
★ Blade change in less than a minute
★ Accessible for rapid clean-up

Coater down in cleaning position

COMPLETE COATING INSTALLATIONS FOR ALL APPLICATIONS

** Trade mark—Patented and other patents pending*

BLACK-CLAWSON INTERNATIONAL, LTD

BLACK-CLAWSON HOUSE, 18/19 SAVILE ROW, LONDON, W.1. Telephone Regent 8341

NEWS PAGE

Technical Section membership

DURING November and December 1959, the changes in membership were as shown—

Newly enrolled

London Division—
G. Bourne—*Junior*
R. H. Boyes—*Associate*
W. Good—*Full*
D. A. Harris—*Associate*
R. P. Hurd—*Full*
J. D. L. Lowenhoff—*Associate*
H. Montgomery—*Associate*
A. Pilkington—*Associate*
M. W. E. Shaw—*Junior*
C. H. Tomalin—*Full*
B. D. Veitch—*Junior*
T. A. K. Wright—*Full*

Scottish Division—
J. M. M. Coutts—*Full*

Overseas Associate—
G. B. Kulvik

Northern Division—
J. Arrowsmith—*Junior*
P. Barker—*Full*
D. Cartwright—*Full*
J. Garwood—*Associate*
T. J. Hamilton—*Full*
T. Kirkpatrick—*Full*
G. Lamb—*Junior*
D. N. Lister—*Full*
E. Lowton—*Full*
S. A. Underwood—*Full*
J. Unsworth—*Full*
J. C. Walker—*Full*
K. A. Wilby—*Junior*

Western Division—
A. T. Davies—*Associate*
K. A. Hyam—*Full*
R. B. Kitchen—*Full**

* Reinstated

Resignations and withdrawals

Northern Division—
J. T. Starkey—*Associate*

Overseas Associate—
J. F. Berger†

Scottish Division—
Holmes & Kingcombe—*Associate*

† Deceased

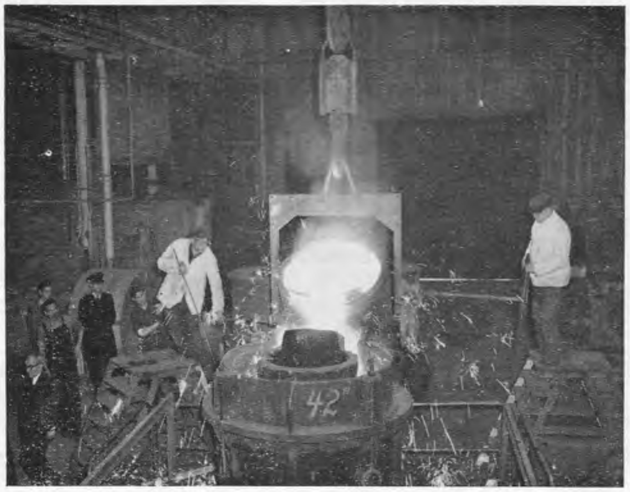
May we introduce . . .

THIS first issue of PAPER TECHNOLOGY represents a further stage in widening the scope of Technical Section membership. We hope the thought and care that has gone into its creation will commend it to members and other readers.

Your attention is drawn particularly to pages 17 and 18 where details are set out showing how PAPER TECHNOLOGY is carrying on the traditions of *Proceedings of the Technical Section* and *Technical Bulletin.*

Westgate Works on view

ON 23rd October 1959, the South Wales Discussion Group arranged a visit to the Black-Clawson International Ltd. Works at Newport.



The two photographs on this page show the absorbed interest in casting a drying cylinder.

This visit was well-attended and proved of great educational value. Visitors received illustrated brochures afterwards and very welcome tea before leaving.

Structure symposium

PLANS are now maturing for the next Technical Section Fundamental Research Symposium. This is to be held at Oxford during the week 24th–29th September 1961. The subject is the formation and structure of paper. Further details will be published in due course.

World forestry

PUBLICITY is now being given to the Fifth World Forestry Congress to be held at the University of Washington, Seattle, U.S.A., during the period 29th August—10th September 1960, the United States Government acting as host. The last congress was held in Dehra Dun, India in 1954.

The congress is essentially technical in nature and, by this exchange of information, it is hoped to advance the science and practice of forestry throughout the world and to foster international co-operation at all levels. The provisional programme includes the following items of special interest to the paper industry—

Section VI: Forest products

Session A—Wood: Its structure and physical and mechanical properties

1. Recent progress in research on wood cell wall structure.
2. Structure of wood as revealed by the electron microscope.
3. Influence of microscopic and submicroscopic structure on the anisotropic characteristics and properties of wood.
4. Rheology of wood.
5. Non-destructive tests to evaluate the physical and mechanical properties (sonic, ultrasonic and other methods).

Session C—Chemistry and biochemistry of wood

1. Chemistry of cellulose and its derivatives.
2. Chemistry of lignin.
3. Biochemistry of natural disintegration of wood.
4. Biochemistry of wood extractives.
5. Chemical conversion products from wood.

Session E—Integrated utilisation, including small sized timber and mill residues

1. Improved utilisation efficiency through integrated wood industries.
2. Use of thinnings and forest residues.
3. Use of sawdust and mill residue.
4. Better utilisation of low-quality woods through processing research.
5. Use of wood and wood residues in production of fibreboard and particle board.

Session G—Progress in developing new pulp sources

1. Pulping broadleaf trees (general paper).
2. Pulping tropical woods.
3. Newsprint from broadleaf woods.
4. Kraft paper and paperboard from broadleaf woods.
5. Feasibility of small pulpmill operation.

The congress will include tours and exhibits. For further information, enquiries should be made to Mr. I. T. Haig, Executive Secretary, Organising Committee, Fifth World Forestry Congress, Department of State, Washington 25, D.C., U.S.A.

TECHNICAL SECTION LIBRARY

✚ Recent acquisitions

Industrial Gums: Polysaccharides and their Derivatives—Edited by Roy L. Whistler
(*Academic Press, New York and London, 1959*)

Contents — Factors influencing gum costs and applications—R. L. Whistler; Agar—H. H. Selby and T. A. Selby; Danish agar—E. Christiansen; Algin—W. H. McNeely; Carrageenan—L. Stoloff; Fucoidan—W. H. McNeely; Laminaran—F. N. Woodward; Some lesser-known seaweed extracts—R. E. Schachat and M. Glicksman; Chitin and its derivatives—W. H. McNeely; Gum arabic—M. Glicksman and R. E. Schachat; Corn hull gum—S. A. Watson; Larch arabogalactan—A. W. Stout; Gum ghatti—J. Fleischer; Guar gum—A. M. Goldstein and E. N. Alter; Gum karaya—A. M. Goldstein and E. N. Alter; Locust bean gum—F. Rol; Pectin—W. A. Bender; Quince seed, psyllium seed and flaxseed gums—R. J. McCredie and R. L. Whistler; Tamarind—P. S. Rao; Ti—J. H. Payne; Gum tragacanth— C. M. Ferri; Wheat gums—J. Saarnio and J. N. BeMiller; Dextrans—P. J. Baker, Jnr.; Methylcellulose and its derivatives—G. K. Greminger, Jnr. and A. B. Savage; Hydroxyethylcellulose—R. T. K. Cornwell; Ethylhydroxyethylcellulose—I. Jullander; Sodium carboxymethylcellulose—J. B. Batdorf; Starch amylose—J. N. BeMiller and R. L. Whistler; Starch amylopectin (waxy corn and waxy sorghum)—J. W. Evans; Starch dextrins—C. C. Gapen and D. M. Rathmann; Starch hydroxyethyl ethers and other starch ethers—E. T. Hjermstad.

Recent Advances in the Chemistry of Cellulose and Starch—J. Honeyman
(*Heywood & Company Ltd., London, 1959*)

Paperboard and Paperboard Containers: A History—H. J. Bettendorf
(*Board Products Publishing Co., Illinois, 1946*)

Physics of Fibres—H. J. Woods
(*Institute of Physics, London, 1955, price 30s.*)

[Donated by the Institute of Physics]

(*continued on page 70*)

1958 Through the eyes of a papermachine designer

W. J. BINNS, A.M.I.Mech.E.
Director, Bentley & Jackson Ltd.

GIVEN AT A MEETING OF WESTERN DIVISION: THE COUNTY HOTEL, TAUNTON ON 30th JANUARY 1959, Mr. L. A. LAWRENCE IN THE CHAIR

Introduction

THE successes of tomorrow are based on the achievements of yesterday and, in examining the immediate past, it is often possible to detect future trends. From a papermaking engineering point of view, 1958 was a fascinating year, marked by many notable new plant installations of considerable size and with interest focused at different times during the year on newer items of development.

New plant installations have taken place in nearly every papermaking country and, in some of the countries we are very apt to dismiss as backward, it is significant to note not only the modern papermaking installations that are there already, but to be aware of the many new machines, etc. at present on order for these countries. New papermachines, particularly those of fairly large size and output, are now almost inconceivably complex, if we compare them with their counterparts of only 10 or 15 years ago. Are we perhaps overrunning ourselves in this striving for the last degree in instrumentation and automation? Very considerable sums indeed are now being spent on superimposed instrumentation and it would be interesting to have a true assessment whether this results in a reduction of manpower per ton of paper.

Certainly, the last seven or eight years have seen a considerable jump in manufacturing speeds on certain qualities of paper, notably newsprint, krafts, etc., but just how necessary a factor elaborate control has become, as a means to this end, is very difficult to gauge. Instances are cited where newer high speed machines are taking appreciably less driving power and manpower per ton of paper than are older machines installed a few years ago, but certainly the capital costs of modern instrumentation for a large machine, plus the background of personnel necessary to maintain and make use of these instruments, must be a considerable factor in cost and one wonders whether this is taken wholly into account.

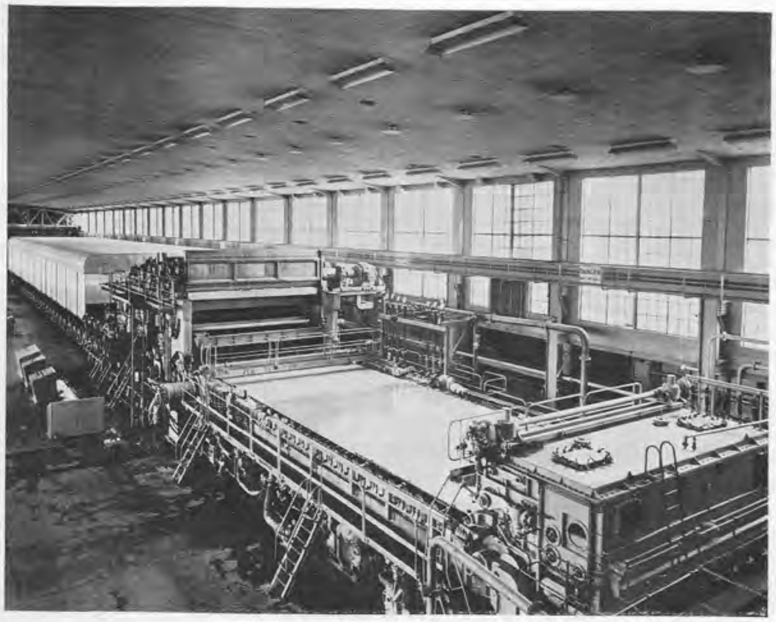
Prominent new machines of 1958

WITH the thought that you would like to have a look at some of the machines that have made the headlines in the past year, I have selected some illustrations of interesting units commissioned this year—naturally, only a tiny example of the whole.

The last new machine to be started up in Britain in 1958 is a 228 in. wire width, 210 in. trim Fourdrinier machine for the manufacture of magazine printings. It is installed at Aylesford Paper Mill and was built by Walmsleys (Bury) Ltd. (Fig. 1). The machine, in addition to being equipped with a machine coating system for magazine printings, is also quickly adaptable for the manufacture of newsprint. It has been built for a top speed of around 2 000 ft./min. and thus has a large overmargin on current speeds now being run on grades of magazine printings for rotogravure, etc. The degree of instrumentation on this particular machine, quoted as being the most highly and effectively instrumented papermachine of its type, may be judged from Fig. 2.

Fig. 3 shows a very interesting machine recently installed at Dartford Paper Mill, built by Millspaugh Ltd. primarily for the manufacture of banks, bonds and imitation glazed parchments of 30—80 g./sq. m. and to run at speeds up to 1 500 ft./min. Like the machine in Fig. 1, the machine is provided with a pressure head box (although of a different type) and has a wire 204 in. wide and 87 ft. long. Rather unusual for a machine of this size, the wire frame is cantilevered and there is an interesting press part (Fig. 4). This press is designed as a pick-up and the first press is of the reversing type, giving convenient immediate reversal of the sheet so as to present the wire side to a smooth roll whilst the sheet is still very moist. An added advantage of this inclined press and the reversal of the sheet in this manner is the easy disposal in a downward direction of broke from the first press, which is most conveniently deflected back into the sheet pit.

T2 A typical illustration of a modern British-built newsprint machine is the recently installed No. 5 machine started up just a few months ago at Bowater's Mersey Mill (Fig. 5) and built by Walmsleys (Bury) Ltd. The wire width is 294 in. and the machine has a top speed of 2 000 ft./min. This unit is now steadily producing supercalendered newsprint with a high machine efficiency. The press part contains a recent innovation—the air-bleed press (Fig. 6). In the normal suction press, it is customary for the felt and the paper to be led over the suction roll completely to seal the suction area: in the air-bleed press, the felt is still led over the whole of the suction area, but the paper is deliberately lifted from the felt, both before and after the nip. This causes a rush of air through the felt, which has an appreciable drying effect on the felt and has resulted in a greater drying effect on the paper, owing to the increased absorbency of the felt to water expressed at the nip.



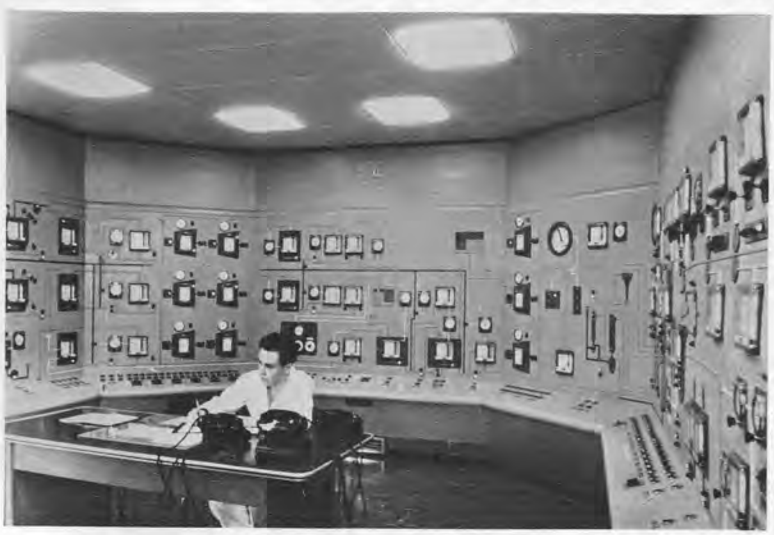


Fig. 1 (*above*) and *Fig. 2* (*below*)

An interesting machine commissioned during 1958 is the Great Lakes machine, known as Jupiter, which has a wire width of 343 in. and is designed to reach a top speed of 2 250 ft./min., when the output is estimated to be around 420 tons per day. This machine, large as it is, is fitted with a cantilever wire frame. This machine is challenged by one recently installed by Coosa River in the Southern States of America. Whichever machine has the edge on the other, there is real achievement in building and installing machines of this size. The boardmachine has 110 in. trim, with a maximum speed of 600 ft./min. and is designed to produce various qualities of lined chipboard and white-lined manilla. The vats are fed via individual rotary screens. The primary press section is unusually located over the vats, followed on machine floor level by a heavy main press section. The dryers in the main are stacked in the conventional board-machine manner, but are preceded by a horizontal two-tier section. The machine is completed by two calenders and a double-arm drum reel. The 150 in. width twin-wire machine built by Walmsleys (Bury) Ltd. for Tullis, Russell & Co. Ltd., Scotland has the second wire located in the machine basement, the paper sheet from the lower wire joining up with the top wire at the first or combining press. This particular machine is now manufacturing twin-wire papers and boards of really top quality on a scale not previously contemplated for such grades.

All these new machine installations embody a high degree of engineering skill.

New material and design features

Newer materials of construction are being used in an increasing manner; firstly, we had stainless steel, latterly, bonded plastics; now fibreglass, for instance, has been tried quite successfully on small machines for such items as saveall trays, when wirechanging has still to be done manually by removal of rolls, trays, etc. Significant changes have taken place in machine clothing; for instance, woollen dryer felts are now almost a thing of the past, Terylene felts are fairly firmly established and who knows, in a few years, whether even these may have been supplanted by clothing of a different type?

The design of Fourdrinier sections for many years has been dictated not only by their function of gravity drainage, but also by the necessity for having to clothe them with bronze woven wires that are easily damaged and have a relatively short life. A little while ago, one commenced to hear that nylon wires might be practicable and very considerable advances have been made in the past few months in such a development. In perhaps two years, we might see their widespread use, which could simplify Fourdrinier machine designs.

Press sections also have their designs in the melting pot and in the adoption of unusual layouts. For instance, the inverted press with a suction roll on top and a hard roll underneath gives quite a new method for reversing the sheet. Modern design, particularly the inclusion of the suction pick-up, has resulted in greater complexity and the designer has accordingly to pay greater attention to facilities for roll removal, felt changing, etc.

There has been unabated interest in size presses for surface sizing in the dry part, because of the undoubted improvement they give in printability in the paper, especially with the more arduous conditions of higher speeds, etc. in printing, which has coincided with moves on the papermaking side—the increased use of refining, the tendency to use raw and freer stock for higher production speeds and the consequent necessity to adopt balancing means of improvement in the finished surface of the paper. Size presses fall into two main types—vertical and horizontal. Claims are made for the convenience of both arrangements and the pros and cons have been well argued; whichever is preferred, the construction of the press and the installation in general should be executed with care and skill to ensure the right positioning of the press, the most advantageous paper leads, etc. (Fig. 7 and 8).

Coating continues to be of major interest, depending to some degree on the same reasons that make the size press popular. Large demand for coated paper has led to the application of much lighter weights of coating, especially for long runs of similar quality. On the other hand, trouble at the coating head results in the complete papermachine being shut down and, if frequent grade changes are desired or particularly heavy coating weights are needed, the value of off-machine coating must therefore still be considered. The tendency to install machine coating has continued quite strongly during the last year, both on new papermachines and on boardmachines.

A very persistent trend of the last year has been the increasing demand for machines of the Yankee or

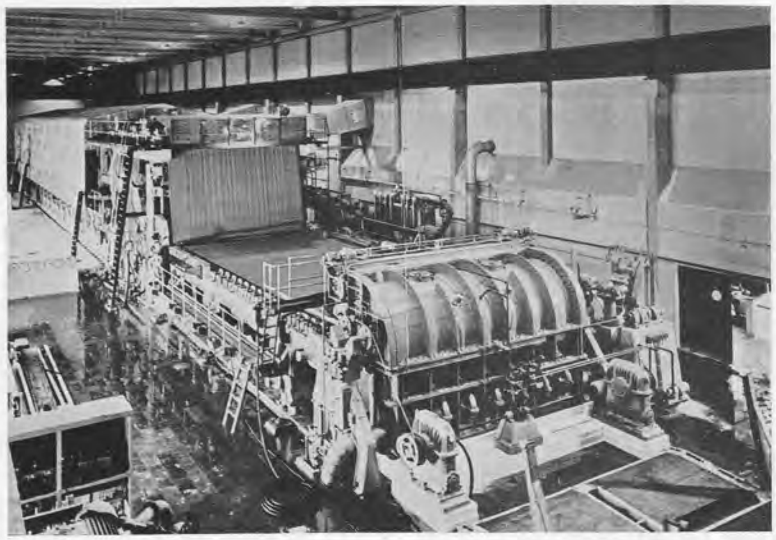
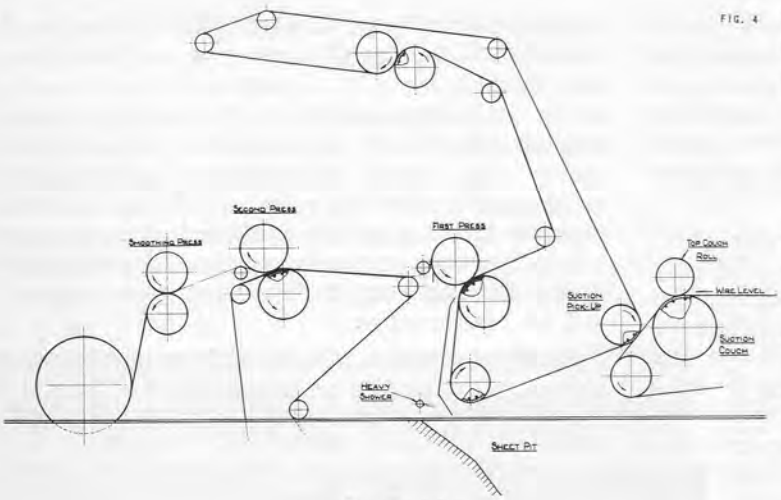
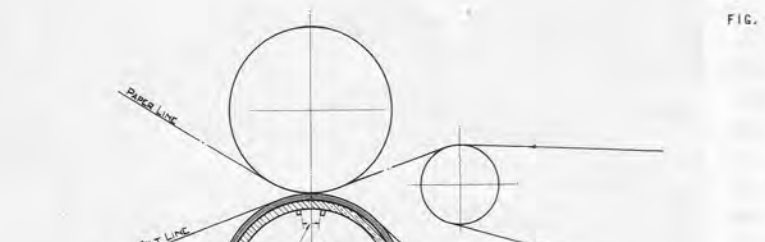


Fig. 4 (*above*) and ***Fig. 5*** (*below*)



Press part



Diagrammatic arrangement of bleed press

MG type, because of the very great emphasis now being given to the manufacture of soft, creped toilet paper for larger markets in this and other countries, resulting in the installation of many high speed tissue machines. These are of particular interest for their speed and other factors. The top speed is normally 2 500 ft./min. and the drying of the paper is done solely by one 12 ft. diameter Yankee cylinder and seven or nine after-dryers in the case of the heavier toilet and towel grades; sometimes even the after-dryers are omitted. This speed of manufacture has been made possible by startling steps forward in the working pressure of Yankee cylinders. Only a few years ago these cylinders were restricted to 50—60 lb./sq. in. working pressure,

FIG. 4

but the use of hitherto unused high tensile cast irons has enabled the working pressure to be boosted up to as high as 150 lb./sq. in. (Fig. 9 and 10).

New thoughts on sheet formation

TWO very significant trends in 1958 that might result in significant changes in fundamental machine design are new methods of sheet formation and a new approach to drying. Two developments associated with sheet formation are exciting current interest—

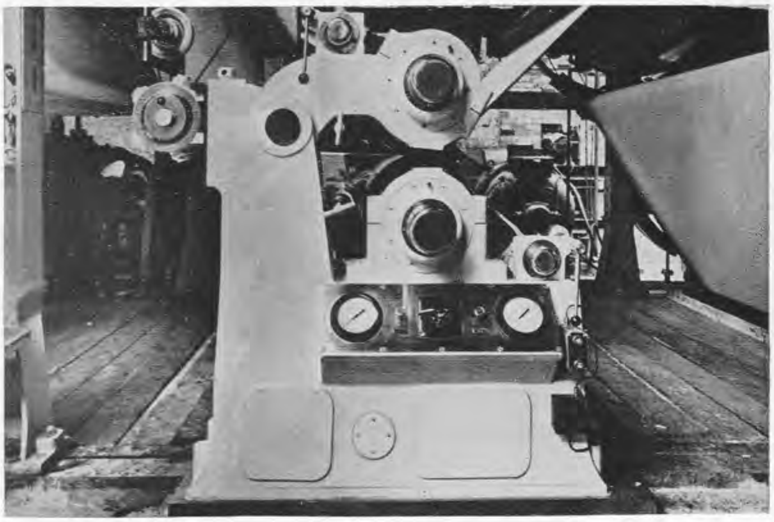
1. The British development of the system known as Inverform.
2. The development in America of formation on a cylinder mould with internal vacuum known as the Stevens former.

FIG. 6

The Inverform method is based on the use of a normal wire, extracting water by conventional means, but employing also a most original invention, the use of a top wire that, broadly speaking, is similar to the under wire but inverted. The dynamic forces so generated have been found sufficient to form the sheet and to force a considerable proportion of the water upwardly through the top wire and up inclined scrapers or deflectors (Fig. 11). The same top wire can be repeated five or six times in order to form a multi-layer sheet, which permits the manufacture of board qualities at speeds hitherto impossible, as conventional mould formation is limited by an optimum speed for the sheet adhering to the mould drum as it rotates in the vat.

A single top wire may be used for general qualities of paper (including, say, newsprint) and it is possible to manufacture single-ply papers, again at speeds not previously practicable—for instance, wet web newsprint has been produced on an experimental machine at speeds in excess of 3 000 ft./min. The method of feeding the stock to the wire also is greatly simplified. With conventional Fourdrinier operation, it is necessary to establish a stock velocity on to the moving wire approximately equivalent to the speed of the travelling wire, necessitating elaborate and expensive flow boxes. With the Inverform method, stock is admitted under a forming roll and the stock velocity is no longer a pertinent factor, as, provided the entry to the forming roll is kept sufficiently charged, the forming roll itself meters and levels the stock, thus doing away with one of the chief drawbacks up to now of conventional high speed Fourdrinier operation. It is believed that this is the first occasion on which public reference has been made to this most interesting development and no doubt in due course a more fitting and fuller presentation of the system will be made.

The Stevens former employs an entirely different method, the principle basically comprising a cylinder mould with internal suction, the stock being directed on to this suction area and the sheet formation being carried out in a very short space of time. The sheet is then lifted from the mould by suction pick-up or other device in the conventional manner (Fig. 12). Again an attempt has been made to do away with the long time for gravity drainage necessary for conventional Fourdrinier operation and it is claimed that the Stevens former (as for Inverform) can be multiplied to make multi-ply paper or board products or used singly for single-ply papers.



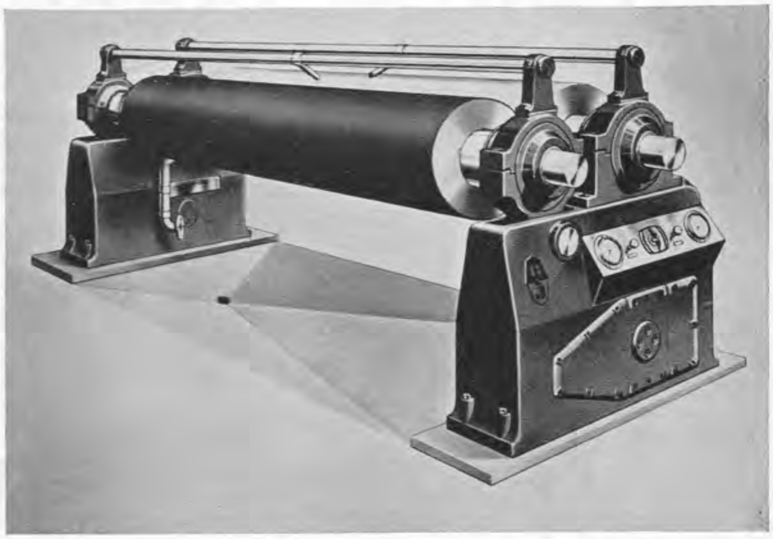


Fig. 7 (*above*) and ***Fig. 8*** (*below*)

New ideas on drying

In recent years, there has been a much greater appreciation of the value of hot, high velocity air as a drying medium. This was first exploited in Yankee hoods to increase greatly the evaporative capacity by establishing a fast-moving layer of heated dry air on the outside of the paper sheet. The temperature of the fast-moving air is of some importance, as one must strike a balance between choosing a temperature that in itself will have a high moisture-bearing potential and yet not reduce the temperature gradient between the inside of the cylinder and the outside of the paper, on which the effectiveness of the cylinder heat transfer is based. This same drying principle is now being experimentally tried with good effect on ordinary Fourdrinier dry parts for rather heavy paper or board (Fig. 13). The hoods are fitted quite close to the top row of drying cylinders and the felts are eliminated. The tendency to cockle (often caused by eliminating the felts) is supposedly overcome by generating sufficient pressure in the narrow band between the cylinder and the hood to keep the paper flat on the cylinder whilst being dried.

Of a more speculative nature has been the interest shown lately in the fluid bed method of drying. This principle consists of passing the web of material to be dried through a bed of many thousands of small particles, maybe glass spheres or even grains of sand, supported on an upward flowing stream of air (Fig. 14). The air velocity is such that the frictional drag on the particles is sufficient to balance their weight, but is not high enough to lift the particles from

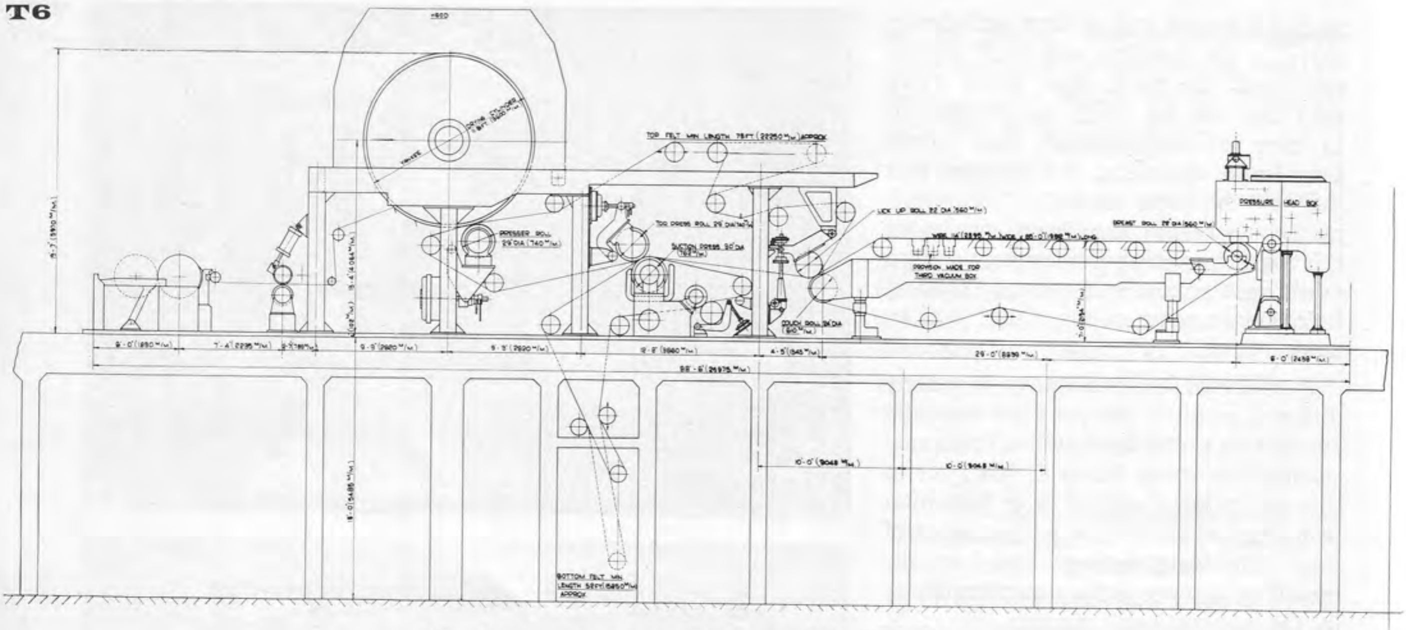


Fig. 9 — Arrangement of high speed tissue machine

Trim width 104 in. (2 640 mm.)
Wire 114 in. (2 895 mm.) wide × 65 ft. (19 812 mm.) long
Yankee drying cylinder 11.81 ft. (3 600 mm.) diameter

Steam pressure 6 atm. (gauge)
Working speed 492 – 1968 ft./min. (150 – 600 m./min.)
Scale of drawing 0.375 : 12

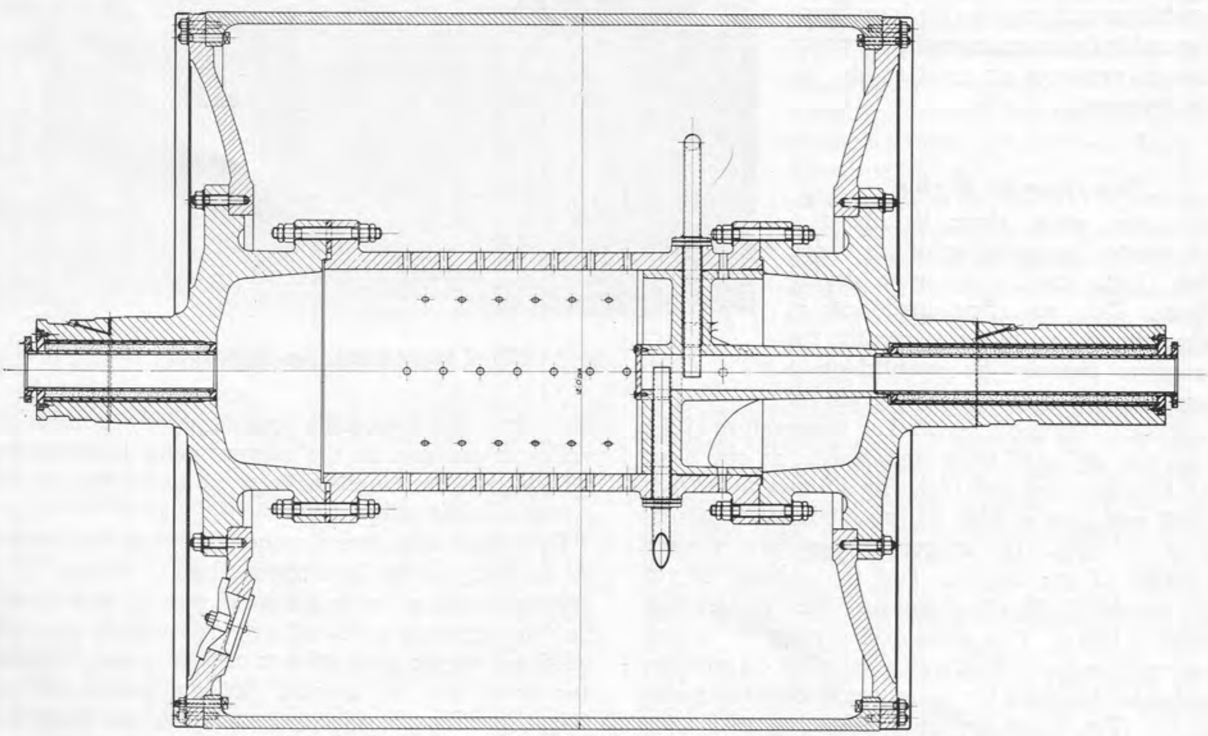


Fig. 10 — Section through a 12 ft. diameter drying cylinder suitable for a working steam pressure of 150 lb./sq. in.

FIG. 12

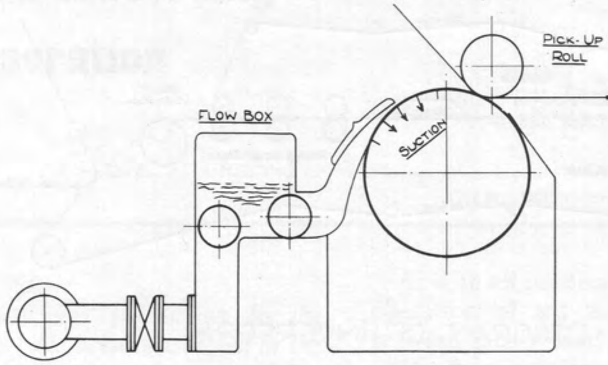


DIAGRAM OF STEVENS FORMER

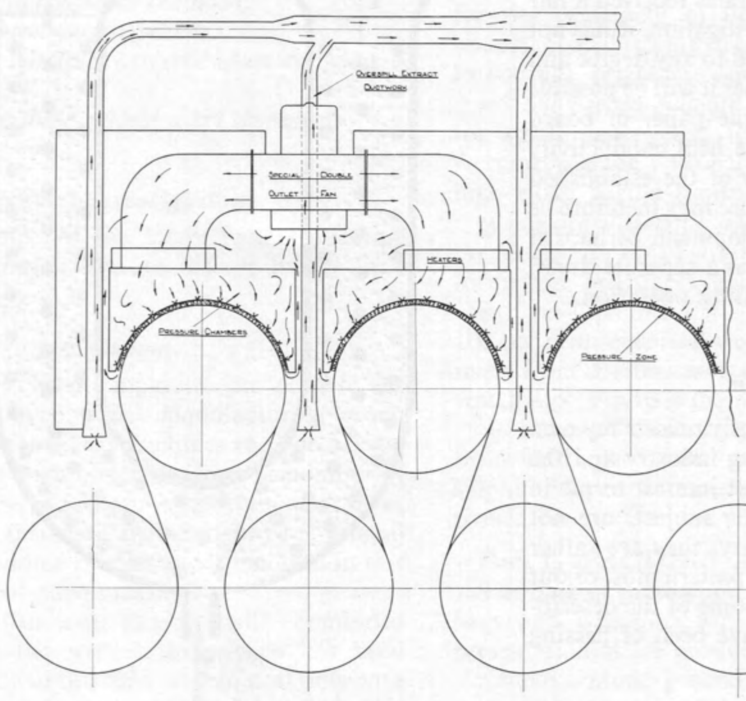


DIAGRAM OF NEW TYPE DRYER HOOD

Fig. 13

FIG. 11

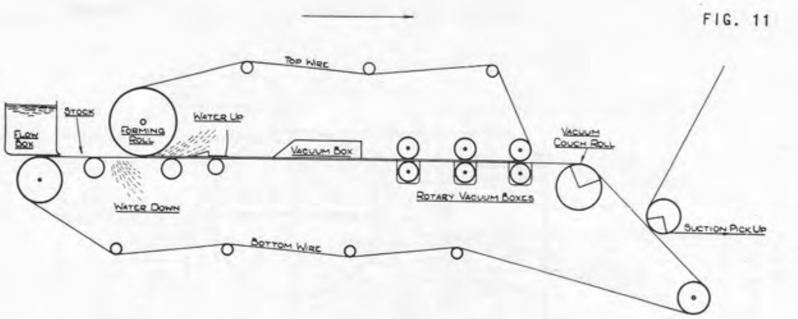


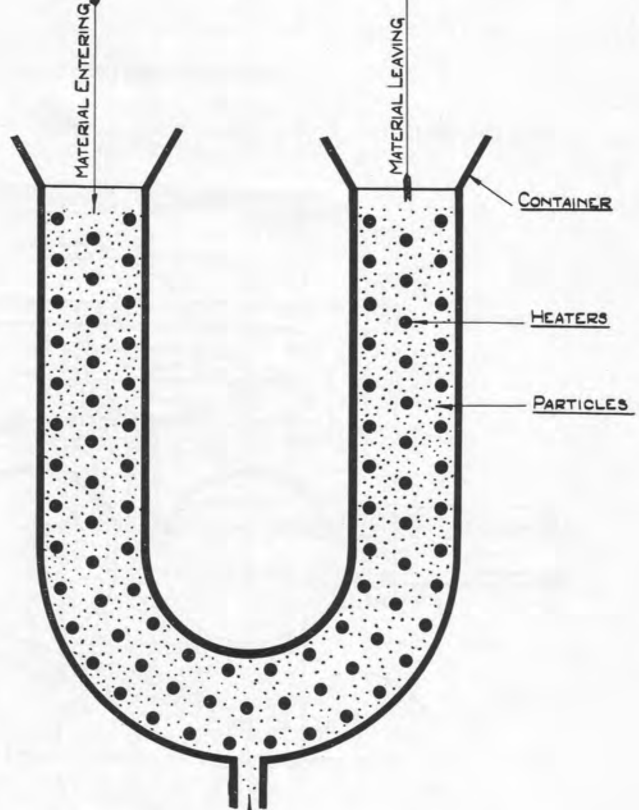
DIAGRAM OF INVERFORM

their container. Under these conditions, the whole bed of material resembles a liquid in behaviour. Its heat transfer properties are amongst the best of any known systems, because of the high thermal of a fluid. Whilst this system has received a fair conductivity measure of investigation, it has not yet been commercially applied to any degree and it seem rather doubtful whether it will be possible to use it effectively on a fragile paper or board web. On the other hand, the heat conductivity would be far superior to any of the established methods of drying and some use may therefore be found for this particular development, perhaps at the end of the dryer part or as a separate dryer, say, after an off-machine coating operation.

Conclusion

THIS review of 1958 obviously reflects my own contact with the papermaking industry and the points that have been of most interest to me in the past year. Inevitably, the subjects are not nicely linked—on the contrary, they are rather disconnected—but this is the pattern most of our lives follow and I trust that some of the descriptions or illustrations may have been of passing interest.

FIG. 14



FLUID BED DRYER

General factors concerning MG machine operation

J. CHAPMAN
Paper and Board Divisional Laboratory, Reed Group

GIVEN AT A MEETING OF NORTHERN DIVISION: ENGINEERS' CLUB, ALBERT SQUARE, MANCHESTER ON 4th DECEMBER 1959, MR. P. A. DUXBURY IN THE CHAIR

Synopsis

Factors affecting quality and production in the manufacture of MG *papers have been considered in the following report. Part 1 deals with quality, gloss being considered to be the most important quality required by the customer. The main factors affecting gloss have been found to be—*

(*a*) *Moisture content of the sheet before the* MG *press roll.*

(*b*) *Pressure at the* MG *nip.*

(*c*) *Freeness of the stuff used.*

In Part 2, it is considered that the main factors affecting drying capacity (and, hence, production) are—

(*a*) *Maximum cylinder temperature allowable.*

(*b*) *Optimum power input to the hood.*

(*c*) *Number of predryers required.*

These should be carefully assessed when designing a new machine.

Factors affecting these variables are discussed.

Object of investigation

To outline some of the many factors affecting MG machine operation and to discuss briefly their interrelationship.

Introduction

The writer has been employed on process investigation work by a paper manufacturing group operating four combined MG machines and two lick-up machines and has been concerned over a number of years with problems relating to MG machine operation. It was considered, therefore, that it might be of general interest to outline some of the factors involved in this particular aspect of papermaking.

It is intended to deal mainly with combined MG machines, as the writer's experience has been confined principally to this field, also to deal only with the dry end (predryers, MG cylinder and hood), as it is this part of the machine that makes the operation so distinctive and is the part that controls quality and on which the output of the machine is dependent.

As with all papermachines, the main problem in the operation of MG machines is to strike a balance between quality and production.

The factors affecting both quality and production are outlined in the following report, but it is considered that it would be useful, first of all, to outline the range and quality of MG papers usually made.

Range of MG *papers usually made and properties required*

MG *kraft*—This is used for the wrapping of fabrics and footwear, for the manufacture of carrier bags and for small packaging in general. Surface appearance and strength are the main qualities required.

MG *bleached kraft* (*sulphate*)—This is used mainly for the packaging of flour and sugar. The most important qualities are strength (in particular resistance to tearing), brightness and good printing surface.

MG *unbleached sulphite paper*—This paper is used for small paper bags for the provision and confectionery trade. Properties required are strength, high gloss, partial transparency.

MG *bleached sulphite paper*—This paper, after waxing, is used for bread wrapping and requires even sheet formation, brightness, good printability.

MG *envelope manilla*—This paper is made from 100 per cent. chemical woodpulp; cheaper grades are made from combinations of chemical and mechanical woodpulp. Finish is the most important property.

MG *tissue*—This paper is made in a variety of grades from 100 per cent. sulphite to 20 per cent. sulphite/80 per cent. mechanical woodpulps for toilet tissue.

Part 1—FACTORS AFFECTING QUALITY

The bulk of production in my own firm is for paper bags and wrapping for the millinery trade, where presentation of the product is of primary importance. To make a broad generalisation, excellent finish and reasonable strength is therefore of more importance than excellent strength and reasonable finish.

As paper in the MG process is put on to the MG cylinder at moisture contents well above the critical moisture content, it is not subjected to stress during the period when the fibre bonds are being formed. Hence, this effect, together with the pressing it receives, gives MG paper a higher burst figure than paper made on a Fourdrinier machine. The strength is thus usually adequate for the requirements and finish becomes a factor of great importance from the sales point of view.

The ideal finish is a perfectly flat sheet with a high uniform gloss, and, where applicable, a good definition of rib markings; however, some defects that can occur either singly or in combination are—

1. Low general gloss.
2. Cockled sheet.
3. Pitted sheet (lack of gloss in patches).
4. Irregular rib markings.
5. Indefinite rib markings.
6. Absence of finish between ribs.

Of all the necessary qualities, gloss is perhaps the most important.

Assessment of gloss

The final judge of the product is the customer, who makes a subjective assessment of the appearance of the sheet.

The Sheen glossmeter and the Ingersoll glarimeter are widely used to assess gloss for production control, but, as can be expected with such a complex phenomenon, neither is completely satisfactory. The subject of paper gloss and its assessment has been very thoroughly covered by V. G. W. Harrison.[(1)]

In the work reported as follows, the Ingersoll glarimeter had been used, as it was found that results from this instrument give good agreement with a subjective assessment made by several people experienced in judging MG finish.

Factors affecting gloss

Work was carried out at Aylesford in 1948 with the object of increasing the gloss of MG paper. Since that date, considerable improvements in operation have taken place, leading to a better product, partly as a result of this work, but it is considered that the conclusions arrived at are still valid and of interest.

It was considered that the major variables likely to affect finish were—

1. Moisture content at the MG nip.
2. MG nip pressure.
3. MG cylinder surface.
4. Type of furnish.
5. Freeness of stuff.
6. MG cylinder and predryer temperatures.

1. Moisture content at MG *nip*

This was investigated by slowing down the machine to produce varying moisture contents at the nip.

Results obtained when producing a 17 lb. D.C. 480, hard-sized MG plain kraft paper beaten to 200° C.S.F. are shown in Table 1. The machine had eleven predryers and the MG nip pressure was 350 lb./linear inch.

This was typical of several experiments and, in general, the moister the sheet at the MG nip the higher the gloss, with a corresponding reduction in production, owing to the increased quantity of water to be evaporated. It was apparent, however, that there was a very sharp reduction in finish in the moisture range 49 - 52 per cent. and that, for general operation, it was advisable to aim at a minimum moisture content of 55 per cent. before the nip under these conditions of nip pressure.

TABLE 1

Sample No.	*Wt. of sheet (lb. D.C.)*	*Condition of nip*	*Moisture content before nip, per cent.*	*Gloss, per cent.*	*Burst ratio*	*Appearance of sheet*
1	17	Dry	58.1	75.4	1.44	Good finish
2	18¼	Dry	57.2	74.3	1.45	Good finish
3	17¼	Dry	54.3	73.1	1.30	Very slightly cockled
4	17¾	Dry	53.2	71.3	1.40	Cockled
5	16	Dry	47.0	Very poor finish	1.30	Cockled and very low finish

2. MG *nip pressures*

At this time, the MG machines were operated at a nip pressure of 250 lb./linear inch, because of roll cambering difficulties across such wide machines (180 in.).

A series of samples of British and Scandinavian MG kraft papers made on combined machines were examined for gloss and bulk; they were also examined microscopically. Fig. 1 shows the variation of gloss with bulk.

These results indicated that the samples having the highest gloss had been subjected to higher compressive forces or were inherently more compressible.

Static tests were carried out in the laboratory, in which the full scale MG process was simulated as closely as possible by pressing a moist sheet under an MG felt on to a heated plate. Conditions were adjusted so that the plate temperature corresponded with the average temperature of the MG cylinder and the moisture content approximated to 55 per cent. when the first application of pressure occurred.

This series of experiments was conducted to ascertain the effect of variations in freeness and applied pressure on gloss when using a plate cut from rolled brass sheet $\frac{1}{16}$ in. thick, subsequently polished with a very light abrasive. This plate was used, because it was considered that the surface approached more nearly to the actual MG cylinder surface than did stainless steel (judged by observing the clarity of reflection of a sharply defined circle of light). However, these experiments were carried out with interesting results.

The glarimeter readings have been plotted in Fig. 2:

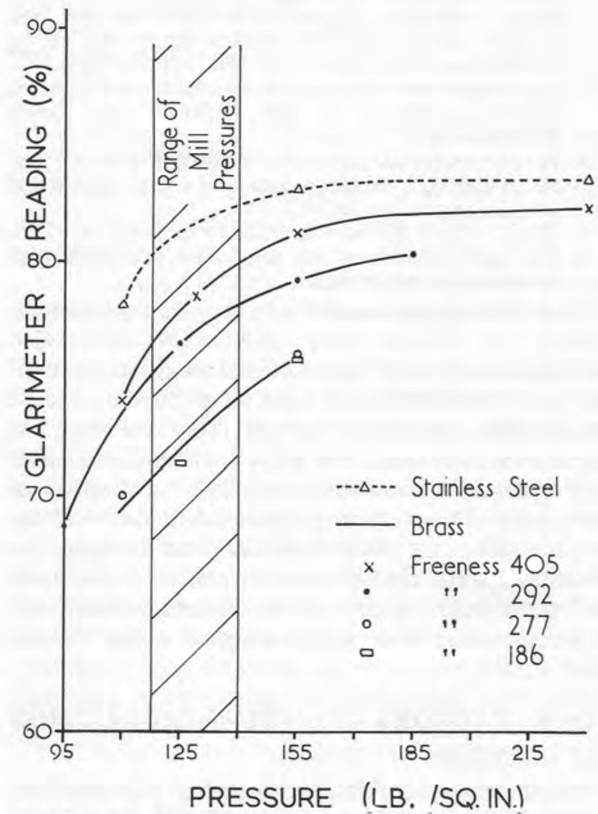


Fig. 1—Variation of gloss at various pressures and freenesses

each point represents the average gloss value of 8 sheets.

The curve for stainless steel was obtained using stuff of 350° C.S.F. freeness, but may be taken as representative of freenesses from 210° - 370° C.S.F., since a large number of sheets (40) was prepared from stuff varying in freeness within these limits and glazed at the same pressure of 155 lb./sq. in., in every case with no appreciable difference in gloss.

The actual pressures used in the mill were determined by placing a carbon paper between two sheets of foolscap, placing these in the nip of the MG machine, bringing the press roll up to 250 lb./linear inch and measuring the width of the carbon impression on the foolscap. This was repeated at 300 lb./linear inch. Of course, the age of the felt will affect the result, but this method was considered to give an approximate value of the pressure used. With a felt that had been in use for three weeks, the actual pressures on the paper corresponding to 250 and 300 lb./linear inch were 120 and 145 lb./sq. in., respectively.

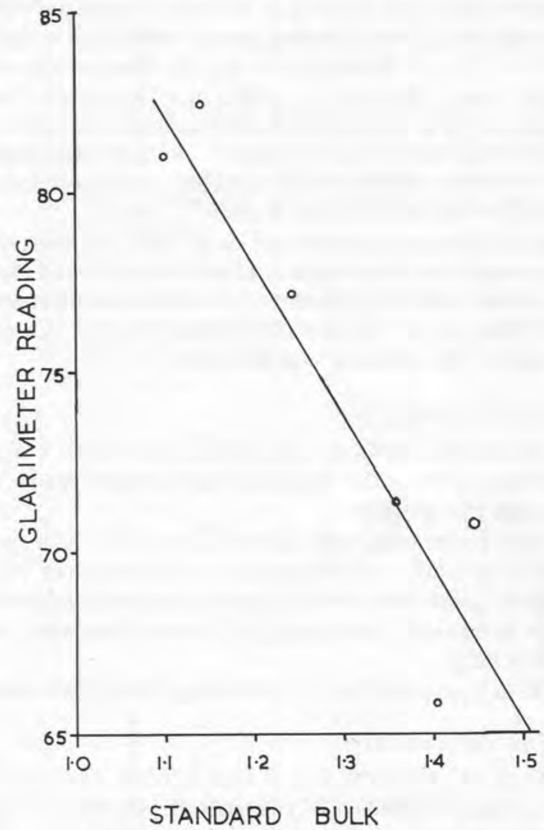


Fig. 2—Variation of gloss with bulk

From these results shown in Fig. 2, it appeared that the gloss/pressure curve for any freeness approached an asymptotic value of approximately 450 per linear inch.

The nip pressure on our MG machines has since been increased to this value and the average gloss increased from the range 65 - 70 per cent. to 75 - 80 per cent. on the Ingersoll glarimeter. Because of more careful cambering, no trouble with felts has been experienced.

T12 3. MG *cylinder surface*

The normal method of cylinder preparation is to grind the surface, using buffing wheels of various grit numbers so that the majority of the metal is removed quickly with a coarse wheel, then to polish with a wheel of a finer variety. The cylinder is then buffed, the buffing wheel being lubricated with normal soda ash fluid; as far as possible, the amount of energy expended in grinding is kept to a constant value as shown by an ammeter on the buffing motor.

When in operation, during the course of the first few days, a dark film of magnetic oxide of iron develops on the cylinder surface, which has a very smooth finish. To investigate whether this finish could be improved, it was intended to buff and polish a small area to a mirror finish and to see the effect of this on paper gloss. However, a rather neat technique was suggested by P. H. Prior, which involved the preparation of 1 sq. in. of silver foil, 0.001 in. thick, burnished to a mirror finish, then inserted during normal operation between the felt and the nip roll.

No difference in gloss could be detected between the paper that had been in contact with the foil and that in contact with the cylinder. It was concluded therefore that, at the nip pressures then used, the normal surface of the cylinder was adequate.

4. *Type of furnish*

The indications from mill operation are that a high proportion of moist pulp in the furnish tends to improve the gloss.

Operational runs on the machine with furnishes consisting wholly of moist pulp produced paper with a higher gloss than similar paper produced under the same conditions, but using a furnish consisting of air-dry pulp.

The average increase in percentage was 4 per cent.

5. *Effect of freeness*

It can be seen from Fig. 2 that freeness of the stuff had an appreciable effect on gloss at pressures of the order produced in the mill; the freer the stuff, the higher the resulting gloss.

Taking the extreme case, if the sheet has been formed from very well-beaten stock, there is a tendency for the final sheet to be pock-marked. This is due presumably to the greater resistance to passage through the sheet of water vapour generated at the metal/paper interface.

6. *Temperature of* MG *cylinder and predryers*

Providing the temperature of the MG cylinder is regulated to obviate the phenomenon of pock-marking mentioned above, MG cylinder temperature does not appear to have any marked effect on gloss. The effect of temperature will be discussed at greater length in the section on production.

The temperature of the predryers is important in so far as an even temperature gradient is necessary to prevent cockling and to produce a flat sheet.

Conclusions relating to MG gloss

To sum up, the main conclusions reached concerning the factors affecting the gloss of MG kraft found from the work described above were—

1. The higher the moisture content of the wet sheet before the nip roll, the better the gloss, 55 per cent. being a minimum figure below which the moisture content should not fall. (This figure related to conditions of nip pressure of 350 lb./linear inch.)
2. The higher the nip pressure, the better the gloss, a minimum pressure of 450 lb./linear inch being recommended.
3. It is considered that the present finish of the MG cylinders is adequate and no further mechanical preparation is necessary.
4. Moist pulp in the furnish tends to increase the gloss.
5. The stuff should be as free as possible, consistent with the strength requirements.

The conclusions reached above were largely confirmed by Brauns and Peterson,[2] who also investigated, on their experimental machine, some of the factors influencing the finish of MG paper. In these experiments, an unbleached kraft pulp was used, the paper substance was 25 lb. D.C., 480 and the machine was operated as a lick-up machine at a speed of 80 ft./min. This work was published in 1953 and the main conclusions were that the best furnish was obtained for the highest moisture content of the sheet and the highest roll pressure at the first pressure roll, in combination with wet beating to about 20° S.R. (600° C.S.F.).

Part 2—FACTORS AFFECTING PRODUCTION

1(*a*) MG *cylinder*

Assuming the heat transfer coefficient of condensing steam to the metal surface, also the conductivity between the outer cylinder surface and the paper to be constant for different cylinders, the drying capacity of the MG cylinder will depend on—

Diameter of cylinder
Steam pressure
Cylinder wall thickness
Conductivity of metal wall

The wall thickness of an MG cylinder is fixed by the steam pressure to be used, the diameter and the tensile strength of the metal, from consideration of the maximum stress allowable (including the safety factor).

As the working steam pressure is increased, the wall thickness has to be increased and a point is reached when the greater heat transfer from the higher temperature steam is more than offset by the increased thermal resistance of the cylinder wall.

Examples showing the range of properties of cast irons available are—

Metal	*Tensile strength, lb./sq. in.*	*Thermal conductivity, B.T.U./ft./hr./°F*
American high tensile cast iron	80 000	17
High tensile molybdenum cast iron	60 000	27
Normal cast iron.. ..	35 000	30

This is complicated by the fact that Janson[3] has developed a method for determining the conductivity *in situ* and has found a value of 22 B.T.U./ft./hr./°F, instead of the normally accepted value of 30 for ordinary cast iron.

M. D. Jepson[4] has calculated the optimum steam pressure for cylinders of different diameters fitted with Spooner hoods (*see* Fig. 3).

An excellent series of papers[5] has been published by the staff of the Papermills Central Laboratory of the Swedish Forest Products Research Institute, in which the factors affecting heat transmission through MG cylinders have been discussed and reporting experimental work carried out to determine the numerical values of various coefficients pertaining to the drying process. It is stated that, "An absolutely clear answer cannot yet be given on the question of which shell thickness gives optimum operating conditions", nevertheless, it is considered that a significant contribution to knowledge about this problem has been made.

The value of this coefficient is very critical for cellulose wadding machines, where a very thin sheet is produced, allowing very high rates of evaporation. Cylinders making this type of material usually operate at steam pressures of 120 - 150 lb./sq. in.

For making normal grades of MG wrapping papers and toilet tissue in this country, however, the normal procedure is not to exceed a steam pressure of 50 lb./sq. in., in order to prevent blistering and pock-marking, particularly on wet-beaten sheets. In mills using slush pulp, this pressure can be increased as the stuff can be run at higher freenesses, so facilitating passage of water vapour through the sheet during the drying process.

The question of cylinder pressure and temperature has been examined more closely in the following section.

1(b). Effect of cylinder temperatures on production and quality

Several American mills were visited in 1955 with the object of investigating the effect of high cylinder temperatures on quality and production of MG papers. The details of the machines examined and the properties of the papers produced are given in Tables 2, 3 and 4.

It appeared from discussions at various mills that the American market is not as discriminating as the British market on the quality of MG paper. Bearing this in mind, it was concluded that—

1. The use of slush stock permits the stock to be run at higher freenesses (600° C.S.F.), which will give far less trouble on a hot cylinder than will a wet-beaten sheet.
2. With slush stock, a lower moisture content can be permitted as the sheet goes on the cylinder and still retains some gloss.
3. The higher the production rate, the lower the quality.
4. With the pulps used in England and the quality of paper required, it is considered that these high cylinder pressures (above 70 lb./sq. in.) could not be used in this country.

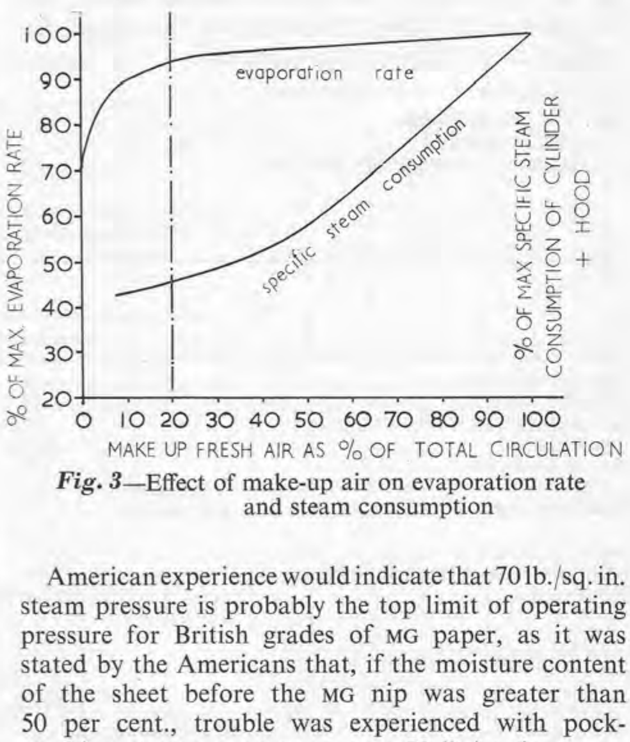


Fig. 3—Effect of make-up air on evaporation rate and steam consumption

American experience would indicate that 70 lb./sq. in. steam pressure is probably the top limit of operating pressure for British grades of MG paper, as it was stated by the Americans that, if the moisture content of the sheet before the MG nip was greater than 50 per cent., trouble was experienced with pock-marking at steam pressures over 70 lb./sq. in.

TABLE 2—PRODUCTION DATA

	Mill A		Mill B	Mill C
	No. 3 machine	*No. 4 machine*	*No. 3 machine*	—
Product	Bleached kraft	Bleached kraft	Kraft (olive green)	Kraft (ribbed)
Air-dry substance, lb. D.C., 480	16.7 – 23.9	23.4 – 28.3	20	17.5
Gloss, per cent.	52 59	55 61	76	59
Burst ratio	1.00 1.15	1.11 1.14	1.34	1.07
Freeness of stuff, °C.S.F.	Approx. 600	Approx. 600	Approx. 600	
Trim width of sheet, in.	156	120	164	136
Production (*1*) on normal deckle, cwt./hr.	55.8	37.2	66.4	79.1
(*2*) on 180 in. width, cwt./hr.	63.1	55.8	48.1	104.7
Moisture content after MG nip, per cent.	40	45	45 – 50	45
Moisture content after MG cylinder, per cent.	5 – 6	5 – 6	7	8
Nip pressure, lb./linear inch	350	350	375	—
Evaporation capacity of MG cylinder and hood Drying rate, lb./sq. ft. of cylinder/hr.	6.7	5.7	7.9	12.6

The maximum cylinder temperatures that can be used for various weights of paper and made at different freenesses without causing pock-marking have not been determined with any degree of accuracy, though this would be a worthwhile exercise before ordering any new MG cylinder.

2. MG *cylinder hoods*

All modern hoods now use the principle of directing jets of high velocity hot air on to the sheet, with recirculation of a large proportion of the humid air.

The factors affecting drying rate are—

1. Distance of nozzle from sheet.
2. Air temperature.
3. Air humidity.
4. Mass air flow (or air velocity).

Considering these in more detail—

1. On MG cylinders, nozzles are of necessity usually placed about 2 in. away from the sheet to facilitate cleaning and to avoid any build up of paper.

2. Air temperatures used in the hood vary from 230°F to 320°F, depending on the steam supply.

3. The air humidity is controlled by the proportion of make-up fresh air and a curve is given by Jepson(4) of the evaporation rate of a cylinder plus hood plotted against steam consumption (Fig. 4).

It will be seen that for the introduction of more than approximately 20 per cent. make-up fresh air, the evaporation rate increases very little for a large increase in specific steam consumption.

TABLE 3—MACHINE DATA

	Mill A		Mill B	Mill C
	No. 3 machine	*No. 4 machine*		
Cylinder diameter, ft.	12	12	12	12
Cylinder width, in.	172	136	174	150
MG cylinder steam pressure, p.s.i.g.	72	86	70	104
Type of hood	Ross	Ross	Ross	—
No. of predryers	23	12	6	15 primary 13 secondary
Pre-dryer steam pressure, p.s.i.g.	30	30	30	1 in primary 3 in secondary
No. of after-dryers	—	—	3	4
After-dryer steam pressure, p.s.i.g.	—	—	30	—
Press section	2 suction presses	2 suction presses	1 suction press	Vacuum pick-up Cloverleaf press (2 suction rolls)
Type of preparation plant	5 Jordans Continuous refining	1 Jordan 3 Amazons Continuous refining	Continuous Jordan refining	—

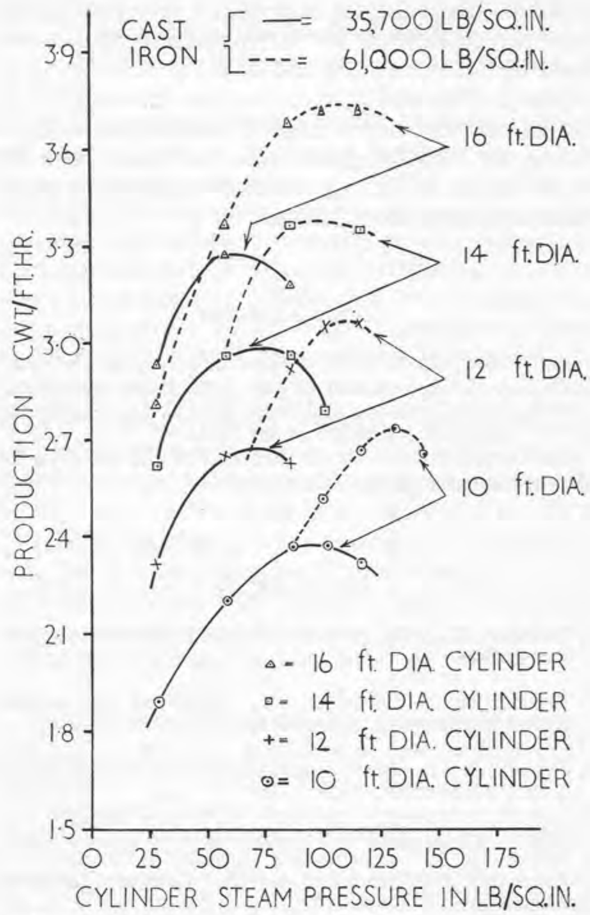


Fig. 4—Optimum steam pressures for MG cylinder fitted with hoods

4. The mass of air brought into contact with the sheet is of great importance in affecting the drying rate: however, the power required is a very important economic factor.

The horsepower required to force gas through nozzles for a given system is proportional to the heat transfer coefficient to the power 3.85—that is, to double the heat transfer coefficient, the gas horsepower must be increased 14.4 times.[4]

On wadding machines, it is common to use as much as 450 h.p. to obtain the required high rates of production; but, on combined MG machines producing thicker paper, 50 - 60 h.p. is normally used, although it is considered that the possibilities of increasing the mass air flow have not been fully explored and could possibly be considerably increased with advantage.

With a power consumption of 50 - 60 h.p., using air at 260°F, a steam pressure of 30 - 40 lb./sq. in. in the cylinder and putting the sheet on the cylinder at 55 per cent. moisture content, a drying rate of about 12lbs./sq. ft./hr. can be achieved.

The highest drying rates yet quoted for any high velocity hood are for the Gardner dryer used on Fourdrinier cylinders.

It is stated that drying rates of 25 - 45 lbs./sq. ft./hr. can be achieved using air temperature of 600 - 1 000°F with nozzles $\frac{3}{4}$ in. between centres, and 0.015 - 0.025 in. nozzle width placed $\frac{1}{8}$ - $\frac{1}{2}$ in. from the sheet. Air velocities are in the range 10 000 - 20 000 ft./min.

TABLE 4—PHYSICAL PROPERTIES OF AMERICAN MG PAPERS

	Mill A		*Mill A*		*Mill B*	*Mill C*
	No. 3 machine		*No. 4 machine*			
Air-dry substance, lb. D.C. 480 ..	23.9	16.7	28.3	23.4	20.0	17.5
Dry bursting strength:						
Average burst reading, lb./sq. in.	27.5	16.8	32.2	26.1	26.8	18.8
Burst ratio	1.15	1.00	1.14	1.11	1.34	1.07
Wet bursting strength (after 5 min. soaking):						
Average burst reading, lb./sq. in.	—	—	—	12.6	—	—
Percentage strength retention	—	—	—	48.0	—	—
Tensile strength (static), lb./$\frac{3}{8}$ in. width strip—						
Machine-direction ..	11.1	9.5	16.2	—	11.2	8.7
Cross-direction ..	8.7	3.5	8.0	—	6.3	5.1
Tensile ratio (static)—						
Machine-direction ..	0.74	0.91	0.91	—	0.90	0.79
Cross-direction ..	0.58	0.33	0.45	—	0.50	0.47
Mean direction ..	0.66	0.62	0.68	—	0.70	0.63
Percentage stretch—						
Machine-direction ..	2.2	1.4	2.4	—	1.6	2.0
Cross-direction ..	4.2	3.8	4.3	—	3.4	4.3
Percentage gloss (Ingersoll)	59	52	61	55	76	59
1 min. Cobb test, g./sq. m.—						
1 sheet: Glazed side ..	—	—	—	—	—	25*
Unglazed side	—	—	—	—	—	23**
2 sheets (20 sq. cm. area):						
Glazed side ..	—	—	—	—	—	27
Unglazed side	—	—	—	—	—	25

Notes—* Paper damp on underside
** Water penetrated at pinholes

All these papers were made at approximately 600° C.S.F.—they contain many pinholes, which would be expected at these high freeness figures

3. Predryers

It was known that a temperature gradient in the predryers is required to avoid cockling in the production of MG paper. It was, therefore, of interest to know what was the minimum number of predryers to provide adequate predrying capacity for an MG cylinder and hood of known drying capacity, at the same time to provide a suitable temperature gradient to avoid cockling.

The degree of fibre treatment will obviously affect the tendency to cockle, but, with a 24 lb. D.C. kraft sheet made from stock in the freeness range 250 - 300° C.S.F., it was found that a minimum of two predryers, working at steam pressures of 1 - 12 lb./sq. in. gauge, would be required for every 1 000 lb. of evaporating capacity of the cylinder and hood.

Conclusions relating to production

The conclusions may best be related to the consideration of the design of a new MG machine.

In designing a new MG machine, it would be advisable to verify experiments in the laboratory on the maximum temperature at which moist sheets at varying substances and freenesses can be pressed on to a hot metal surface without pock-marking or blistering the sheet. The cylinder could then be designed to give the maximum heat transfer at the corresponding steam pressure.

Prerequisites are that—

1. The hood should be about 2 in. from the cylinder surface.
2. The sheet should have a minimum moisture content of 55 per cent. before the MG nip.
3. There should be two predryers for every 1 000 lb. of evaporative capacity of cylinder and hood.

Bearing these factors in mind, an economic assessment should be made for varying power inputs to the hood for air circulation and of the production to be expected. This would, of course, take into account the capital cost and depreciation of extra equipment for the higher rates of production associated with the higher ranges of drying capacity—preparation plant, predryers, hood modifications, etc.

Acknowledgements

The writer has received considerable help in this work from Mr. P. G. Sussman of the Reed Paper and Board Development Division, and from Mr. C. O. Fitness and Mr. C. Miller of Aylesford Paper Mills.

His thanks are due to the directors of the Reed Group for permission to publish this work.

REFERENCES

1. Harrison, V. G. W., 'Definition and measurement of gloss': *Patra*, 1945
2. Brauns, O. and Peterson, V., 'Gloss of MG papers': *Svensk Papperstidn.*, 1953, **56** (19), 727
3. Janson, A. L., *Private communication*: to be published in *Svensk Papperstidn.*, 1959
4. Jepson, M. D., 'Some applications of forced convection drying in the papermaking industry': *Convention of Paper and Pulp Section of the East German Chamber of Technology*, 1958, April 15
5. Brauns, O. and Jansson, A. L., 'Heat transmission in the drying of paper on a Yankee cylinder': *Svensk Papperstidn.*, 1957, **60** (17), 621;
Janson, L., 'Determining the capacity of Yankee cylinders': *Svensk Papperstidn.*, 1957, **60** (19), 713

discussion

MR. F. A. CRAIG: We members of Northern Division are much indebted to Mr. Chapman for having presented to us a paper on a subject that so far has received little attention. His paper contains much practical information and several helpful suggestions. I am substantially in agreement with his conclusions and was particularly interested in his statement that moist pulp in the furnish tends to increase the gloss, an effect that so far I have not myself observed.

His statement that the stuff should be as free as possible consistent with strength requirements may require further qualification. We find, when the stock is very free, that there is a tendency to get lifting of the paper surface, with consequent reduction of the glaze.

I should like the speaker to amplify his statement that, because of more careful cambering, no trouble with felts has been experienced. What trouble with felts has he experienced and what degree of cambering did he find necessary to obviate it?

MR. J. CHAPMAN: Unless the press rolls are carefully cambered, there is a tendency to cut the felts at the edges.

A typical example of cambering would be that for a roll 15 ft. long and 26 in. diameter, with a rubber hardness of 17—18 P & J, the primary camber would be 135 thousandths of an inch and the secondary camber 210 thous, 27 in. from each end with a further 60 thous camber over 6 in. at each end.

MR. B. W. ATTWOOD: I should like to congratulate Mr. Chapman on preparing and presenting an extremely interesting paper, which I am sure will become a useful addition to the literature of papermaking.

Can Mr. Chapman give details of the effect on MG finish of additives either as—

1. Beater additions or

2. Applied as coating immediately before the nip?

What is the effect of pressure applied at the nip on the strength characteristics of the finished product?

MR. CHAPMAN: No work by us has been carried out on the effect on gloss of addition of additives at the beater or as coatings before the nip.

What evidence we have indicates that there is a tendency for high burst figures to be obtained at the higher nip pressures.

MR. J. D. DAWSON: Do you find it necessary to express water at the MG cylinder press nip?

MR. CHAPMAN: We run our machines with both dry and wet nips, but this is not deliberate and it depends on the substance of the paper, stock freeness, machine speed, etc.

MR. DAWSON: In a circulatory type hood, do you find it necessary to adjust the temperature settings for varying thicknesses of paper?

MR. CHAPMAN: No.

MR. DAWSON: Do you grade the pressures in the pre-drying cylinders to avoid cockle?

MR. CHAPMAN: Yes, this is essential.

MR. DAWSON: Dual MG cylinder press rolls are usually operated, especially in the Scandinavian countries, where MG machines are running without pre-drying cylinders. The function of the first press roll is to replace the pre-dryers, to raise the temperature of the water in the sheet (thereby reducing its viscosity) and to enable it to be more easily removed at the second cylinder press nip.

MR. C. G. LAWRENCE: The surface temperature gradient for pre-dryers is given as 100°F to 230—240°F and hand-controlled. At the lower temperature, does hand control give sufficient accuracy over long periods? What special means are provided at the low temperature to give a constant and level temperature across the cylinder?

MR. CHAPMAN: It would certainly be preferable to have automatic control of the pre-dryer temperatures rather than hand control. No difficulty is experienced, as far as I know, with temperature fluctuations across the cylinder using hand control.

MR. A. M. THOMSON: The optimum pressure for the MG presser roll is given in lb./linear in.—what is the actual pressure applied to the paper in lb./sq. in.?

MR. CHAPMAN: The width of the MG nip at the press roll is approximately 2 in., but the pressure distribution will be parabolic with the maximum pressure at the centre of the nip. The optimum pressure of

450 lb./linear in. would correspond to a static pressure applied for a few seconds of approximately 160 lb./sq. in.

MR. THOMSON: As no water was said to be removed by the MG presser roll, could production be maintained by using the pre-dryers to raise the temperature of the water in the web to a maximum, with minimum evaporation? The higher temperature would reduce the viscosity of the water and thereby increase the efficiency of the presser roll as a means for removing water, while the higher initial water content would improve the MG finish, thus removing water by mechanical means instead of by steam. What was the temperature of the water in the web entering the nip and what was the water content after the nip?

MR. CHAPMAN: As you say, the higher the temperature of the sheet coming from the pre-dryers, the better; but a sufficiently gentle temperature gradient must be obtained to prevent cockling.

As far as can be ascertained by experimental work, the temperature of the sheet entering the nip is usually 140—160°F. It has been impossible to obtain an accurate estimation of the water content after the nip.

MR. R. BARNETT: Does Mr. Chapman consider that a better finish would be obtained from fine stock with, say, refiners than from long stock at the same freeness with, say, beaters?

What is Mr. Chapman's opinion of the statement that the moisture is required on the surface, rather than within the sheet at the cylinder press roll to obtain a good finish?

At the higher chloride content of the process water referred to during the discussion on corrosion, did Mr. Chapman notice any loss in finish compared with the use of the lower chloride content water?

MR. CHAPMAN: I am afraid we have no definite information about the first question.

The importance of moisture at the surface is shown by the fact that thicker papers and boards can be pressed on to the cylinder at quite low moisture contents—that is, 45 per cent.—and still give a good gloss, indicating the moisture in the bulk of the sheet has been forced to the surface during pressing.

No difference in the furnish of the paper was noticeable when using high and low chloride content waters.

MR. M. D. JEPSON: I have very much appreciated Mr. Chapman's paper, which has been valuable both to my colleagues and myself. So much of our time is taken up in developing evaporating hoods to increase the output of MG machines that it is easy to lose sight of the many other problems that arise on the whole machine from the ensuing higher production. These problems are particularly associated with maintaining or, if possible, improving the quality of the sheet, particularly its glaze and flatness. A paper such as this, covering so many of the variables encountered in producing a high quality glazed sheet, is therefore of particular interest and value to us.

Mr. Chapman raised the interesting point of further progress in the design of evaporating hoods as far as the use of higher air velocities (hence, fan powers) are concerned. There is no doubt that the use of higher fan powers can result in higher evaporation rates and this is seen particularly in connection with high speed cellulose wadding machines, where very high steam pressures are used in the cylinders and very high fan powers are used for the hood.

On most existing MG machines making glazed wrapping papers, however, we have found that there is not the same advantage in being able to obtain very much higher evaporation rates than are at present possible with our hoods, because factors other than the evaporation rate have been found to limit the production. In this connection, has increasing the evaporation rate on machines making high quality glazed paper, in itself, in any way impaired the quality?

One other question is whether, in his work on MG machines, he has found any relation existing between the evaporation rate and the line pressure of the MG press roll?

Incidentally, as Mr. Chapman has shown in Fig. 3, we have arrived at the economical figure of 20 per cent. fresh air as a proportion of the total air circulation in the hood. In this particular design, it corresponded to a specific humidity in the exhaust air of approximately 0.2 lb. water per lb. dry air.

MR. CHAPMAN: We have not found that increasing the evaporation rate affects the finish in any way over the range 6—12 lb. water evaporated per sq. ft. of contact area per hr.

In answer to Mr. Jepson's second question, we have not made any determination of evaporation rate at different nip pressures. One would expect the closer contact at the higher nip pressures to assist the evaporation rate, with a possible modification owing to the sheet having a denser structure.

Suction couch operation on newsprint machines

A. A. IVES, A.M.I.Mech.E.
The Bowater Paper Corporation Ltd.

GIVEN AT A MEETING OF LONDON DIVISION: YORK HALL, CAXTON STREET, S.W.1.
ON 12th NOVEMBER 1959, Mr. G. THOMPSON IN THE CHAIR

Synopsis

In pursuance of the search for high operational efficiency on papermachines, it was decided to carry out a survey of the vacuum and airflow conditions at the various suction points of several papermachines operating at medium and high speed ranges at a large newsprint mill. This paper deals firstly with the method employed in the testing of vacuum pumps, with some reference to the British and American standard method of airflow measurement through orifices. Secondly, it discusses the leakages into the vacuum system, more particularly as they apply to the rotating perforated shells of the suction couches and shows the influence of this leakage in the application of high vacuum at the suction couch. Thirdly, arising from the number of tests carried out and the data obtained in the analysis, an empirical relationship between the airflow through the the sheet and the production of paper on the machine is put forward; also discussed are certain other formulations from the results. This work has been confined mainly to suction couches, as it is considered that the problem of air permeability through the sheet has little relevance at the presses.

Introduction

A SURVEY was made that consisted primarily of efficiency and capacity tests of all the vacuum pumps in the papermill and was carried out in conjunction with technicians from the Norman Engineering Company, as Nash pumps are installed on most of the machines. The subsequent part of the survey consisted of an analysis of the various test results and it was during this part of the survey that several conjectures and further investigations were made. It is the method of testing, the results and the conjectures that will be discussed in this paper.

Testing procedure

STANDARD accurate air measurement by the Nash orifice system was adopted for the pump tests and the equipment that was utilised in these tests is shown in Fig. 1[(1)] and described below.

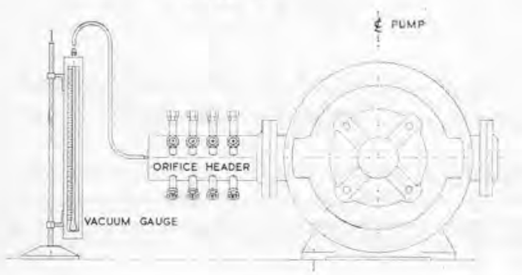
Nash[(1)] have found that a special type orifice offers the most satisfactory method of accurately measuring the air flow in tests on vacuum pumps and therefore standardised orifice equipment for this work has been designed by Nash and carried to a high degree of perfection by an extensive degree of investigation and calibration; in fact, it is claimed that the results obtained are accurate within ± 2 per cent. The equipment comprises a standard multiple header, with a certain number of nozzle holder units incorporated as shown in Fig. 1 and these headers are produced with varying numbers of nozzle holder units according to size of pump to be tested. These units are designed to house standard orifice plates and, as the number of orifices actually open to air flow can be varied merely by blanking off with rubber discs, the air flow and therefore vacuum can be varied, thus affording an easy means of measuring air flow through the whole vacuum range. The orifice header thus serves as a pressure-controlling device and simultaneously as a flow meter.

The actual orifice plates or nozzles are usually made from hardened stainless steel and ground to a uniform thickness of $\frac{1}{8}$ in. The holes through the plates are reamed to accurate size, care being taken to ensure that sharp, square edges are obtained; it is most important that these square edges are maintained, otherwise the results will fall off in accuracy. The flange mounting of the multiple header is made suitable for attaching to the flange inlet branch of the pump or a suitable adaptor piece can be used. The other end of the multiple header is blanked off, but includes a small bore connection for attaching flexible or rubber tubing to a mercury U-tube manometer fixed on a calibrated backboard for measuring the vacua at various flow quantities.

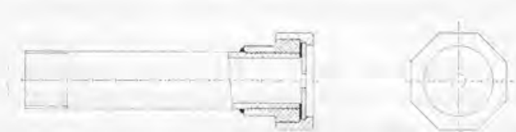
Tests and correction factors

AFTER setting up the test equipment as shown, each pump was started up and the number of orifices open

FIG. 1



DIAGRAMMATIC ARRGT. OF TEST RIG



DETAIL OF STANDARD ORIFICE HOLDER UNIT

DETAIL STANDARD ORIFICE PLATE

was adjusted to give 5 in. mercury vacuum. The number of open orifices was then noted. The remainder of each test consisted of a number of similar operations, adjustments being made to the number of orifices open to air flow against definite vacua and appropriate notes being made. It is sometimes advantageous to work to a certain number of open orifices for each test, reading off the vacua accordingly. In addition, ampere readings for the motor were taken for each vacuum and air flow in order to calculate motor power after consideration of the motor power factor. Tests on all other pumps followed the same procedure.

From the information so collected, the quantities of air flow in the various tests in question were obtained from Nash calibrated curves giving air flows for various sizes of orifice at the various vacua; a typical set of curves is shown in Fig. 2.[1] The air flow for one orifice was read directly off the curve for the vacuum obtained and the resultant air flow for that particular test was obtained by multiplying the figure from the curve by the proper number of open orifices for that particular test. The airflow figures so derived from the curves are given at standard conditions—60°F, 50 per cent. relative humidity and 29.92 in. standard mercury barometer at 32°F. They had therefore to be corrected for the actual conditions around the pump on test. Because of this ambient temperature, sealwater temperatures and barometric pressures were observed for each test: temperature corrections for flow (when the ambient temperature differs from the 60°F applying to the Nash pump tests) can ordinarily be neglected. Similarly, corrections for changes in relative humidity that do not vary substantially above or below 50 per cent. are not very important (as in normal conditions in this country the relative humidity does not vary appreciably) and did not vary in the wet end basements under the circumstances of these tests. Nash curves are also available for correcting the air flow at the test conditions, the first one for temperature correction to mercury column and barometer being shown in Fig. 3.[1] Here, one merely reads off the correction in inches of mercury, according to observed mercury vacuum reading and mercury column or barometer temperature, which, when subtracted from the observed vacuum or barometer reading, corrects for thermal expansion of mercury and brass scale from 32°F.

Flow correction for barometer reading was another factor to be considered and, for barometric pressures other than 29.92 in. mercury, the rate of flow and the ratio of expansion for a given vacuum differ from the calibrated curve values. The curves available for correcting these calibrated figures gave the factors for calculating the actual volume flow at the observed vacuum and at 60°F and these curves are based upon the formulae as given in Table 1.

These formulae are derived from Fleigner's equations for pressure across an orifice above and below the critical values, which formulae are again shown in Table 1 at (*i*) and (*ii*). [2,3,4]

The density for any non-standard conditions will be different than at standard conditions by the ratio of the absolute pressures at the vacuum, therefore this ratio is as shown in (*iii*), Table 1. Then the correction factor may be expressed as the multiplier for the flow at standard conditions, to obtain flow at the non-standard conditions and hence, by cancellation, the original formulae are derived.

It was known that the sealwater temperatures were high on some machines. To find what effect this had on pump capacities, etc., these temperatures were measured during the tests.

It is well known that the essential use of water within the Nash type pump is to accomplish the liquid ring pumping action. A variation in temperature of this sealing water has a modifying effect upon the

TABLE 1 — FLOW CORRECTION FOR BAROMETER FORMULAE

For vacua above critical value —

$$FF_1 = \frac{Bc}{29.92} \; \frac{(29.92 - Hc)}{(Bc - Hc)}$$

For vacua below critical value —

$$FF_1 = \sqrt{\frac{29.92 - Hc}{Bc - Hc}}$$

where FF_1 = flow factor,
Bc = barometric pressure corrected to 32°F in in. mercury,
Hc = vacuum corrected to 32°F in in. mercury.

Pressure across orifice above critical —

$$V = DK_1 \; \frac{AP_1}{\sqrt{T}} \quad \ldots\ldots\ldots \quad (i)$$

Pressure across orifice below critical —

$$V = DK_2 \; \frac{A}{\sqrt{T}} \; \sqrt{P_2 (P_1 - P_2)} \quad \ldots \quad (ii)$$

where V = volume flow,
D = density (cu. ft. per lb.),
K_1 & K_2 = constants,
A = area,
T = temperature,
P_1 = upstream pressure,
P_2 = downstream pressure.

$$\frac{29.92 - Hc}{Bc - Hc} \quad \ldots\ldots\ldots\ldots \quad (iii)$$

pump performance, because of the accompanying change in the partial vapour pressure within the displacement chambers of the pump; this in turn modifies the nett proportion of air that can be handled by the pump, as well as the total absolute pressure. It will be appreciated that, if water vapour coming in with the air can be condensed by cool sealing water, the capacity of the pump will be increased, owing to the additional space available within the pump chambers.

Nash have produced a series of curves showing percentages of standard curve capacity against various vacua, considering a variety of seal water and saturated air temperatures. Fig. 4(1) is a reproduction of two of these curves and illustrates the previous point. One curve shows saturated air at the pump at 120°F against 60°F sealwater temperature and the other again considers saturated air at the pump at 120°F, but this time with seal water at 100°F. From these curves, it is immediately seen that at a vacuum of 24 in. there is a loss of over 50 per cent. capacity at the higher sealwater temperature and therefore exemplifies the importance of low sealwater temperatures. The reference to standard curve capacity is of course considering dry air at 60°F and it is the saturated air at higher temperatures with the cooler sealing water that causes the condensation and hence increases standard capacities above 100 per cent.

In our tests and calculations, we were not able to determine exactly what effect a high sealwater temperature had on the resultant test capacities, because of a number of undesirable features in the layouts; but, as will be seen from the results shown in Table 2 and Fig. 6, we were able to determine that in practice pumps were in some cases considerably below makers' performance curve figures, which are calculated on a 60°F sealwater temperature basis.

Before dispensing with this section, it will no doubt be realised that the Nash orifice method of air measurement differs considerably from airflow measurement as laid down in B.S. 726 : 1957, 'Measurement of airflows for compressors and exhausters', also as published by the American Society of Mechanical Engineers in Power Test Codes PTC-1954, 'Displacement compressors, vacuum pumps and blowers'.

Both these publications stipulate methods using specially shaped nozzles or orifices in pipelines and these methods specify certain distances in terms of pipe diameters after nozzle positions in the pipe and,

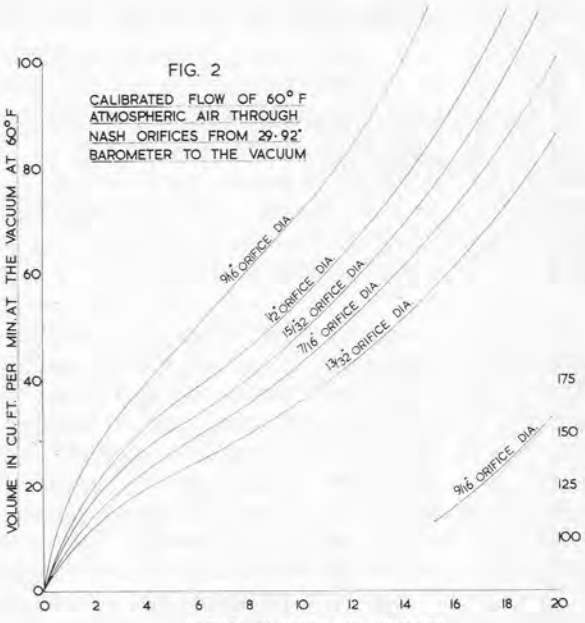


FIG. 2

CALIBRATED FLOW OF 60° F ATMOSPHERIC AIR THROUGH NASH ORIFICES FROM 29·92" BAROMETER TO THE VACUUM

T22 in the case of the British Standard, also in front of the nozzle in order to dampen pulsations. In both cases, formulae are given for calculating air volumes based upon the usual differential pressures across the orifice, coefficient of discharge for the orifice in question, absolute temperatures and pressures at various points of flow, orifice throat diameter, etc. It will immediately be seen, however, that these systems are much more difficult to apply than the Nash system, inasmuch that pipeline dismantling in order to achieve the specified distances on both sides of the orifice, also orifice size changing to achieve a complete range of performance would occupy considerably more time than the Nash method. In view of this, it is not difficult to apprehend Nash's pursuit of an alternative method of airflow testing on their pumps, the result of which as described previously is extremely simple to put into operation to obtain the varying capacities against vacua.

Leakage into vacuum system from couch shell holes

THE results of the various tests on the six suction couches are given in Table 2. The first question to be solved was—what is the nett amount of air passing through the sheet into the vacuum pump and what is the known leakage at the couch? The only leakage that could be calculated as a result of these tests was that due to the holes in the shell. All other leakages such as that through the box sealing strips and pipe joints, etc. must be estimated. It is not, however,

FIG. 3

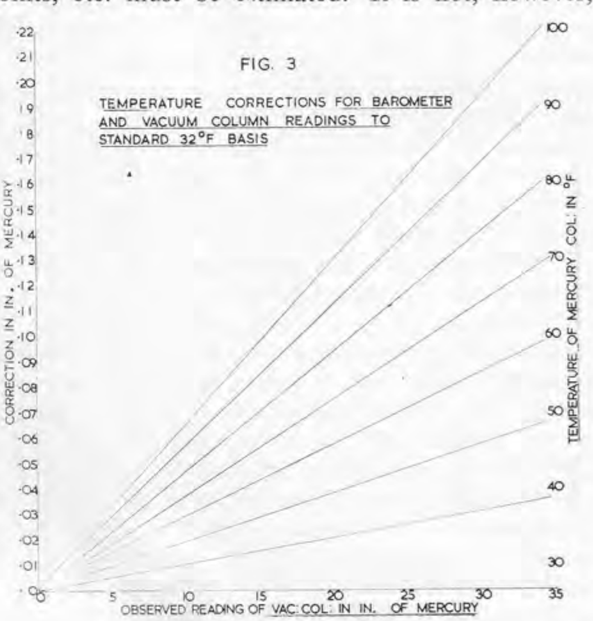
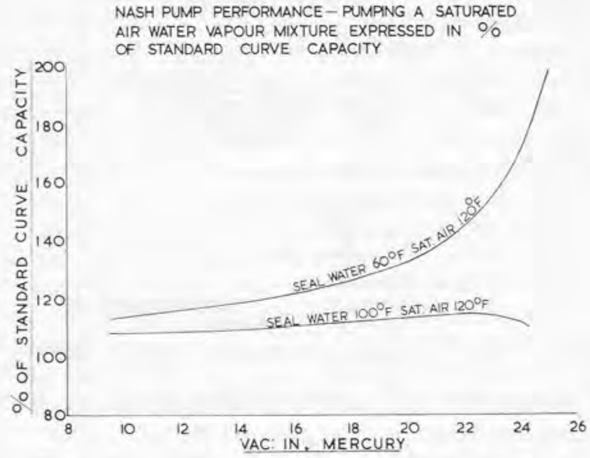


FIG. 4



considered that such losses are high in proportion to the leakage through the shell and will be neglected for the purpose of this paper. In the calculations and graphs that follow, we have had to make certain assumptions, the principal one being that the sheet forms such a resistance to the flow of air that the vacuum in the holes of the shell corresponds almost exactly with that in the box. It is acknowledged that this cannot be true exactly, as the real velocity of air through the various holes in its expansion to the vacuum box cannot be accurately calculated. For the purpose of the calculations, therefore, it is assumed that a hole approaching the inlet side of the vacuum box is filled with air at atmospheric pressure (30 in. mercury barometer) throughout its volume and that the same hole passing the outlet side of the box is at the vacuum within the box throughout its volume. Taking a hypothetical case (Fig. 5), where the amount of air approaching the box in the shell holes is assumed to be 1 000 cu. ft./min., then it follows that at 20 in. mercury vacuum there is $(1\,000 \times 10/30) = 333$ cu. ft./min. air at 30 in. mercury barometer left in the holes at exit of the box. Subtracting this amount from the original air of 1 000 cu. ft./min., the leakage into the box is 667 cu. ft./min. at 30 in. mercury barometer. At the pump, however, which is assumed to be at the same vacuum as the box (20 in. mercury vacuum), the quantity of air is $(667 \times 30/10) = 2\,000$ cu. ft./min. at 20 in. mercury vacuum. This calculation was applied to all the suction couches on which tests were carried out and in each case the drainage area of the holes, also the thickness of the shell, has been measured accurately, but the original diameter of the suction couch has been accepted for the purpose of these calculations. The results of the

TABLE 2 — RESULTS OF AIRFLOW TESTS AT COUCHES

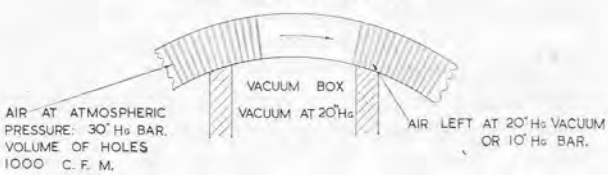
Machine	Type of pump	Pump vacuum at test, in. mercury	Rated capacity at test, vacuum, cu. ft./min.	Test capacity at test vacuum, cu. ft./min.	Leakage at shell cu. ft./min. at vacuum	Rated flow through sheet at test vacuum, cu. ft./min.	Rated flow through sheet lb./min.	Tested flow through sheet at test vacuum, cu. ft./min.	Tested flow through sheet lb./min.	Flow per sq. ft. of vacuum box drilled area at test vacuum, cu. ft./min.	Flow per sq. ft. of vacuum box drilled area free air, cu. ft./min.	Paper production, lb./min.
A	Liquid ring	20.5	4 400	4 080	1 580	2 820	65.5	2 500	58	900	285	219
B	Liquid ring	20	4 750	4 210	900	3 850	93.3	3 312	81.2	1 190	397	219
C	Liquid ring	22	4 350	3 470	1 460	2 890	56.7	2 010	39.4	636	170	216
D	Liquid ring	20.5	7 320	6 310	1 685	5 635	131	4 625	107.5	1 255	397	264
E	Liquid ring	17	17 950	8 750	1 640	16 310	520	7 110	227	1 150	500	346
F	Blowers	20.4	18 000	17 000	3 900	14 100	330	13 100	308	2 310	740	433

leakages through these various shells for a given range of vacuum are shown in Fig. 6.

On the same graph, we have shown curves of the tested capacity, also curves of the rated capacity of the pump serving each particular couch. The ordinates between the graphs of leakage and the graphs of pump performance represent therefore, respectively, the amount of air actually passing through the sheet and the amount of air that should theoretically pass through the sheet, according to pump rated capacities.

FIG. 5

SHELL LEAKAGE DIAGRAM



Air left in shell holes

$$= 1\,000 \times \frac{10}{30} = 333 \text{ cu. ft./min.}$$

Therefore, air extracted by pump

$$= 1\,000 - 333$$
$$= 667 \text{ cu. ft./min. at 30 in. mercury barometer}$$

Converted to the vacuum

$$= \frac{667 \times 30}{10} = 2\,000 \text{ cu. ft./min.}$$

Therefore, shell leakage

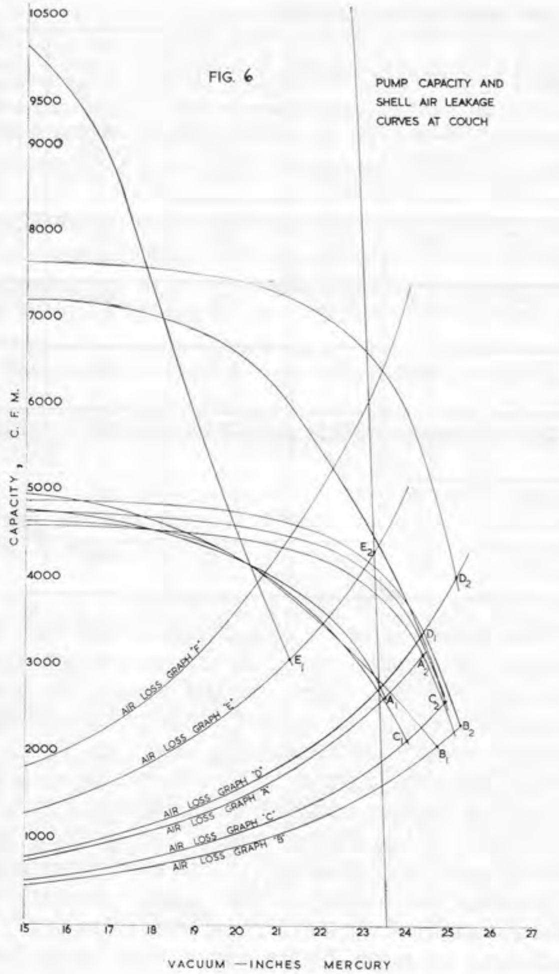
$$= 2\,000 \text{ cu. ft./min. at 20 in. mercury vacuum}$$

These graphs indicate very clearly indeed that the higher the vacuum required, the greater the losses through the shell holes and the greater the pump capacity needs to be. In fact, at the point where the pump capacity on an existing couch as shown in Fig. 6 meets the point of leakage for the same shell is given the vacuum at which no air will pass through the sheet, unless further pumps are applied. Very clearly seen from these curves also are the maximum theoretical vacua at the various couches in relation to those actually obtainable. These curves also show that attempts to reach higher vacua than those being obtained on any machine should be examined in relation to the shell leakages before making decisions.

To clarify the actual and theoretical quantities of air passing through the sheet the ordinates mentioned previously have been plotted in relation to vacuum in Fig. 7, from which the differences between designed and actual air quantities through the sheet are easily discernible.

The second question that was raised is not unknown in papermaking circles, if such an understatement may be used. It is this—what is required at the couch to compact the wet sheet of paper sufficiently to carry it over the gap on to the first press felt or, in the case of a pick-up roll machine, to sustain it in its passage through to the first press? Is it vacuum as such in terms of differential pressure above and below the sheet? Is it the quantity of air that flows through the sheet or is it a combination of both?

Our results do not give a completely satisfactory



answer to these questions; in fact, at first sight, there appears some conflict, as it was considered that, arising from the number of tests taken and the number of couches tested, there might be some relation between the nett air flow through the sheet as obtained by previous calculation and the paper produced; at the same time, the estimated quantity of water absorbed by the air passing through the sheet appears negligible in comparison to the total quantity of water extracted at the suction rolls.

Dealing with the relation of air flow through the sheet expressed as a function of paper produced, it is emphasised that at the time of the tests the mill was running in a perfectly normal manner, vacua at the couches being what was normally obtained. So far as is known, the pumps were giving at that time as much vacuum as they were capable of and the assumption must surely be that the sheet being made on the various machines was determining by its porosity the amount of vacuum that could be obtained on those particular pumps.

That being the case, we calculated in lb./min. the amount of air going through the sheet on each particular couch and, at the same time, the amount of paper produced on each machine was taken from the mill records. These figures were plotted (Fig. 8) and the mathematical regression line through these points shows that a straightline relationship represents the behaviour of these six machines at this particular time of the test. This relation only holds good, however, for these machines and it will be noted that the vacua being obtained on each machine were not the same. It remained therefore a matter of conjecture why one machine with a somewhat equivalent capacity of pumps to another was not achieving the same vacuum. The production results showed no appreciable difference because of the difference of vacuum; but, as will be seen from the graph, the nett

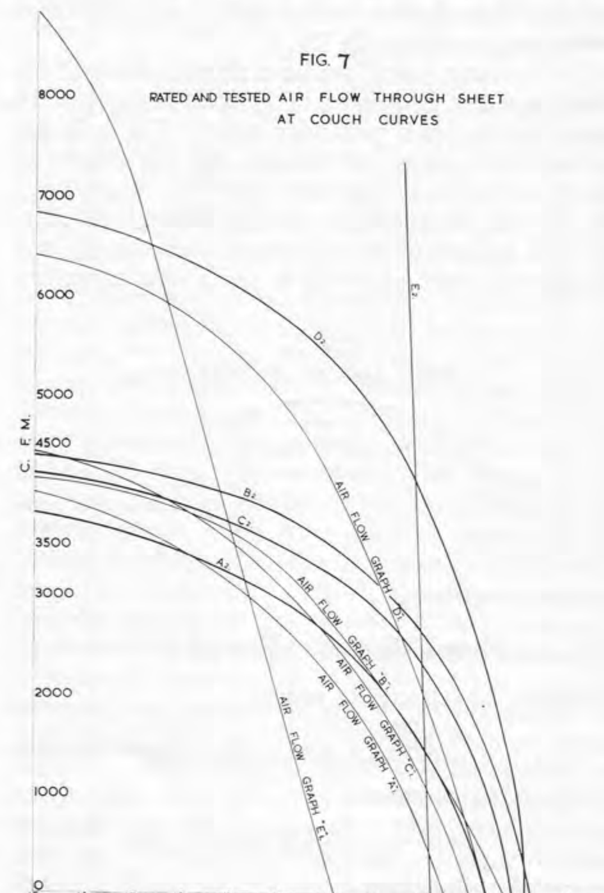
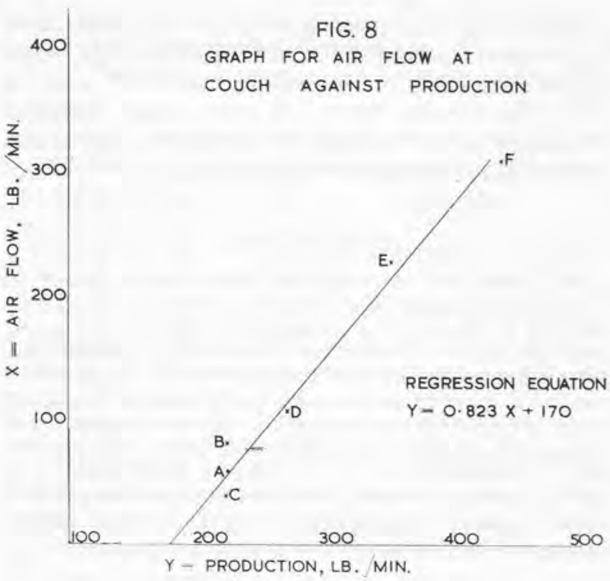


FIG. 8
GRAPH FOR AIR FLOW AT
COUCH AGAINST PRODUCTION



air flow does roughly correspond proportionately to the production. As it cannot be considered correct that no air flow is required at the couch for production rates under 170 lb./min., it is presumed that the bottom portion of the line is not true and that it must take the form of a curve for low production rates to pass through zero at both the horizontal and vertical axes. It is possible to conjecture, however, that the air flow has a direct relationship to the efficiency of papermaking.

Now, considering the question of water removal by absorption in the air, from our calculations from the tests, the machine with the highest production passes through its suction rolls 1.313 lb. air per 100 sq. ft. of paper produced. If we consider the air to be 80°F and 50 per cent. R.H., it will have a moisture pick-up rate of 75 grains per lb. and the previously mentioned air quantity will therefore absorb $(1.313 \times 75)/7\,000$ lb. water, which equals 0.01407 lb.

If this is now compared with the total water removed by the suction rolls on the same machine, it will appear to be negligible.

Unfortunately, no tests for water removal were made with the tests that are the subject of this paper, but information from other tests on water removal at suction rolls on newsprint machines can be used effectively to prove this point.

From tests, the water content is reduced from 80 per cent. to 65 per cent. approximately through the suction rolls. Therefore, the water removed on this basis from 100 sq. ft. of paper at 14.5 lb. demy is as follows—

$$100 \text{ sq. ft. paper weighs } \frac{14.5 \times 100 \times 144}{500 \times 17\tfrac{1}{2} \times 22\tfrac{1}{2}} \text{ lb.}$$
$$= 1.06 \text{ lb.}$$

Water content at approach of couch —
$(1.06/0.2) - 1.06 = 5.3 - 1.06 = 4.24$ lb.

Water content at approach to dryers —
$(1.06/0.35) - 1.06 = 1.97$ lb.

Therefore, water removed at couch and presses
$= 4.24 - 1.97 = 2.27$ lb.

The amount of water absorbed by the air passing through the sheet is thus about 1/160th of that removed at the suction rolls.

Arising from this, it is perhaps possible to conjecture that, if water removal is by air flow, it is achieved by the effect of air velocity through the sheet rather than by absorption. A method therefore of answering this besides the previously mentioned questions might be to carry out some experiments for water removal with the highest possible vacuum at the pumps accompanied by low air flow through the sheet. This might be achieved, in view of the influence of air leakage at the shell, by reducing the vacuum box width. To check the feasibility of this approach, an attempt was made from the test results to determine the velocity of the air through the shell. From this, the time taken for a particle to move through the shell was calculated and compared with the shell peripheral movement over this period, which was again compared with the vacuum box width.

It has already been assumed that the vacuum in the shell holes is the same as that in the vacuum box and therefore the air velocity through the holes was calculated relative to the nett air flows at the vacuum. This again was calculated on the assumption that the velocity would be reasonably constant through the holes and the results are shown in Table 3. The final figures on this chart show that it takes 1.008—2.29 in. of shell movement under the circumstances of these tests for any particle of air to pass through the shells, from which, considering these distances against vacuum box width, it is possible to conjecture that the boxes might be reduced in width. In this event, higher vacua and less air flow through the sheet would most certainly be obtained as will be observed from the shell leakage and capacity curves previously referred to in Fig. 6.

Machine	Flow per sq. ft. open area, cu. ft./min. at vacuum	Assumed speed through holes, ft./min.	Time over vacuum box, sec.	Time for passage through shell, sec.	Couch movement, in.	Vacuum box width, in.
A	900	900	0.0292	0.009	2.16	7
B	1 190	1 190	0.0292	0.0042	1.008	7
C	636	636	0.0292	0.0084	2.02	7
D	1 255	1 255	0.0333	0.006	1.44	8
E	1 150	1 150	0.0462	0.0088	2.29	12
F	2 310	2 310	0.0349	0.00486	1.67	12

Conclusions

It is concluded from this investigation that (*a*) there is reason to believe that the air flowing through the sheet bears some definite relationship to the paper produced, (*b*) some consideration should be given to air leakage at the shell when specifying vacuum pump capacity for suction couches with special reference to high vacuum and (*c*) higher vacua can best be obtained, if required, by a reduction in vacuum box width until air flow through the sheet is almost eliminated. In this case, the amount of air passing to the pump will be a function only of the leakage through the shell holes and the vacuum obtained at the pump. Whether such conditions would contribute to higher water removal at the couch can be investigated only by experimentation.

The foregoing covers ground about which much has been written and spoken and this obviously points to the complexity of the problems involved, also the need for further study. If this paper therefore stimulates further research, it will have achieved one of the salient reasons for its production.

Acknowledgements

In closing, acknowledgement with thanks is due to The Bowater Paper Corporation Limited for kind permission in making the information used in this paper available, also to The Norman Engineering Company for permission to publish information on the Nash orifice method of air measurement and for the firm's co-operation in the testing of the vacuum pumps. Acknowledgement and appreciation is also recorded for the useful criticism and advice afforded by Mr. G. R. Roberts, Chief Engineer of the Engineering Division, The Bowater Paper Corporation Limited and for the help and advice given by my colleagues during the preparation of this paper.

REFERENCES

1. Harold E. Adams, *Accurate Air Measurement by Nash Orifice Method*
2. Fleigner, A., 'On the flow of atmospheric air': *Minutes of Proceedings of the Institution of Civil Engineers*, 1875, **39**, 370
3. Fleigner, A., 'Experiments on the flow of air through well-rounded orifices: *Minutes of Proceedings of the Institution of Civil Engineers*, 1878, **53**, 295
4. Fleigner, A., 'Experiments on the flow of air through orifices in a thin plate': *Minutes of Proceedings of the Institution of Civil Engineers*, 1879, **55**, 379
(These *Minutes of Proceedings of the Institute of Civil Engineers* are abridgements (in English) of publications in *Civilgeneur*)

discussion

MR. P. G. SUSSMAN: Could Mr. Ives say whether he investigated the leakage of air that occurs, not through the sheet, but between the wire and the top surface of the suction couch ?

I have carried out a rough experiment and found that the amount of air leaking under the wire can be up to one half of the amount of air coming through the sheet—assuming here that the air is only leaking between the wire and the couch face on the dry side of the vacuum couch.

MR. A. A. IVES: I have difficulty in visualising the air leakage referred to by Mr. Sussman, unless he is referring to air that may leak through the wire meshes in a horizontal direction. In other words, it appears that Mr. Sussman is stating that we might consider the wire as a very low but long duct through which air might pass from under the wire and hence through the shell holes into the vacuum box. This possible leakage was certainly not considered.

Whilst I agree that an air leakage by this means is possible, I cannot believe that it would be considerable in practice because the gaps between the meshes of the wire would be filled with water and this also in my opinion is applicable to the wire at the dry side of the suction box at the couch.

MR. SUSSMAN: I am suggesting, however, that a considerable amount of air passes between the wire and the couch and thus into the vacuum box.

MR. IVES: As stated previously, the idea of air leaking into the box horizontally through the wire is possible, but carrying out experiments under working conditions to prove it would appear rather difficult.

MR. A. F. TOUT: If the air flow is due to air entrapped on the inside of the wire, one would expect that the relation between air flow and production would be linear at constant paper substance. Perhaps this is the reason for the relationship exhibited by Fig. 8.

For this reason, I suggest that Mr. Sussman's correction should be not a constant quantity, but one proportional to the production.

MR. G. F. GLOVER: Are we really interested in obtaining better suction or in water extraction ? I suggest that we are not so much interested in water extraction at the couch as in getting efficient removal of the web from the wire.

On the question of width of box, I think we must consider the time it takes to accelerate the water into the holes, therefore we must not have too narrow a box.

MR. IVES: Obviously, water extraction at the couch is of paramount importance and, if more water can be removed by higher vacuum, then I would say that this would be an advantage. I cannot visualise how a higher vacuum would affect the efficient removal of the sheet from the couch, as, once the sheet has passed the vacuum area, it is free to be picked off; in fact, owing to centrifugal force, water probably returns to the underside of the sheet, acting as a lubricant for its removal.

On the possibility of reducing vacuum box width, I agree that the mechanics of water removal through the shell holes is complex and the time over the vacuum box must be such that water particles would pass from the sheet through the shell to the vacuum box. In theory, however, assuming that the water particles move at the same speed as the air, it does appear that boxes as designed today could be narrower.

MR. W. F. E. ROBINSON: What is the advantage in having such a high vacuum, as it was stated that no extra air is drawn through the sheet ? If, in fact, the passage of air through the sheet facilitates water removal, does this mean that the high vacuum does not remove any extra water ? Could the speaker suggest what we are actually doing with such a high vacuum ?

MR. IVES: I have proved that, if a higher vacuum is achieved with no increase in pump capacity, less air will in fact pass through the sheet, as more work will have to be done by the pump(s) in expanding the air in the shell holes to the vacuum. The question asked by Mr. Robinson regarding whether or not a higher vacuum removes extra water is not solved in this paper. I have stated, however, that, as the quantity of water actually absorbed by the air passing through the sheet appears negligible in comparison with total water removed at the suction rolls, it may well be that differential pressure above and below the sheet influences water removal quite considerably and an

T28 increase in this pressure differential may therefore improve water removal.

MR. G. R. ROBERTS: These tests were carried out in the first place, as it was considered that the pumps were not efficient and not doing their job. Engineers are always asking what is really wanted—higher vacuum, a greater air flow or what? It has been proved in the past that a narrower box can increase vacuum. A wider box costs extra money and it was hoped in these investigations to find out if any extra value was obtained for the extra capital outlay. The addition of more and more pumps to papermachines is not only costly in capital, but also in power consumption and sometimes one cannot see much improvement for all this extra money. In the results, there was no relationship shown between the vacuum readings and the production at the time of the tests, but there is some relationship shown with the air flow. The entrainment of the water in the air flowing through the sheet is a factor of which we know little, but which we think is of great importance.

MR. SUSSMAN: If I am correct in stating that there is considerable air flow underneath the wire, then the figures of air flow through the sheet should be modified. This would lead to an appreciable reduction in the values given for air flow through the sheet in Fig. 8.

MR. ROBINSON: It is easily shown on a slow papermachine that, over the vacuum area of the flat boxes, as water is removed, this takes place over both the land *and* the hole area. This same effect of the spreading of the vacuum can be seen with a suction press.

MR. M. HANCOCK: Higher vacuum means more wear on the wire. What is required is an efficient couch, but not higher vacuum.

MR. GLOVER: My company has carried out quite a lot of work on couching and has given it much thought. We believe that the proper function of a couch, whether the top roll type or a suction couch, is not really to remove water, but to facilitate the release of the web from the wire. This is brought about by the release of pressure allowing water removed from the web to flood back and lift the fibres from the wire. This function can be carried out by a flat box, as well as by a suction couch.

MR. ROBERTS: The vacuum pulls the fibres into the surface of the wire and some energy must therefore be used on newsprint machines to remove the sheet from the wire after the couch.

MR. ROBINSON: As the wet web passes from the suction area to the land area on the outgoing strip of the box, the water taken by vacuum into the wire tends to float back as the vacuum is released and this water lubricates and facilitates the removal of the sheet from the wire. If the sheet is removed from the wire at a lower position, then the water has been absorbed from the sheet and it is not so easy to remove, the sheet again sticking to the wire.

MR. N. C. UNDERWOOD: Would the author agree that one of the most important features of the suction couch is that it should lower the moisture content of the sheet so that the wet web strength is increased as much as possible? I suggest that this question of moisture content is secondary to the question of whether or not air break-through occurs.

Support is given to this view by Mr. Ives' calculation that very little water can be evaporated by the air that is flowing and therefore we may assume that water removal is purely a mechanical process, with the water remaining in the liquid phase.

MR. IVES: I have stated earlier that it appears to me logical to aim at reducing the moisture content at the couch so that the wet web strength is increased as much as possible. Considering existing installations, the question of air break-through also appears important and there seems little doubt that it does in fact occur at the suction box of the couch on the newsprint machines tested. Furthermore, the higher the paper production, the higher the airflow figure.

MR. UNDERWOOD: Would the author care to comment on the position of the operating point of the vacuum pumps he has investigated? Has he any advice to offer whether one should work on the flat or on the falling part of the pump characteristic?

MR. IVES: In every case, each pump tested was operating at a point on the capacity curve just below the point at which the curve commences to fall away to the lower capacity and higher vacuum ratings. This presumably points to the fact that operators consider necessary high air flows as opposed to high vacua, also that this point on the curve offers the most efficient operation of the pumps and the machines.

On the second part of Mr. Underwood's question, it is difficult to advise that it is best to work on any particular part of the pump characteristic curve, because it depends so much on what vacuum the papermaker requires. Moreover, power consumption is in most cases fairly constant through the whole vacuum range up to about 25 in. mercury vacuum, therefore no great saving is apparent at the lower vacua.

THE CHAIRMAN: Has Mr. Underwood any data to show that water is removed from the couch ?

MR. UNDERWOOD: Some years ago, we carried out measurements on the vacuum couch of one newsprint machine to obtain water, air, heat and power balances. Whilst the main objective was to try to reduce power input to the pumps, other results showed that reasonable quantities of water were being removed. The quantities concerned were approximately 45 gal./min. of water from a 60 g./sq. m. sheet running at 1 050 ft./min. on a machine 230 in. wide in a vacuum of approximately 19—21 in. mercury.

A MEMBER: Is there any correlation between the air flow you have investigated and the final porosity of the sheet at the reel ?

MR. IVES: To my knowledge, there is no relationship between the air flows at the couches as calculated from the tests that are the subject of this paper and the porosity of the sheet at the reel.

MR. ROBERTS: Six years ago, we carried out some experimental work on porosity. We were then trying to obtain the porosity of the sheet before reaching the couch, and, to do this, we developed a special sampling device for picking up the paper off the wire: however, we found the task impossible and the work has been dropped. Certainly, the relationship between air permeability at the couch and the porosity of the sheet at the reel is not known to me.

MR. ROBINSON: As well as air passing through the holes, has allowance been made for the fact that there may be water in the holes ?

MR. IVES: The calculations on air leakage at the couch shell holes were made on the assumption that the holes were full of atmospheric air.

Obviously, there will be water in the couch shell holes at the point of passing the dry side of the vacuum box sealing strip, but it appears logical to assume that this water will have been extracted by centrifugal force and the holes kept clear by this force at the point of passing over the wet side of the vacuum box sealing strip.

MR. ROBINSON: The pump efficiency fails at higher vacuums, because proportionally more air than water is being removed.

MR. GLOVER: In your work, you have assumed that there is only air in the holes. Though this may be so, is it not rather unsafe to make such an assumption in work of this nature, as it affects your calculations ?

MR. IVES: Mr. Glover admits it is possible that air only occupies the couch shell holes at the point of approaching the vacuum box. At the same time, I feel it is possible that some water might be in the holes, but the question is how much ? In any case, if water is present, on the basis that the total water removed at the couch is small compared with air removed from the holes (volume for volume), I feel that the results as given in this paper would not be altered appreciably.

MR. ROBINSON: Water will come out from different places at different speeds.

MR. ROBERTS: In my experience, the only time water is carried back in any volume from the couch to the underside of the wire is when a saveall tray is used. With no saveall tray on a couch, the water is not likely to be drawn up to any appreciable extent.

MR. J. P. FIRRELL: If one calculates the amount of water removed at the couch per minute and compares the volume of this with the 1 000 cu. ft. of space in the holes approaching the vacuum box, it is seen that the water can represent only a relatively small volume. On the other hand, I suggest that the calculation of leakage should be related to the vacuum immediately undei the shell and not to a figure measuied at some distance from this point. Would Mr. Ives comment on this suggestion ?

If we take a lower vacuum at the holes, this will give us a lower figure for leakage and therefore a higher figure for the air flow at a given rate of production. This will shift the curve in Fig. 10 towards the origin.

MR. IVES: Whilst I agree that it appears strictly correct that the leakage calculation at the shell holes should be related to the vacuum immediately under the shell, the difficulties of obtaining such vacuum figures are apparent. Moreover, the vacuum gauge reading on the pipe from the roll end cannot be taken as a true indication of the vacuum in the box immediately under the shell.

Quite correctly, if we take a lower vacuum figure, we would arrive at a lower leakage figure from the shell holes, but we must still consider the vacuum at the pump for determination of the total air extracted by the pump as shown on capacity curves in Fig. 6. In addition, if we convert the total air passing to the pump to its equivalent volume at the lower vacuum occurring at the box and then subtract from this the lower leakage figure, it will be found that, when converting the volumes I have used to their equivalent volumes at the lower vacua, the difference is in one case about 1·6 per cent. up, but in general the quantity passing through the sheet is under 1 per cent. more. I suggest therefore that this difference could quite easily be accounted for by experimental error.

A MEMBER: Pipework can cause restrictions that affect tests such as those mentioned. It is important to know exactly what we wish to do to the paper at the couch—whether there is a squeezing or a drying action. If the former, we must measure the vacuum in the box; if the latter, there can be no drying without heat obtained from the sensible heat in the paper or in the air drawn through it. Much depends on the humidity of the air before and after its passage through the sheet. When talking of pressures, we should ensure that power is not wasted by too small a pipe being used.

MR. UNDERWOOD: Is not the function of heat at the wet end to raise the temperature of the water in the sheet and so lower its viscosity that the water may be removed more easily by mechanical means ? This effect probably outweighs the evaporation effect at this stage of the process.

MR. IVES: It is possible that pipework can affect the results of tests such as are the subject of this paper, but the pump manufacturers recommended alterations only to discharge piping, which was intact throughout the tests.

Mr. Underwood's comment is certainly a view that can be taken of the method of water removal at the wet end. As already stated, it appears that water removal mechanically is far greater in proportion than water removal by evaporation.

MR. ROBERTS: I do not consider that there is any drying of the sheet taking place at the couch; in fact, during the experiments, the amount of absorption of moisture vapour into the air was found to be negligible. I think the flow of air through the sheet removes only free water that is finally diffused into the air in the vacuum box.

MR. ROBINSON: I suggest comparing water passing through the web near the couch and through a fibre pad on a Buchner filter. At the couch, there is several times as much water as fibre and the thickness of the sheet might be some $\frac{1}{8}$ in. I question how air can flow through such a mat. Can it be proved that air does, in fact, go through the sheet for normal or wet-beaten grades or is the air leaking in measured in some other way ? Lastly, does air removal really enter into the problem of water removal at all ?

MR. SUSSMAN: It might happen that raising the vacuum as suggested would cause the expansion and breaking out of small air bubbles in the fibre mat and so cause pinholes.

J. E. Atchison

Recent results with rapid continuous pulping of agricultural fibres

This paper reports preliminary studies in a continuous pulping pilot plant by J. E. Atchison and J. N. McGovern (Parsons & Whittemore Inc., New York, N.Y.) and E. R. Gremler (Pandia Division, The Black-Clawson Co., Hamilton, Ohio).

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

INTRODUCTION

Important trends in pulping

DURING recent years, there have been several noticeable trends in the rapidly expanding pulp and paper industry over the world. Two trends that have gained tremendous impetus over the past five years are—

1. The trend towards ever greater utilisation of agricultural fibres such as cereal straw, rice straw, bagasse and other quick-growing crops such as reeds.

2. The trend towards continuous pulping with special emphasis on the rapid continuous pulping of the agricultural fibres. By rapid pulping is meant total cooking times of 5—25 min., which are almost unbelievable when traditional cooking cycles of 2—12 hr. or even longer are considered.

These two developments have actually been closely related. As more and more large companies and large research institutions have become interested in pulping agricultural fibres, development work in this field has been intensified and more information has been obtained regarding the basic characteristics of these fibres, how to prepare them for pulping and how they react to various conditions and methods of pulping. It is believed that the results of these concentrated efforts during the past five years have gone far towards bridging the great gap that existed between the level of woodpulping technology and the level of technology related to pulping agricultural fibres and fast-growing fibres such as reeds.

Perhaps the most significant finding has been that the long cooking times traditionally used for these materials in either batch or continuous processes were completely unnecessary. In fact, these long cooking times have been found to be extremely detrimental to the quality of the pulp. Therefore, maximum efforts have been concentrated upon finding the best possible methods of carrying out the cooking process in the shortest possible time.

At the same time, progress has also been made in solving the problems posed by the bulkiness of the agricultural fibres. Because of the bulky nature of these materials, capacities of the traditional batch or continuous digesters have been low and high liquor-to-solid ratios have been required for uniform pulping. Therefore, efforts have been directed towards perfecting methods of obtaining greater digester capacity per cubic foot of digester space and towards reducing the liquor ratio when pulping these materials.

Undoubtedly, the most vigorous efforts in the entire field of agricultural pulping have been concentrated on sugar cane bagasse. This is logical, because this raw material is one that is readily available and easily accessible in a great many of the wood-poor countries of the world. As a result of these concentrated efforts, progress in the bagasse pulping field has been rapid.

There have been two extremely important developments in bagasse pulping that have changed entirely the past concepts of how best to handle materials of this type—

1. The comprehensive investigations by the Hawaiian Sugar Planters Association, in collaboration with the Crown Zellerbach Corporation. A report of the results of this work was given at the 1957 TAPPI annual meeting.[1] Definite proof was given that the pulping of bagasse should be performed as rapidly as possible, in the time range of 1—10 min. for the complete cooking cycle, to obtain optimum lignin removal and best pulp quality.

2. The successful pilot plant and commercial application of continuous pulping systems, using the horizontal-tube type of continuous digester with the screw feeder and the orifice discharger, in which these same rapid pulping principles were put into full-scale operation.

Continuous pulping pilot plant

The success of the rapid digestion methods on bagasse immediately indicated the desirability of their application to other agricultural fibres. In order to implement this application, the organisation with which the authors are associated established a complete continuous pulping pilot plant at the Brown Co., Berlin, New Hampshire, in 1957. The first objective of the pilot plant, which is described on page 60, was to demonstrate the operational feasibility of producing pulps from a variety of fibres in continuous runs of 4—12 hr. duration. In these runs, quantities of pulp of 1 000—3 000 lb. were produced and the feasibility of applying the rapid digestion methods in the continuous digester to wheat straw, sugarcane bagasse and esparto was proven without doubt. For example, commercial quality pulps, equal or superior to pulps made by conventional, long batch methods, have been made in the above quantities (Table 1).

TABLE 1

Fibrous material	*Pulp grade*	*Active alkali applied (Na_2O),* %*	*Pulping time, min.*	*Pressure, lb./sq.in.,*
Wheat straw	Corrugating	4.6	8	75
Sugarcane bagasse	Bleachable	12.0	10	130
Esparto	Bleachable	12.4	20	120

* Based on oven-dry weight of fibre charged

These pulps have been successfully made in subsequent pilot plant operations into corrugating board and bleached pulp and paper products, respectively and these products have been of high commercial quality.

Although the main effort at the pilot plant so far has been to demonstrate the operational feasibility of the continuous pulping equipment, as explained above, certain preliminary studies have concerned the variables of pulping in the continuous method. It was thought that the results of these studies would be of interest to this symposium.

Scope of report

This report gives the results of certain preliminary studies on application of the continuous pulping method to rice straw, sugarcane bagasse and reeds; also included are a description of the pilot plant and a general description of the rapid continuous pulping method using the horizontal-tube digester with special metering and pre-impregnation features. Finally, there are mentioned methods for preparing agricultural fibres for pulping in as much as the importance of this phase of pulping these materials cannot be overemphasised.

PREPARATION OF AGRICULTURAL FIBRES FOR PULPING

MANY times, the importance of properly preparing agricultural fibres or other fast-growing fibres before digestion is overlooked to a great extent. However, when the heterogeneous nature of these materials is considered, including the large proportion of undesirable material present with many of them, it becomes obvious that each must be prepared very carefully before pulping, if good results are to be obtained. They may contain pith, leaves, nodes, sheath material, dust and even colloidal soil. These materials must be separated from the good fibre, if good quality pulp is to be obtained.

In the past, most of the preparation methods for these raw materials have been dry methods such as dry depithing of bagasse, dry cutting and cleaning of cereal straw and rice straw and dry cutting and cleaning of reeds. During the past ten years, however, concentrated efforts have been made to improve these preparation methods by going to moist and wet operations. Very significant improvements in pulp quality have resulted.

Improved methods of depithing bagasse and for cutting and cleaning straw are described briefly as follows.

Bagasse depithing

Tremendous progress has been made in improving the efficiency and effectiveness of bagasse depithing methods. The principal efforts have been in moist or humid depithing at the sugarmill (at 50 per cent. dry) and complete wet depithing in dilute suspension at the pulpmill.[(2)]

By methods now perfected and in use, it is easily possible to remove approximately two thirds of the pith at the sugarmill with the bagasse at 50 per cent. dry just as it leaves the sugarmill conveyors. The pith so separated, representing about 20 per cent. of the total weight of the bagasse, can then be burned and its fuel value retained by the sugarmill. The partially depithed bagasse can then be baled for storage or transported directly to the pulpmill. By this procedure, the pulpmill gets a much higher quality raw material and, at the same time, the cost of storage and transportation of raw material per ton of pulp produced is reduced substantially. For best results, it is

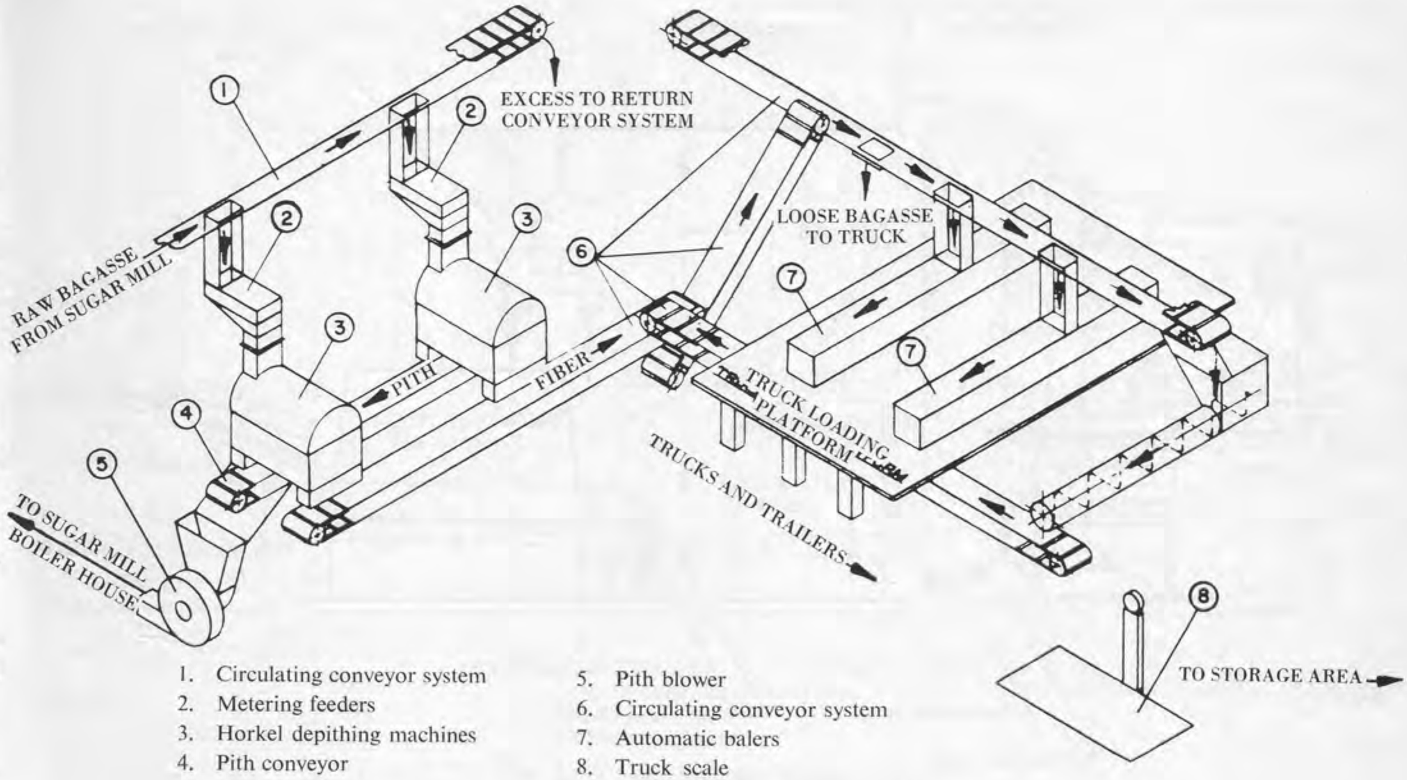


Fig. 1—Bagasse depithing and baling station using Parsons & Whittemore 'Horkel' system

then desirable to have secondary depithing operation at the pulpmill to remove the remainder of the pith and to clean the fibre and prepare it in the best possible form for subsequent digestion. Excellent wet depithing methods have also been worked out, which produce an extremely clean pith-free fibre of uniform particle size that is very easily pulped by means of rapid continuous digestion methods.

One method carries out the partial depithing at the sugarmill, followed by baling, as shown in Fig. 1. This method was developed at Louisiana State University.(3) The final depithing conducted at the pulpmill by a wet method is shown in Fig. 2. This method was developed by the Hawaiian Sugar Planters Association.(4) The method of wet separation is also applicable to depithing corn stalks.

Wet method for straw preparation

Depending upon the method of harvesting and the type of straw involved, this raw material may contain a high proportion of undesirable extraneous material that must be removed before pulping. In the past, dry methods of cutting and cleaning straw have been used almost exclusively. In some cases, however, it is extremely difficult to obtain a clean material entirely by means of dry methods. Furthermore, these methods always create an undesirable dust problem. Rice straw, with its dirt, dust, and leaf material, is a good example of a material that is extremely difficult to clean by dry methods.

To improve the quality of the straw going to the digesters and thereby to reduce chemical consumption and improve pulp quality, efforts have been towards wet cutting and cleaning. One such system is shown in simplified form in Fig. 3.

This method includes the use of the hydrapulper for breaking up the straw bales, for cutting the straw and for cleaning the dirt and dust from the straw. A suitable hydrapulper for this purpose should have solid plates or, in some cases, it can be equipped with plates having $\frac{5}{16}$ in. or $\frac{1}{4}$ in. perforations. If the hydrapulper is equipped with perforated plates, then it should be so constructed that the dirt and fine material can be removed from beneath the plates at the end of the cycle and also so that the clean straw fibre can be removed in slush form very rapidly from

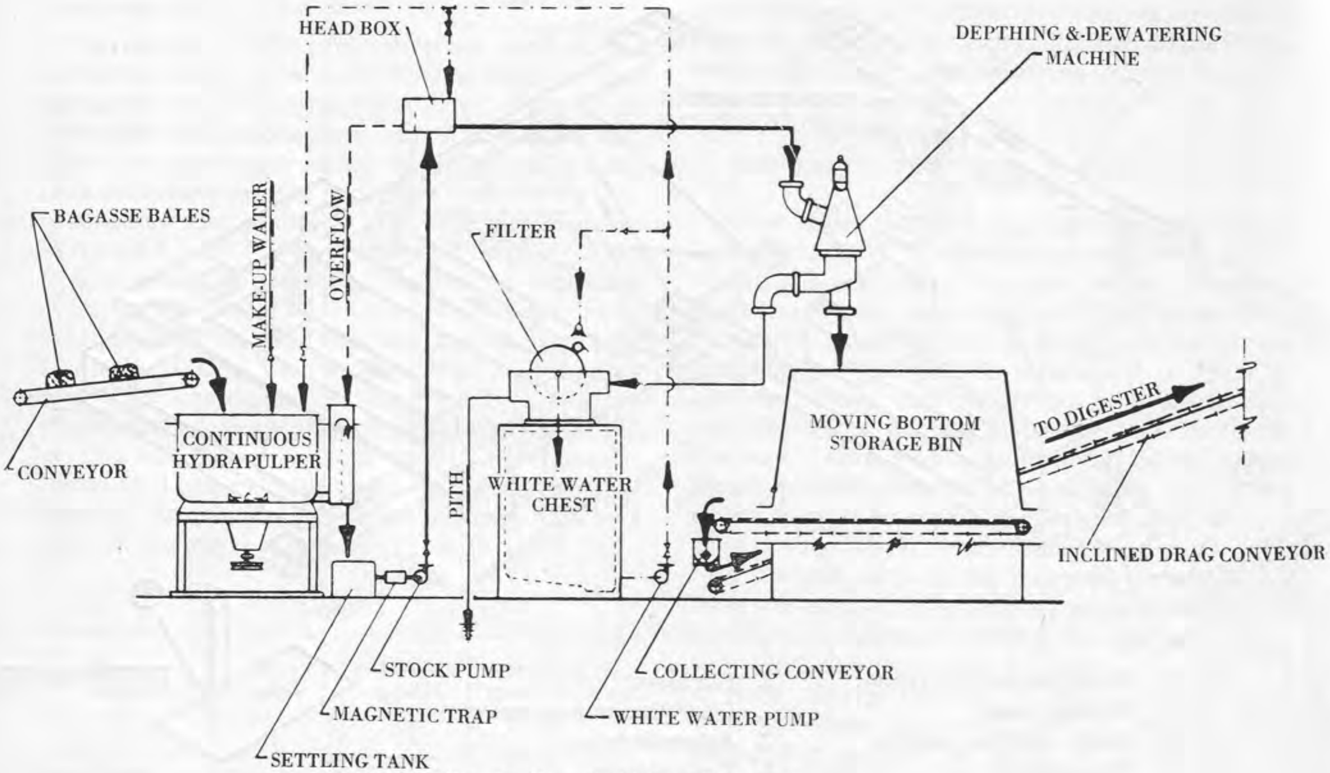


Fig. 2—Wet depithing of bagasse

above the plates. With a hydrapulper of this type, the dirt is removed while the straw is still in the hydrapulper. In the case of using a hydrapulper with solid plates, it merely breaks the straw bales up, performs a rapid cutting action and loosens up the dirt and extraneous material, including breaking up the leafy material. The entire mass is then dumped into a chest and the dirt and extraneous material is removed in a secondary operation through drainer conveyors. It is the latter method that is shown in the flow diagram Fig. 4, using a hydrapulper with solid plates.

It has been found that by use of a hydrapulper of the proper design and with the proper conditions, the hydrapulper actually cuts the straw into short lengths and also loosens up all the dirt and extraneous materials so that these undesirable parts can then easily be removed.

At the same time, any decayed straw that might be present in the bales is broken up into fine particles and can be washed out along with the dirt, leaving very clean straw for the further digestion step.

The cut fibre is pumped from the hydrapulper to the dump chest by means of a special pump and is removed from the dump chest by a drag-type drainer conveyor. In this condition, it can easily be used for feeding the continuous type digester or it can also be used in the conventional batch type of rotary digester or many other of the pulping processes suitable for pulping straw.

It is believed that this wet method of cleaning and preparing straw, especially rice straw, offers very considerable advantages over the traditional method of cutting it and dusting it in the dry state.

RAPID CONTINUOUS PULPING SYSTEM FOR AGRICULTURAL RAPID-GROWTH FIBROUS MATERIALS

General comments

THE pulping of cereal straws and sugarcane bagasse and rapidly-growing grasses and reeds is different from the pulping of wood for the following reasons—

1. The agricultural fibres are much more bulky than wood.
2. The natural structure of agricultural fibres is more open and the stems are much smaller in diameter than is wood, with the result that the agricultural fibres are quite easily penetrated by alkalis at room conditions.

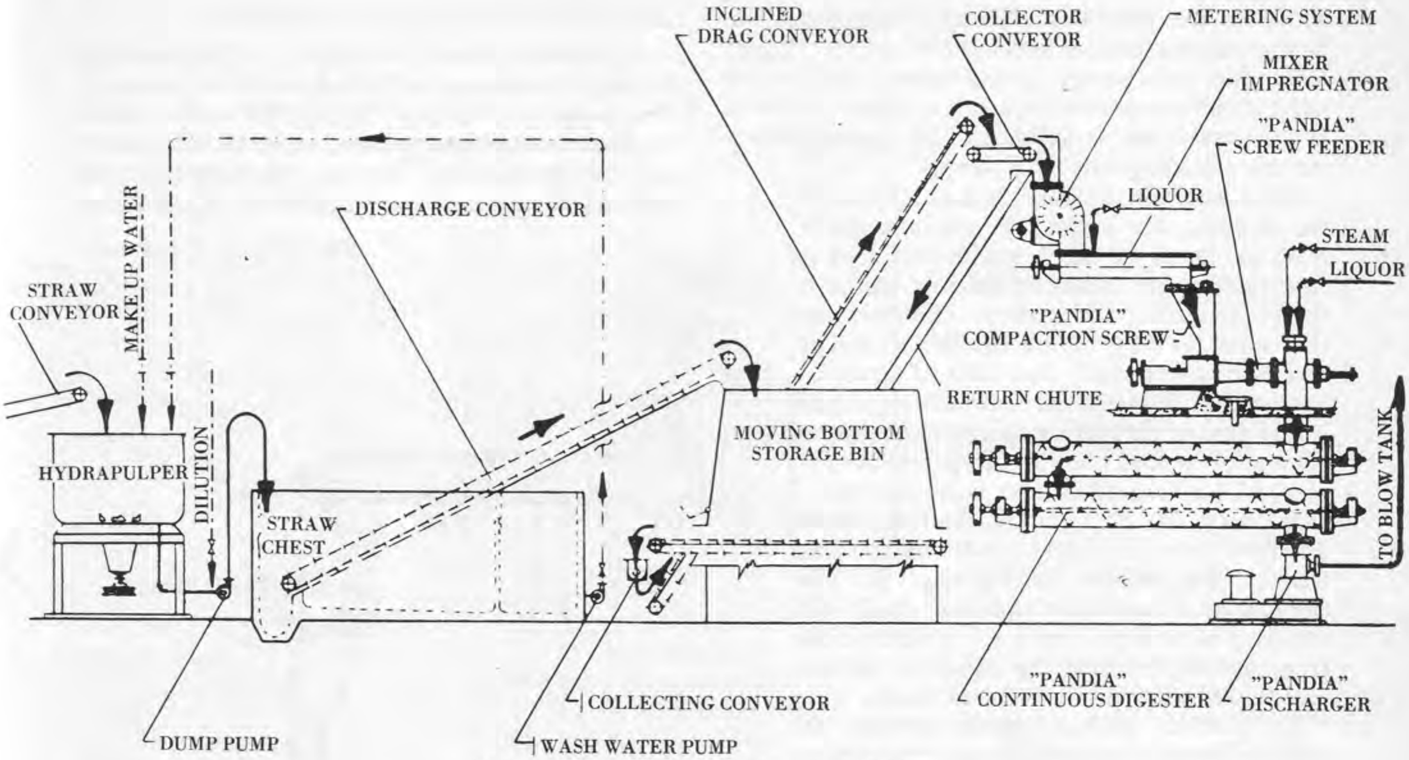


Fig. 3—Wet cleaning and digestion of straw

3. The lignin in the agricultural fibres is considerably more reactive than the lignin in wood. Thus, the agricultural fibres are readily delignified with relatively low requirements of pulping chemicals.

The above properties of agricultural fibres, reeds and grasses have been taken into account in developing a method of continuous pulping designed in accordance with the modern concepts of pulping these materials mentioned previously. This method involves (*1*) regulated, uniform flow of the fibrous material into the system, (*2*) pre-impregnation or preconditioning of the material, (*3*) positive continuous feeding of the material to the digester, (*4*) mild compressive introduction into the cooking zone, (*5*) regulated movement through the digestion zone under uniform pulping conditions and (*6*) continuous discharge with mild fiberising action. The equipment and its arrangement are illustrated in Fig. 4 and described below.

Metering and pre-impregnation

The fibrous material, properly prepared, enters the system from preparation or storage suitable for its nature through a rotary vane metering device with a variable speed drive. The design of this feeder or meter was evolved after considerable engineering and field work with agricultural fibres. The meter is operated with an excess of material presented to it to provide a constant head. Pre-mixing or pre-impregnation is accomplished in an open tube fitted with a special mixing shaft. The fibre is metered into the mixer and the appropriate amount of liquor is sprayed into the fibrous material at the head of the mixer. In traversing the length of the mixer, the liquor is thoroughly mixed into the fibrous material. The mixer or impregnator is followed by a vertical compaction screw. This compaction screw is designed to handle at all times all of the material coming to it, so there is no opportunity for hang-ups. It also provides a positive continuous feed of material to the screw feeder of the digester.

Digestion

The fibrous material is introduced into the pressure zone of the digester by means of a screw feeder. This method of feeding a continuous digester has proved exceptionally successful with bagasse, straws, reeds and grasses. It solves the problem of handling bulky materials by reducing the material to a practical operating density, it compresses the cooking reagent added at the pre-mixer uniformly throughout the fibrous material and, at the same time, removes excess liquor that may prevent a satisfactory pressure seal and also causes removal of air. Any liquid expressed at the screw feeder is returned to the digester from a suitable collecting tank by a pump.

Immediately on entering the pressure zone of the digester, the expanding, pre-impregnated material comes in contact with the cooking liquor and steam and is heated in a matter of seconds to pulping temperature. This procedure eliminates the temperature rise period and its several disadvantages. The ratio of liquor-to-fibre is controlled to suit the material being pulped.

The fibrous material containing the necessary amount of cooking chemical drops into the first of a series of horizontal tubes with time-control conveyors. The conveyor in the first tube is usually of the mixing type to ensure uniform heat transfer, thus uniform pulping. The first tube can also be operated at a high liquor ratio with recycling of the liquor removed at a determined stage, although none of the numerous material investigated showed this to be necessary.

The fibrous material passes through the requisite number of tubes to give the desired production with the required retention time. These tubes are of relatively narrow diameter in order to give maximum uniformity of heating.

The cooked material, semi-chemical or full type, is finally discharged continuously from the pressure zone through an orifice to a blow tank or other receiver. Discharging in this manner imparts a certain beneficial fiberising action.

CONTINUOUS PILOT PULPMILL FOR AGRICULTURAL FIBRES

General

The investigations presented in this report were conducted in the continuous pulping unit of a small commercial size maintained by the Pandia Division, The Black-Clawson Company, within the pilot plant of the Brown Co., Berlin, N.H. The Pandia digester is tied in with the facilities of the pilot plant, which is well known in the industry for development work. The continuous pulping unit is arranged for the pulping of wood chips and agricultural fibres. The capacity is 3—7 tons per 24 hr., depending on the characteristics of the raw fibrous material and pulp yield.

Description and arrangement of equipment

Agricultural fibrous materials are prepared for pulping by means of a Nyblad cutter, as necessary. The chopped or otherwise reduced material then enters the continuous pulping system, which includes metering, pre-impregnating, digesting, fiberising and pulp receiving equipment. The arrangement of this equip-

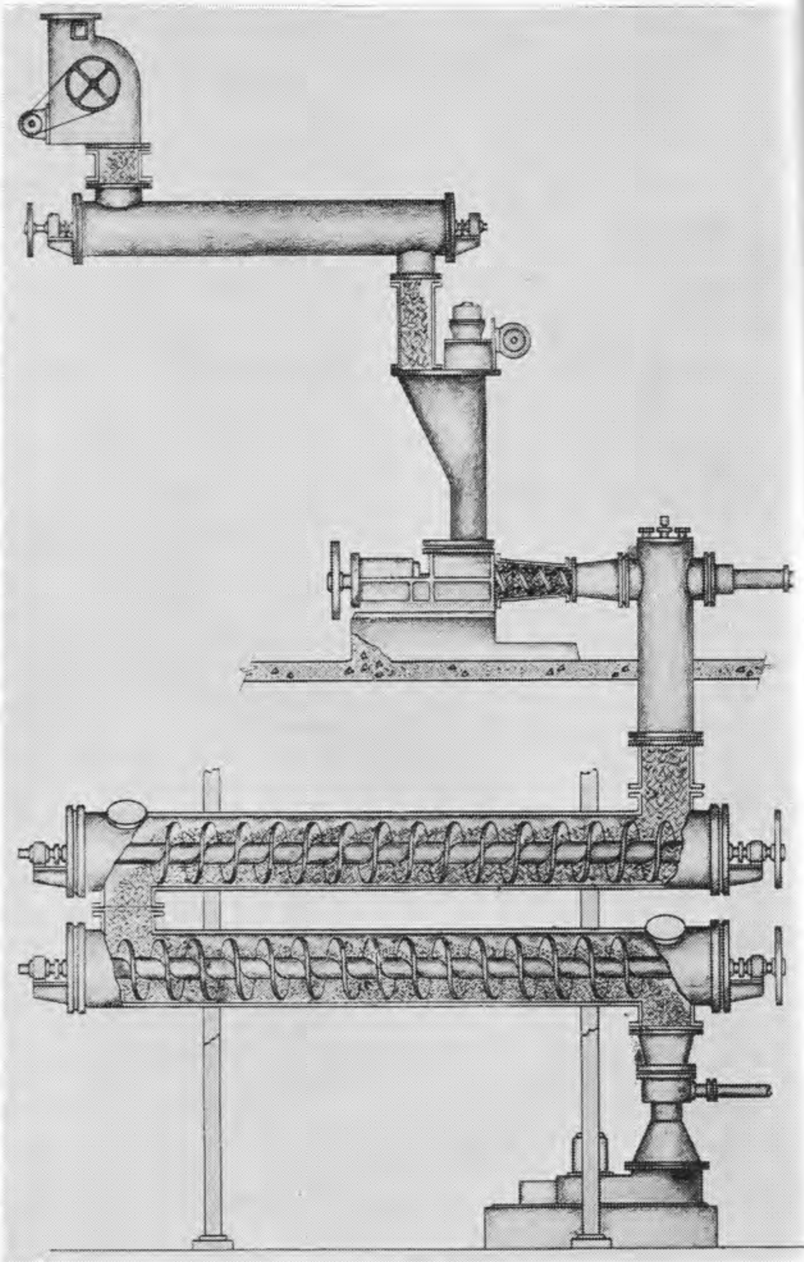
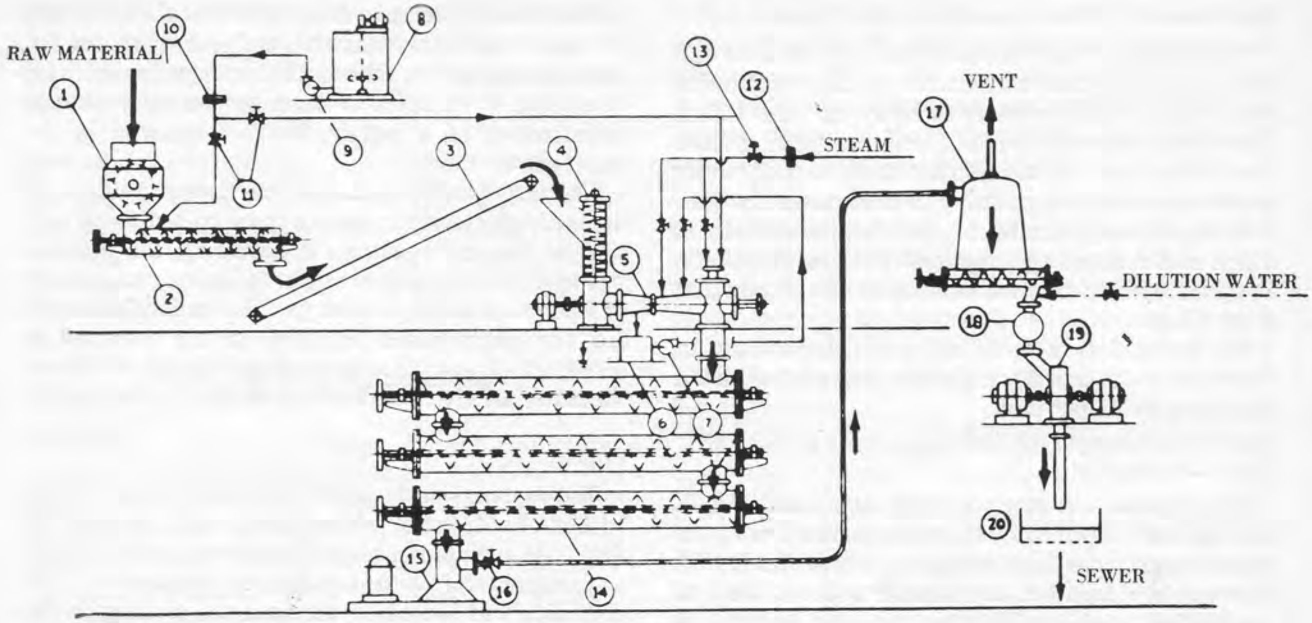


Fig. 4



1. Metering feeder
2. Mixer-impregnator
3. Inclined conveyor
4. 'Pandia' compacting screw
5. 'Pandia' 7½ in. screw feeder with variable speed drive
6. Liquor collecting tank
7. Recirculating pump
8. Cooking liquor storage tank, with agitator
9. Cooking liquor pump
10. Liquor flow transmitter
11. Liquor flow control valves
12. Steam flow transmitter
13. Steam pressure control valve
14. Three (3) 'Pandia' cooking tubes, each equipped with variable speed drive
15. 'Pandia' discharger with constant speed drive
16. Continuous blow valve
17. Live bottom blow tank
18. Refiner feeder with variable speed drive
19. Disc refiner
20. Screen box

Fig. 5—'Pandia' pilot plant

ment is shown in Fig. 5 and the major items are listed as follows—

1. Metering feeder with variable speed drive.
2. Mixer-impregnator with variable speed drive.
3. Inclined belt conveyor with variable speed drive.
4. Compacting screw, constant speed drive.
5. Screw feeder, 7½ in. size, with variable speed drive.
6. Three cooking tubes, each 18 in. diameter, with variable speed drives on the cooking time control screws to give retention times of 2.6—80 min.
7. Discharger, 18 in. size, with drive.
8. Digester controls.
9. Live bottom blow tank.
10. Disc refiner, 24 in. size, equipped with two 50 h.p. motors.
11. Pulp chest.
12. Cooking liquor make-up and storage tank with agitator.
13. Cooking liquor pump.
14. Liquor tank (for liquor expressed from screw feeder).
15. Liquor recirculating pump.

AGRICULTURAL FIBRES USED AND THEIR PREPARATION

General comments

THE importance of proper preparation of agricultural fibres to remove dirt, pith, leaves and other undesirable material was emphasised earlier in this report. Of the several materials available for the pulping tests, however, only the bagasse was suitably prepared. It was necessary to use the rice straw and reeds as received, except for chopping, because proper cleaning equipment was not available at the time these tests were carried out. The uncleaned nature of these latter materials undoubtedly affected adversely the quality of the resulting pulp; however, these particular tests were primarily to determine the suitability of the rapid continuous digestion method for handling these various materials efficiently.

Rice straw

The rice straw was received from Egypt in bales and was chopped as above. Because of U.S. quarantine regulations, it was necessary to spray the bales with a 3 per cent. soda ash solution before removing them from the waggon. It was also necessary to spray water on the material during cutting to hold down the dust. Other than this pretreatment, the chopped rice straw, which was reduced to lengths of 1—3 in. plus fines, was used with its original content of dirt, leaves and other fibres.

The material as received had a moisture content of 9 per cent., but the water added for dust control raised this figure to 45 per cent.

Sugarcane bagasse

The bagasse was received from Louisiana, U.S.A. and had been depithed by the moist method, using the Horkel machine as described previously in this report, followed by a final wet depithing in a second stage of the Horkel machine. This material was bright and well depithed. The depithed bagasse had been dried for storage following the wet depithing and had a moisture content of 5 per cent.

Reeds

Reed canes (*Phragmites* communis) of $\frac{3}{8}$—$\frac{3}{4}$ in. diameter were received from Egypt and were chopped in the straw cutter. The reeds as received contained dry flowers and had retained their sheaths. The chopped reeds had a length of $\frac{1}{4}$—3 in. and contained the fines from the flowers and sheath. The chopped reeds had a moisture content of 16.5 per cent. and had a density of 10 lb./cu. ft. (oven-dry weight).

EXPERIMENTAL PROCEDURES

Metering and pre-impregnating

PRE-TRIALS were made with the prepared fibrous materials to determine the setting of the drive for the metering device. A quantity of the particular fibrous material being tested was fed uniformly by hand to the metering feeder in a manner to maintain the hopper above the feeder at a constant level. The output was collected for a given span of time and weighed. The speed of the feeder was then adjusted to give the desired feed rate in lb./min.

The metered material was then sprayed with cooking liquor at the beginning flights of the mixer tube. This liquor was added at a valve-controlled rate to give the desired dosing at this point.

The speed of the mixer-conveyor was then adjusted to remove the fibrous material at the same rate as fed to it. The retention time in the impregnator was also controlled by the speed of the mixer-conveyor through maintenance of a certain level of material in the impregnator tube.

The impregnated material next dropped on to an inclined belt conveyor run at a speed co-ordinated with that of the impregnator. If necessary, the material was spread out on this conveyor to improve uniformity of feed to the subsequent stage. The inclined conveyor fed the impregnated material to the compacting screw, which was run at a speed high enough to take all the material fed to it without any build up in the hopper.

Pulping

The material next entered the screw feeder of the continuous digester, whose speed was regulated to form and maintain a plug of minimum density to give a pressure seal with satisfactory operation. This condition was judged by the ammeter reading on the control panel.

The additional cooking liquor was added at the desired rate by means of a pump and a calibrated orifice. This rate was controlled and recorded on the control panel. The desired steam pressure was also controlled at the control panel and the flow was recorded.

The retention time in the digester was controlled by calibrated settings of the drives of the time-control screws of the individual tubes. The orifice of the discharger was adjusted to give a minimum of steam escape at this point.

Liquor preparation

The cooking liquor was made up from technical grade chemicals in a calibrated tank equipped with an agitator. The liquor concentration was tested by standard methods.

Yield determination

The determination of the pulp yield was made by collecting the pulp for a given length of time in a chest of approximately 750 gal. size and measuring the consistency of the pulp in the chest after dilution to a known volume. The percentage yield was then calculated from the feed rate of raw fibre during a corresponding length of time, taking into account the retention time in the digester.

Pulp testing

The pulps were tested according to TAPPI standards, except for the processing of certain pulps in a ball mill, noted in the tables of results to follow.

In reporting the test values for permanganate number, these are referred to as K no.

Equivalent pulping times

In comparing results of tests conducted at different pressures, it is found convenient to convert times at one pressure to equivalent times at another pressure. The conversion values reported by K. E. Vroom[5] are used in this report.

RESULTS AND DISCUSSION

Rice straw

General—The uncleaned rice straw, which had been treated with a mild soda ash solution during handling and conditioned with water in the pre-mixer, was pulped uniformly in the Pandia digester using a caustic soda pulping liquor. The effects of the main pulping variables on amount of chemical applied, time and pressure on degree of pulping and pertinent pulp properties are discussed below and the results given in Table 2.

It is noted that the pulps are made with low K no. in the range of 4.9—6.7. It was also observed that the freeness values of the pulps were very low—115—145 C.S.F.—which was attributed to the uncleaned nature of the raw material. The pulps were made in the brightness range of 45—47 per cent.

Effect of amounts of applied active alkali—The effect of decreasing the amount of active alkali applied within the range of 10.6—6.5 per cent. (as Na_2O) based on the straw was to increase the K no. and ash contents of the pulps and to decrease the burst factors (Series A and B, Table 2). The tear factors varied only slightly. These trends were noted at two levels of ratio of liquor-to-straw.

Effect of time of digestion—An increase in cooking time from 5.5 min. to 8 min. with constant active alkali (Na_2O) application resulted in increases in K no. and ash contents (Series C, D and E, Table 2). The trends above were noted at three levels of alkali application. It is apparent that reversion of lignin and ash removal has taken place. This occurrence has been reported for bagasse pulping.[1]

Although strength values were not available for the time comparisons, it can be noted that the strongest

TABLE 2—CONDITIONS AND RESULTS OF SODA PULPING TESTS ON UNCLEANED RICE STRAW

Series no.	*Chemical applied*			*Liquor ratio** *(to unity)*	*Pressure, lb./sq. in.*	*Time, min.*	*K no.***	*Ash, %*	*Burst factor*	*Tear factor*
	Test no.	*NaOH, %*	*Na_2O, %*							
	I. Effect of amount of chemical									
A	7	10.8	8.3	3.1	100	5.5	5.4	7.7	86	90
	10	8.4	6.5	3.1	100	5.5	6.7	17.4	76	87
B	4	14.4	10.6	3.9	100	5.5	4.9	5.4	110	91
	6	12.2	9.4	3.5	100	5.5	6.1	8.3	—	—
	9	9.9	7.7	3.7	100	5.5	6.7	11.7	86	90
	II. Effect of time									
C	7	10.8	8.3	3.1	100	5.5	5.4	7.7	86	90
	8	10.8	8.3	3.1	100	8.0	5.7	—	—	—
D	2	12.7	9.8	2.0	100	5.5	4.9	4.4	123	102
	1	12.2	9.4	1.9	100	8.0	5.8	8.2	—	—
E	4	14.4	10.6	3.9	100	5.5	4.9	5.4	110	91
	5	14.4	10.6	3.9	100	8.0	6.6	9.7	—	—
	III. Effect of ratio (and chemical concentration)									
F	2	12.7	9.8	2.0	100	5.5	4.9	4.4	123	102
	6	12.2	9.4	3.5	100	5.5	6.1	8.3	—	—
	IV. Effect of pressure (and temperature)									
G	2	12.7	9.8	2.0	100	5.5	4.9	4.4	123	102
	3	12.2	9.4	1.9	130	5.5	4.9	5.4	—	—

* Ratio of liquor-to-solids, including moisture in straw
** Permanganate number

pulp was obtained under conditions of the intermediate alkali application and lowest ratio of liquor-to-straw.

Effect of ratio of liquor-to-straw or liquor concentration—A comparison of pulping with a low ratio of liquor-to-straw (high alkali concentration) with a high ratio (low concentration) at the same level of alkali application showed that a lower K no. and a lower ash content were obtained with the lower ratio (Series F, Table 2).

Effect of pulping pressure—Pulping at 130 lb./sq. in. (180°C) in comparison with 100 lb./sq. in. (170°C) with other conditions constant resulted in pulps with the same K no., but the pulp made at 130 lb./sq. in. had a higher ash content than the pulp made at 100 lb./sq. in. This is another evidence of ash re-precipitation.

Pulp strength—The unprocessed pulps had very low freeness values in accordance with the uncleaned nature of the rice straw. The strongest pulp (freeness 135 C.S.F.) had an unbeaten burst factor of 123 (Table 2), which is within the range of a moderately beaten, hardwood kraft pulp. However, the tear factor was low in reflection of the fines from the extraneous matter. The presence of this unwanted material completely masked the intrinsic strength properties of the rice straw pulps.

Summary of rice straw pulping—The most favourable conditions for pulping rice straw in this investigation were those giving adequate pulping without exceeding the point of lignin and ash re-precipitation. These conditions with the uncleaned material were (*a*) 10 per cent. applied alkali, (*b*) a ratio of liquor-to-straw of 2 : 1 and (*c*) 5.5. min. cooking time at 100 lb./sq. in. The unbeaten pulp had a low freeness, but a moderately high burst factor. Removal of the undesirable extraneous matter would undoubtedly reduce the chemical requirement and improve pulp strength.

Pulping of depithed bagasse

General—The depithed bagasse was pulped uniformly by the rapid continuous method using a sulphate pulping liquor in making pulps in a range of K no. of 7—16. The material was uniformly impregnated in the pre-mixer with application of about 20 per cent. of the total chemical requirement. The results of this brief investigation, which involved a variation in the amount of active alkali applied in two time series at a digestion pressure of 130 lb./sq. in., are given in Tables 3 and 4 and are discussed below.

TABLE 3—CONDITIONS AND RESULTS OF SULPHATE PULPING OF DEPITHED SUGARCANE BAGASSE (SERIES PBW-8)

Run no.	*Chemical applied (Na_2O),* %*	*Liquor ratio** (to unity)*	*Pulping time,† min.*	*Pulp yield, %*	*K no.††*
4	7.6	1.68	7	—	16.9
1	10.9	2.38	7	57.2	13.3
5	11.8	2.58	7	—	9.0
2	12.5	2.73	7	—	7.7
7	9.3	2.04	10	54.6	10.2
8	12.0	2.45	10	—	7.4
6	12.5	2.74	10	52.6	7.2

* Sulphidity 24 per cent.
** Ratio of liquor-to-solids, including moisture in bagasse
† Pressure 130 lb./sq. in.
†† Permanganate number

TABLE 4—RESULTS OF BEATER STRENGTH TESTS ON BAGASSE SULPHATE PULPS (SERIES PBW-8)

No.	*K no.**	*Beating time, min.*	*Freeness (C.S.F.), ml.*	*Burst factor*	*Tear factor*	*Tensile strength, m.*	*Folding endurance, folds*
4	16.9	0	435	77	143	3 970	168
		3	420	92	131	5 490	185
		6	325	104	121	6 400	390
		9	265	110	109	6 580	655
1	13.3	0	525	70	158	3 400	104
		3	505	85	155	4 970	177
		6	430	96	136	5 260	295
		9	375	109	132	6 540	535
7	10.2	0	410	102	153	6 100	417
		4	355	122	138	7 100	538
		8	290	128	129	7 840	1 050
		12	225	134	122	7 700	1 310

* Permanganate number

Effect of applied active alkali—The amount of active alkali applied was varied in the ranges of 7.6 per cent. and 12.5 per cent. Na_2O in two times series of 7 min. and 10 min. at a pulping pressure of 130 lb./sq. in. The pulping degree increased (K no. decreased) with increase in alkali used in the two series (Table 3). The K no. was lower for the pulps made in 10 min. than for those made in 7 min. for the same application of alkali. This is normally the case.

Effect of pulping degree on pulp yield—Although only a limited number of yield values were available, pulp yield increased with increase in K no., as would be expected (Table 3). The data were insufficient to show any effect of pulping time.

Effect of pulping degree on pulp strength—Pulp strengths decreased with increase in K no. (Table 4) in the range studied, although the number of tests was too few to show any possible effects of pulping variables.

In the standard strength evaluation of three pulps covering a range of K no., typical increases in burst factor, breaking length and folding endurance with increase in beating degree (decrease in freeness) were obtained (Table 4). The tear factor also was typical in showing maxima in the early stages of beating.

The pulps with K no. above 12 were less defibred after blowing than those with lower K no. This indicated that the defibring point was near this degree of pulping.

Summary of bagasse pulping—The strongest pulps were made with K no. of 7—8 with an alkali application of about 12 per cent. alkali and a digestion time of 7—10 min. at 130 lb./sq. in.

Pulping of reeds

General comments—The reeds were pulped uniformly by the rapid continuous method in producing pulps in a wide range of K no. of 12—30, using a caustic soda pulping liquor. The material was satisfactorily pre-impregnated with 2.8 per cent. alkali (2.2 per cent. Na_2O) and was processed with complete success in the continuous digester.

The effects of the major pulping variables of amount of cooking chemical, time and pressure (temperature) on degree of pulping, yield and pulp strength were determined within the limits of the brief investigation and the results are given in Tables 5 and 6.

TABLE 5—CONDITIONS AND RESULTS OF SODA PULPING OF REEDS (SERIES PBW-6)

Run no.	*Chemical applied*		Liquor ratio* (to unity)	*Yield*			K no.**	Freeness (C.S.F.), ml.	*Pulp strength*†	
	Alkali (NaOH) %	Alkali (Na_2O), %		Total, %	Screened, %	Screenings, %			Burst factor	Tear factor
A. 100 lb./sq. in., 60 min.										
14	17.8	13.8	3.6	42.0	41.9	0.1	15.9	370	85	169
B. 100 lb./sq. in., 80 min.										
13	15.0	11.6	3.3	43.0	42.7	0.3	18.8	400	85	141
C. 130 lb./sq. in., 10 min. (equivalent time at 100 lb./sq. in., 22.2 min.)										
1	22.0	17.0	4.5	45.7	—	—	15.0	380	85	170
D. 130 lb./sq. in., 20 min. (equivalent time at 100 lb./sq. in., 44.5 min.)										
8	12.1	9.3	2.5	60.7	††	—	32.5	415	68	149
3	16.2	11.6	3.4	51.7	51.6	0.6	18.8	425	84	155
2	17.2	13.3	3.5	48.5	48.0	0.5	16.1	410	91	161
E. 130 lb./sq. in., 35 min. (equivalent time at 100 lb./sq. in., 77.8 min.)										
12	11.7	9.0	2.5	48.6	††	—	29.8	340	81	148
9	14.7	11.4	2.9	43.6	43.4	0.2	18.0	395	81	165
10	16.5	12.8	3.3	43.7	43.6	0.1	14.6	370	92	173
17	18.9	14.6	3.6	41.4	41.3	0.1	12.1	395	86	170
F. 150 lb./sq. in., 10 min. (equivalent time at 100 lb./sq. in., 33.5 min.)										
16	11.8	9.1	2.9	50.0	††	—	29.7	405	67	148
11	13.5	10.4	2.9	47.6	††	—	24.8	370	83	165
4	17.0	13.2	3.5	46.4	45.0	1.4	16.6	425	85	162
5	19.7	15.2	4.1	47.0	46.0	1.0	14.9	420	86	155
G. 150 lb./sq. in., 15 min. (equivalent time at 100 lb./sq. in., 50.4 min.)										
6	15.3	11.8	3.2	—	—	—	19.8	440	75	155
7	17.3	13.4	3.6	—	—	—	15.3	445	77	164

* Ratio in liquor-to-solids, including moisture in reeds
** Permanganate number
† Processed 20 min. in ball mill
†† Pulp fiberised in a disc attrition mill

Effect of active alkali applied on pulping degree—The degree of pulping increased normally (K no. decreased) with increases in application of active alkali in the various pressure/time series (Table 5). The several relations between K no. and active alkali applied showed that (*a*) lower levels of K no. were obtained with 35 min. pulping at 130 lb./sq. in. than at 20 min., (*b*) approximately the same levels were obtained at 10 min. and 15 min. at 150 lb./sq. in. within the range studied and these levels fell between the two relations above and (*c*) the results at 100 lb./sq. in. also fell within the range of results at 130 lb./sq. in. The results at 150 lb./sq. in. possibly indicated that the optimum pulping degree for a given active alkali application would be obtained between 10 min. and 15 min. of pulping and that a reversion in pulping degree may be involved between 10 min. and 15 min. Although the lowest K no. for a given amount of active alkali in these tests were shown for the runs of 35 min. at 130 lb./sq. in., the general data also indicate that K no. (obtained by estimation) decreases slightly with increasing pressure (temperature) for equivalent cooking times, providing the above-mentioned reversion tendency is not involved.

Effect of pulping degree on yield—Pulp yields also increased normally with decrease in pulping degree (increase in K. no.) for the several pressure/time series (Table 5). The yield values in the two series of longer times at 130 lb./sq. in. and 150 lb./sq. in. were respectively lower than those in the shorter time runs. In the series at 130 lb./sq. in., the differential yield values were of the order of 5—10 per cent., depending on the K no. Furthermore, the two runs at 100 lb./sq. in. for 60 min. and 80 min. also resulted in pulps having relatively low yields of 42.0 per cent. and 43.0 per cent., the latter being made with a lower amount of active alkali (Table 5). In as much as it was noted previously that given K nos. were obtained in lower levels of active alkali at the longer time in the runs at 130 lb./sq. in., it appeared that these lower K nos. were obtained at considerable expense of yield. Thus, at a K no. of 15 and a cooking pressure of 130 lb./sq. in., the following data can be derived from the relations above—

Time, min.	*Na_2O, %*	*Yield, %*
20	17.4	49.0
35	13.8	42.5

The situation at 150 lb./sq. in. is similar, although not as striking, because the original data were apparently influenced by overcooking. If the trends indicated in these brief tests prove valid in commercial operation, there would seem to be an important advantage from a yield standpoint in using the shortest possible digestion time. This trend has been reported for bagasse.[1]

Effect of pulping degree on pulp strength—Burst and tear factors were found to increase generally with increase in pulping degree or decrease in K no. within the limits of these tests (Table 5). Therefore, from the standpoint of both strength and bleachability, pulping to a K no. of 15 appeared to be optimum within the limits of these brief tests. In comparing the results for the several time/pressure series, however, it was observed that the highest burst factors were obtained in the shorter time respectively for the digestion at 130 lb./sq. in. and 150 lb./sq. in., whereas the reverse was true with the tear factors. Furthermore, the highest burst or tear factors were obtained at the lower pressure of 130 lb./sq. in.

Summary of reed pulping—The strongest pulps had a K no. of 15. At this level of pulping degree, it was noted that there was a general decrease in active alkali requirement, pulp yield and burst factor and an increase in tear factor with an increase in equivalent pulping time (Table 6). Therefore, the long cooking times were unfavourable in all respects, except tear factors. In as much as there appeared to be small advantages in pulping at 130 lb./sq. in. compared with 150 lb./sq. in., the optimum pulping condition within the limits of these tests appeared to be a digestion time of 20 min. at 130 lb./sq. in. with 13.6 per cent. active alkali.

TABLE 6—SUMMARY OF REED PULPING RESULTS (BASED ON PULPING TO A K NO.* OF 15)

Equivalent pulping time at 100 lb./sq.in., min.	*Digestion Conditions*			*Pulp yield, %*	*Burst factor*	*Tear factor*
	Pressure, lb./sq. in.	*Time, min.*	*Chemical applied (Na_2O), %*			
33.5	150	10	15.4	46.6	84	150
44.5	130	20	13.8	48.5	95	161
50.4	150	15	13.6	—	85	—
60	100	60	13.6	42.2	79	171
77.8	130	35	12.8	43.0	82	167

* Permanganate number

TABLE 7—COMPARISON OF OPTIMUM PULPING RESULTS FOR WHEAT AND RICE STRAWS, BAGASSE AND REEDS

Material and process	*Pulping conditions*				*K no.**	*Pulp strength (ball mill test)*			
	Chemical applied (Na_2O), %	*Time, min.*	*Pressure, lb./sq. in.*	*Yield, %*		*Freeness (C.S.F.) ml.*	*Burst factor*	*Tear factor*	*Folding endurance, folds*
Rice straw,** soda ..	9.8	5.5	100	39	4.9	135	123	102	—
Depithed bagasse, sulphate	12.0	10	130	52	7.5	415	118	150	600
Reeds,** soda	13.8	20	130	48	15.0	410	95	160	—
U.S. hardwoods, sulphate	15.6	60 — 90†	100 — 120	48	11.0	375 — 450	100 — 140	150 — 175	60 — 10 000

* Permanganate number ** Material used uncleaned † Time at pulping pressure in a batch operation

COMPARISON OF RESULTS FROM THE DIFFERENT FIBROUS MATERIALS

THE several agricultural fibres and reeds varied in their response to soda or sulphate pulping as gauged by the amount of active chemical applied, the time and pressure of pulping and the K no. of the pulps; however, all of the materials were pulped with relative ease in comparison with wood. The conditions and results for the most favourable digestions as determined from these brief investigations are summarised in Table 7, which also includes typical results for sulphate pulping of U.S. hardwoods.

The rice straw was pulped with less chemical and a shorter pulping time than the other fibrous materials (Table 7). The active alkali requirement was about 10 per cent. and the pulping time was only 5.5 min. at 100 lb./sq. in. to give a pulp with a very low K no. of about 5. The depithed bagasse was somewhat more resistant to pulping than the straw and required about 12 per cent. alkali (Na_2O) and a time of 10 min. at a pressure of 130 lb./sq. in. to give a pulp also with a low K no. of 7.5. The reeds were the most difficult of the materials studied to pulp and required 13.8 per cent. alkali (Na_2O) and a cooking time of 20 min. at 130 lb./sq. in.

The depithed bagasse gave a stronger pulp than the uncleaned rice straw and reeds. The bagasse pulp strengths fell in the range of high quality U.S. hardwood sulphate pulps. The pulps from the uncleaned reeds approached the bagasse pulp in strength and it is probable that improved strength would be obtained from properly cleaned material. The rice straw pulp had a very low freeness and this pulp appeared to be greatly influenced by the presence of non-fibrous leaves, soil, etc.; therefore, a properly prepared rice straw would be expected to give considerably improved properties.

CONCLUSIONS

1. Successful runs of 4—12 hr. duration have proved the operational feasibility of the particular equipment used and the applicability of rapid digestion methods for wheat straw, sugarcane bagasse and esparto.

2. Preliminary studies of uncleaned rice straw, depithed bagasse and uncleaned reeds have indicated that—

(*a*) The rapid, continuous pulping method, including pre-impregnation, is eminently suitable for pulping agricultural fibres and quick-growing reeds.

(*b*) The above materials can be pulped to strong and bleachable grades with soda and sulphate liquors in 5—20 min. at pressures of 100—130 lb./sq. in. with chemical amounting to 10—14 per cent. alkali (Na_2O), based on the raw fibrous material.

(*c*) Of the materials investigated, the reeds are the most difficult to pulp (20 min. at 130 lb./sq. in. with 13.8 per cent. Na_2O) and the rice straw is the easiest (5.5 min., at 100 lb./sq. in. with 10 per cent. Na_2O). The bagasse is intermediate to the others in pulpability (10 min. at 130 lb./sq. in. with 12 per cent. Na_2O). These fibrous materials are pulped much more easily than are hardwoods.

(*d*) The pulp from depithed bagasse has somewhat higher general strength properties than the pulps from the rice straw or reeds used in these tests and falls in the range of strength properties for U.S. hardwood sulphate pulp.

(*e*) The chemical consumptions, yields and strength properties of the pulps from the straws and the reeds are probably affected adversely by the raw material not being cleaned before pulping.

REFERENCES

1. Knapp, S. B. and others, 'Sugarcane bagasse as a fibrous papermaking material': *Tappi*, 1957, **40** (8), 595
2. Atchison, J. E., 'Rapid continuous methods for depithing and pulping bagasse': *Paper Trade J*., 1957, **141** (34), 36
3. Keller, A. G., 'The mechanical depithing of sugarcane bagasse': *Sugar J*., December 1957
4. Knapp, S. B., Milliken, J. H., Wethern, J. D., 'Sugarcane bagasse as a fibrous papermaking material—III. Effect of depithing and bagasse variables on pulping characteristics': *Tappi*, 1957, **40** (8), 602
5. Vroom, K. E., 'The "H" factor: A means of expressing cooking times and temperatures as a single variable': *Pulp and Paper Mag. Can*., 1957, **58** (3), 228

for your reading

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

The sorption of water vapour by the constituents of wood K. E. Kelsey and G. N. Christensen
Aust. J. appl. Sci., 1959, **10** (3), 269; 284

II. Heats of sorption—It is concluded that during the sorption of water, lignin (like wood and cellulose) behaves as a swelling gel and that the sorption of water by wood may be considered approximately as the sum of the sorptions by its major constituents.

III. The swelling of lignin—The results demonstrate that during sorption of water vapour, lignin behaves predominantly as a swelling gel rather than as a rigid porous absorbent.

A new crystalline modification of cellulose as revealed by X-ray diffractograms of hydrolysed cotton and woodpulp

Ö. Ellefsen, J. Gjönnes and N. Norman
Acta Chem Scand., 1959, **13** (4), 853

In an attempt to obtain cellulose II with a high degree of crystallinity, it was discovered that surgical cotton as well as mercerised surgical cotton after 2–4 hr. treatment at 20°c with 40.3 per cent. hydrochloric acid gave X-ray diffractograms that could not be explained exclusively by the hitherto known crystalline modifications of cellulose.

Production planning with paper converting A. C. Plant
Pulp & Paper Mag. Can., 1959, **60** (8), T243

Plastics—a solution to corrosion problems in the paper industry J. M. Brady
Pulp & Paper Mag. Can., 1959, **60** (8), T255

Machine trials prove value of polyacrylamide-type retention aids
J. L. Date, J. M. Shute and A. Shand
Paper Trade J., 1959, **143** (45), 32

The evaluation of a versatile new consistency regulator *Paper Trade J.*, 1959, **143** (44), 24

Maintenance in papermills W. R. Bowen
Pulp & Paper Mag. Can., 1959, **60** (10), T295

The effect of beating on fibre length distribution M. W. Kane
Pulp & Paper Mag. Can., 1959, **60** (10), T308

A theoretical approach using mathematical analysis.

Electronics and the paper industry P. G. Jacobs
Paper Mill News, 1959, **82** (40), 35

The automatic pulpmill W. W. Brown
Paper Mill News, 1959, **82** (40), 40

New role for inspection in the age of automation D. P. Antos
Paper Mill News, 1959, **82** (40), 44

Good instrument maintenance means successful automation C. D. Lindwall
Paper Mill News, 1959, **82** (40), 46

Adhesives in the paper industry
Paper Ind., 1959, **41** (5), 311

Part 6—Inorganic adhesives
Synthetic resin adhesives: aldehyde-based resins
Paper Ind., 1959, **41** (6), 382

Part 7—Synthetic resin adhesives:
epoxy, polyurethane and polyester resins
Paper Ind., 1959, **41** (7), 460

Synthetic resin adhesives:
polyvinyl alcohol and polyvinyl acetate
Paper Ind., 1959, **41** (8), 545

Hollingsworth and Vose uses acrylonitrile to make improved paper *Paper Trade J.*, 1959, **143** (42), 44

Cyanoethylation of pulp with acrylonitrile makes it possible to produce paper with greater resistance to deterioration by heat and prolonged retention of dielectric and tensile strengths in a sealed system, as well as improved dimensional stability and resistance to rot and acids.

Some studies of the abrasion and corrosion of Fourdrinier wires J. D. Boadway, J. Friese and R. M. Husband
Pulp & Paper Mag. Can., 1959, **60** (8), T231

(continued on page 14)

TRANSLATIONS
FROM FOREIGN JOURNALS

x

FOUR announcements have been made (**Technical Bulletin** 1954, **31** (6), 197; 1957, **34** (1), 8; 1958, **35** (5), 153 and 1959, **36** (4/5), 73) and a fifth supplement is now given. Copies of all these items are available and interested members are requested to obtain from the Librarian details of charges of those already published, as well as of those listed below.

Readers are reminded that the Technical Section translations service is available to Section members at competitive rates covering the following languages—

Czech, French, German, Dutch, Swedish, Italian, Polish and Russian

Rates and other information about original translations being undertaken can be obtained from the Librarian, Technical Section, B.P. & B.M.A., St. Winifred's, Welcomes Road, Kenley, Surrey.

Stainless steel suction rolls — A. P. Oboevtsev
Bumazh. Prom., 1959, **34** (2), 15

The use of CMC in the making of printings — I. P. Volkova
Bumazh. Prom., 1958, **33** (10), 15

Rapid refractometric method for determining the concentration of solutions — E. Ya. Vinetskaya
Bumazh. Prom., 1959, **34** (2), 5

The influence of fractional beating on pulp quality — R. E. Reizin'sh and L. R. Kalnin'sh
Bumazh. Prom., 1959, **34** (3), 16

The detection of wax in paper — P. V. Prober
Bumazh. Prom., 1959, **34** (3), 21

The influence of relative humidity on paper properties — W. Brecht
Papierwereld, 1958, **13** (2), 35

An ultrasonic apparatus to control pulp consistency — M. G. Bogyslavski, K. N. Marenina and G. N. Feofanov
Bumazh. Prom., 1958, **33** (12), 10

Studies on the slice of the newsprint machine — Dr. W. Müller-Rid
Wochbl. Papierfabr., 1959, **87** (11/12), 478

Experience gained in the use of a new type of wire — G. S. Shapiro
Bumazh. Prom., 1959, **34** (6), 21

Traces of iron and copper in condenser paper — N. V. Golyb
Bumazh. Prom., 1957, **32** (7), 8

A method for the estimation of conducting material in condenser paper — L. M. Vaisman and G. P. Doichenko
Bumazh. Prom., 1957, **32** (7), 10

The use of the size press for surface treatment of printing paper with pigment coating containing CMC — J. G. Reich
Norsk Skogind., 1958, **12** (9), 325

Measurement of fibre length — G. van Nederveen and H. A. Westra
Papierwereld, 1959, **14** (1), 337

The activation of chlorate for pulp bleaching — A. I. Kachalov and I. G. Vikova
Bumazh. Prom., 1959, **34** (7), 5

Decreased losses and increased production
Oesterr. Papier-Zeit., 1958, **64** (10), 13

(News page continued from page 24)

Paper testing

RECENTLY, the Paper and Board Testing Committee has set up new sub-committees to deal with tests not included in its previous programme. It is the policy of this Committee to publicise the formation of new sub-committees so that anyone interested can volunteer to serve on them. Such participation will be very cordially welcomed and offers from members should be forwarded to the Secretary of the Technical Section at St. Winifred's, Kenley.

The sub-committees recently formed are as follows—

Fluff test—Chairman, Miss E. J. Pritchard
Curl test—Chairman, Mr. G. K. Abercrombie
Top and wire side of paper—Chairman, Mr. J. H. Martin
Dirt count—Chairman, Mr. R. M. Macnaughton

Introducing

A UNIQUE WET STRENGTH RESIN

HERCULES

KYMENE 660

KYMENE 660 is the latest addition to the Hercules group of Wet Strength Resins. This new resin is designed for use in paper making systems that operate under any pH condition. It is particularly effective in the range of 5 to 10.

Greater dry strength and better ageing properties are imparted to the paper while acid corrosion of paper making equipment is reduced or eliminated.

KYMENE 660 is an entirely new resin of a type not previously used in paper or known to form wet-strengthening bonds. This resin contains no formaldehyde, urea or melamine.

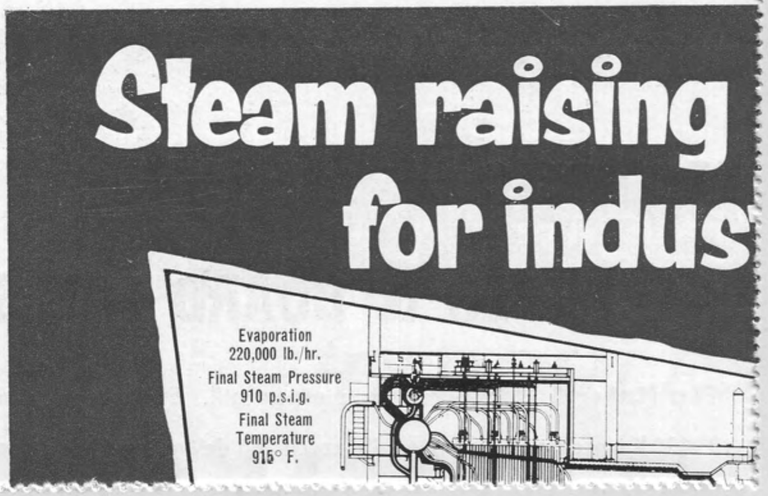
Please write for full technical details and sample to the Paper Makers Chemical Department.

HERCULES POWDER COMPANY LIMITED

ONE GREAT CUMBERLAND PLACE · LONDON · W1

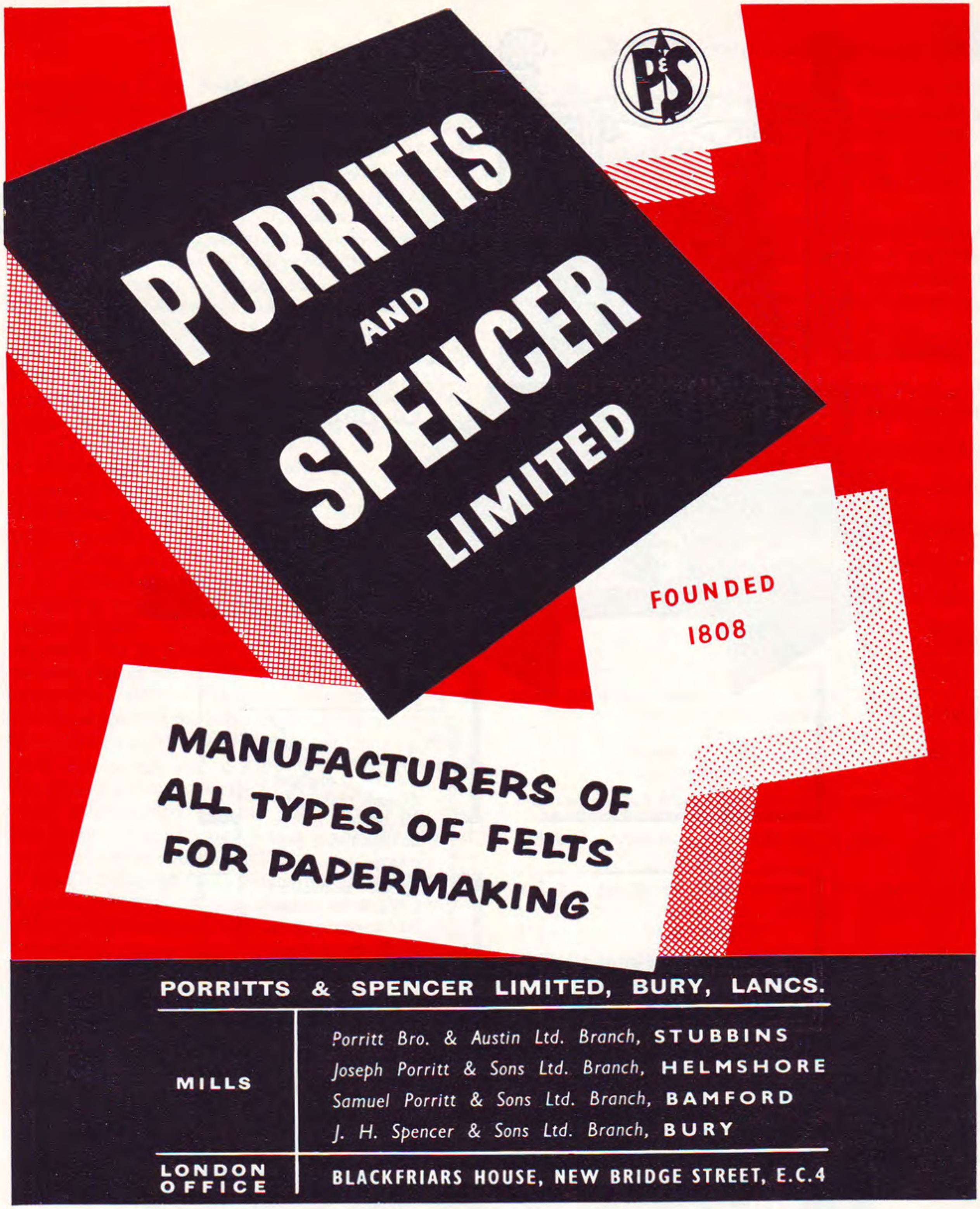
Telephone AMBassador 7766

[p.t.o.



REPLY PAID CARD SERVICE

✱ This readers' service is intended to provide you with information in a way that will save time—we hope you will make use of it.


PORRITTS
AND
SPENCER
LIMITED
FOUNDED
1808
MANUFACTURERS OF
ALL TYPES OF FELTS
FOR PAPERMAKING
PORRITTS & SPENCER LIMITED, BURY, LANCS.
MILLS
Porritt Bro. & Austin Ltd. Branch, STUBBINS
Joseph Porritt & Sons Ltd. Branch, HELMSHORE
Samuel Porritt & Sons Ltd. Branch, BAMFORD
J. H. Spencer & Sons Ltd. Branch, BURY
LONDON OFFICE
BLACKFRIARS HOUSE, NEW BRIDGE STREET, E.C.4

(Summaries from foreign journals continued from page 12)

Investigation of the fluffing of printing papers

S. Lipko and T. Nierychlewski

Prace Inst. Cel.-Papiern., 1957, **6** (1), 46

THE authors have attempted to develop a simple and rapid method of determining the tendency of printings to fluff. Their method does not reproduce the conditions existing during printing, but it makes possible a relatively satisfactory estimation of the printability of paper.

The apparatus for the determination of fluffing was designed on the basis of the Riesenfeld and Hamburger tester (*Papierfabr.*, 1930, **28**, 119). It consists of a heavy base that supports three principal parts of the device: the roller, which stretches the sample of paper under test, the device that presses the blade to the surface of the sample and the electric motor driving the roller. The roller has an operative circumference of 500 mm. and an effective width of 37 mm. It is connected by means of ballbearings to the cylinder, fixed to the support. The sample is held by a spring, which is under a slit in the ring part of the roller. The slit is 0.8 mm. wide. There is a device consisting of a lever, to one arm of which is fixed a clamp for a razor blade. The other arm of the lever is provided with a weight, by means of which the pressure of the blade on the paper can be varied. By moving the weight, the pressure can be varied by 100 g. stages between the limits 200—1 000 g. The angle between the razor blade and the tangent to the roller at the point of contact is 67°. There is a device to facilitate the bringing of the blade to the sample and back during the determination. The electric motor drives the roller by means of a belt, which is so adjusted that the speed is 500 rev./min. The apparatus is provided with a revolution counter connected to the roller.

The procedure of the determination is that 10 strips of paper 600 mm. × 37 mm. are cut from the sample under test and weighed with an accuracy of 0.0002 g. One strip is placed on the circumference of the roller so that one end of it passes through the slit and it is pressed to the inner wall of the roller by the spring. The weight is then placed in the position giving the required blade pressure. As soon as the roller begins to rotate, the blade is brought into contact with the paper and is held there for 3 min. The strip is then weighed, in order to determine the weight of the material scraped from the surface. Before weighing, small particles adhering to the surface should be removed with a soft brush. For calculating the percentage of material scraped off by the blade, only the weight of the part of the strip in contact with the blade should be taken into account. Since the strip was scraped over 500 mm. of its length, the correction factor is $\frac{5}{16}$ in. Five strips are so placed on the roller that the top side of the paper is scraped; with the other 5, the wire side is scraped. One razor blade is used for 5 determinations.

The results of the individual determinations differed from the mean value within the limits 0—8 per cent. This scatter of the results is due to the non-uniform structure of the paper and to the uneven finish of the surface.

The following formulae are used for the calculations—

$$I_s = A_s - Z_s\,; \quad I_g = A_g - Z_g$$

where I_s = amount of dust in g. scraped from the wire side of the paper,
I_g = amount of dust in g. scraped from the top side of the paper,
A_s = mean weight of sample in g. before determination, for wire side,
A_g = mean weight of sample in g. before determination, for top side,
Z_s = mean weight of sample in g. after determination, for wire side,
Z_g = mean weight of sample in g. after determination, for top side.

$$K_s = \frac{I_s \times 100}{5/6 \times A_s} = \frac{I_s \times 120}{A_s} \qquad K_g = \frac{I_g \times 100}{5/6 \times A_g} = \frac{I_g \times 120}{A_g}$$

where 5/6 is the correction factor, defined above,
K_s = percentage of dust scraped from the wire side of the paper,
K_g = percentage of dust scraped from the top side of the paper.

The dust scraped from both sides of the paper (g.) $= R = I_s + I_g$.
The dust scraped from both sides of the paper (%) $= K = K_s + K_g$.

The amount of dust scraped from both sides of the paper having an area of 1 sq. m. $= M = R \times 100\,000/50 \times 3.7$,

where 50 = length of the sample in cm.
3.7 = width of the sample in cm.

The above formulae are applicable for a constant pressure of the blade. The determinations carried out by the authors indicated that the amount of dust scraped from the paper increases with increasing pressure of the blade. Papers having a high ash content have a pronounced tendency to fluff. Some kinds of paper were found to be completely unsuitable for printing. Examination of them under the microscope indicated that they were made from sub-standard pulp, which formed a certain amount of fines during beating. The best papers for not fluffing were characterised by good sizing and a moderate amount of filler. With papers unsatisfactorily sized, the fluffing increases with increasing amounts of filler. Addition of starch to the pulp decreases the tendency for fluff.

More dust is scraped from the top side of the paper than from the wire side. This is due to the non-uniform distribution of the filler in the sheet during drainage on the wire; the suction boxes remove particles of the filler from the wire side of the sheet.

The most convenient blade pressure for fluff determination is 200 g. The authors suggest that by comparing the data obtained by their method with the estimated printability of the paper, appropriate analytical standards could be defined. Due to the lack of suitable material, the authors were unable to determine the relationship between the tendency for fluff and such factors as the composition of the pulp, thickness and apparent specific gravity of the paper, smoothness of the surface, etc.

The continuous production of hypochlorite bleach liquor

J. G. A. Schmidt

Wochbl. Papierfabr., 1959, **14** (87), 6/6

MAKING hypochlorite bleach liquor by a batch process has many disadvantages, including the large floor area occupied by the stirring and mixing tanks and the settling and storage chests. The operation and maintenance of this type of installation requires a large personnel and the system is time-wasting, since long periods are needed for the sludge to settle and be removed. A continuous operation avoids all these disadvantages and, at the same time, chemical losses are reduced by approximately two thirds, the bleach liquor produced is more uniform (particularly important for calcium hypochlorite) and more exact control of chlorine and alkali concentration is possible. The continuous, automatic process for the preparation of hypochlorite is relatively cheap to install and simple to operate.

In the batch process, careful control must be exercised to obtain information on whether the neutralisation of the alkali solution by the chlorine is causing the pH to approach neutrality and to ensure that there is always an excess of alkali. Usually, these control tests are made by titration or by phenolphthalein, though the reaction is controlled in some cases by a method based on the measurement of oxidation potential. If two electrodes of suitable materials—in this case, platinum and silver with a coating of silver chloride—are immersed in a hypochlorite solution, then an electric potential is produced between them. This potential increases with the addition of chlorine to the alkali, the rate of increase becoming greater as neutrality is approached. The potential between the electrodes can be measured and the information transmitted to a regulating valve that controls the addition of chlorine to the alkali.

A less well-known fact is that, in the reaction between chlorine and alkali, the initial speed of reaction of both chemicals is relatively slow, but increases rapidly with the greater content of hypochlorite ions, which occur as reaction products. These two principles are used in the continuous preparation system.

The main part of the system is the reaction tower, consisting of a long outer tube and a shorter inner tube. The alkali solution enters at the foot of this double-pipe system, moves up the inside of the shorter tube and mixes with the chlorine gas, which is forced through a nozzle at a given pressure. The system is designed to ensure that the liquid in the inner tube can rise more quickly and in excess of the hypochlorite liquor flowing out of the outer tube further up. Circulation in the lower part of the double-pipe installation ensures that the part of the hypochlorite liquor that cannot get through the outflow pipe is drawn back down between the inner and outer tubes.

At the bottom, the liquor is again mixed with the chemicals entering at that point and is further concentrated. The essential feature of this is that the liquor rising up the inner tube already has a fairly high hypochlorite concentration and the reaction rate is much higher than the initial reaction rate between chlorine and alkali. This enables a relatively short reaction column to be used, the length usually being about 3 m. (about 10 ft.) and the diameter is determined by the hypochlorite demand. The reaction tower and the system of pipes must be resistant both inside and out to the corrosive action of moist chlorine gas and hypochlorite and materials suitable for this purpose are, for example, PVC, polythene hardened by beta-radiation, high-grade stainless steels. The two electrodes are fitted tangentially at a point not far from the end of the inner pipe and this ensures that the time lag is not more than 2 sec. between the inflow of chlorine and measurement of the reaction effect.

The alkali inflow is used as the basic value and the amount of chlorine is regulated accordingly, since measurements on a flowing liquid are simpler to make and are more exact than any method of measuring gas flow. The concentration of sodium hydroxide can be determined either by finding its specific gravity or by the conductimetric method, but only the latter method is applicable for use with milk of lime. With this type of system, therefore, both sodium and calcium hypochlorite can be produced.

The determination of fold number

P. Fink and R. Schweizer
Textilrund., 1958, **13** (12), 694
(from *Das Papier*, 1959, **13** (7/8), L39)

IN an attempt to obtain uniformity in fold number determinations in Switzerland, a range of 5 different papers were distributed to testing laboratories. The tests covered 5 Schopper double-fold testers, 3 Brecht-Wesp pressure folders, 1 L'Homme and Argy pliagraph, 1 Köhler-Molin double folder and 1 Frank folding endurance tester. The testing conditions for each instrument are closely specified and comparable and the experimental results, both under normal operating conditions and with systematic alterations in these conditions, are set out in detail and evaluated statistically. It was proved in this way that the paper properties that the different apparatus measure as 'folding endurance' are never exactly the same, but differ to a varying extent so that the results of classifying the five grades of paper can be quite different.

The Schopper, Köhler-Molin and L'Homme and Argy instruments operate on roughly the same principle and, of these, the Schopper is preferred, since it is already extensively used. The Brecht-Wesp pressure folder has such advantages as short testing time, lower spread of results and, in many cases, a result much nearer that found in practice, but shows a significantly different classification from that given by the above group, particularly with speciality papers. Since this raises the question of which classification is to be preferred in a given case, the experiments do not make it possible to choose a particular instrument. The whole question of fold number determinations remains open.

Some problems in the use of urea-formaldehyde resins to improve moulded wastepaper products

W. Laskawski, J. Malczewski and T. Rabek
Polish Paper Rev., 1959, **6** (15), 1747

THE results of this work, which was limited to some of the problems only, provide some new data on the problem of the use of urea-formaldehyde resin for the improvement of moulded wastepaper products and, more generally, on the problem of precipitating the resin on the wood cellulose material.

1. Urea-formaldehyde resin 121, which was used in the work, could be satisfactorily used for precipitation on repulped waste paper only when the concentration of the resin in the solution was very low, that is, when the resin content of the pressing was very small or when coagulating agents were added. This leads to the following conclusions—

(*a*) Coagulating agents must be used, since the decrease in pH is not sufficient.

(*b*) Higher polymers of the resin should be used, since they are better utilised and the curing process is more rapid.

2. Because curing and coagulating agents must be used in impregnation with the resin, use is recommended of electrolytes that act as both agents at the same time. Comparison of the action of sodium acetate and aluminium sulphate indicates that sodium acetate acts only as a coagulating agent and the water absorption characteristics of the products obtained by its use are unsatisfactory.

3. It is surprising that even a considerable increase in the amount of resin added to the wastepaper stock does not increase the resistance to water to the same degree. The effect of adding the resin to wastepaper stock is much smaller than the effect of adding it to woodpulp, owing to the non-uniform structure of the pressed wastepaper. Hence, in many cases, an increase of more than a few per cent. in the amount of resin added is not economical.

4. The results of direct impregnation of the pressed products by immersion in a solution of the resin are very interesting and encouraging.

5. The resistance to water is an unsatisfactory and one-sided criterion of the quality of the pressings, although it is of primary importance in the practical use of these products. It should be mentioned that the test consisting of boiling with water for 30 min. is very radical, both for the wastepaper and the resin. A better idea of the quality of the products is given by the results obtained after a 24 hr. immersion in water. The mechanical strength of the products was not determined, because of their unsuitable shapes. It was found that the water absorption value is affected by a number of factors such as pressure and the method of pressing, considerable increase in the rate of drying and the kind of wastepaper or other fibrous material used.

Since the pulp is not a material that can flow in the mould and become homogeneous, the arrangement of the fibres in the pressing is of considerable importance. Thus, in the manufacture of saucers, better results are obtained by placing the mould so that its bottom is uppermost, since then the directions of pressing, movement of pulp and flow of water are identical.

A certain scatter in the results of the determination of water resistance is due to the difficulty of maintaining uniform conditions in pressing. Furthermore, it was found that rapid drying of the wet products decreases their resistance to water, probably owing to the disruption of the structure of the pressed product by the water vapour, which quickly escapes from it. The increased water resistance of moulded wastepaper products is accompanied by a considerable decrease in the tendency to rot in humid and warm atmospheres.

6. Certain further problems of a theoretical and practical nature appeared in the course of the work, one of them being the problem of fractionating the urea-formaldehyde resin during adsorption and coagulation on cellulose and also during the determination of the ease of precipitation. It is obvious, in the view of the incomplete adsorption, that higher polymers are more readily precipitated. This is of considerable importance for the utilisation of the resin and for the repeated precipitation of the resin, when the solution is used several times. These and similar problems with melamine resins are the subject of further studies.

Carubin and guaran in papermaking

W. Schmidt

Allg. Papier-Rund., 1959, **12**, 605

THE galactomannans, carubin and guaran, are valuable agents for the papermaker, especially when used in wood-free papers or papers that have only a small groundwood content. The improvements in qualities attained by the use of the galactomannans can be summarised —

1. An average tensile strength increase of 20 per cent.
2. An average tensile stretch increase of 8—10 per cent.
3. An average increase in bursting strength of 20 per cent.
4. Improved surface smoothness and formation.
5. An improvement in the degree of sizing.
6. An increase in filler retention.

Pulps containing galactomannans also have better drainage properties and the paper made from such pulps lies flatter.

The galactomannans are available in powder forms that are soluble in the cold and can be added dry to the Hollander or pulper. Carubin has proved particularly successful when used with sulphate woodpulps and guaran has given similar results with sulphite woodpulps. Only small amounts need to be used to improve retention, as well as strength and properties effluent treatment is made easier.

The curl tendency of paper

W. Brecht, P. Räderer and W. Weitzel

Das Papier, 1959, **13** (11/12), 237

THE investigation was concerned with the curl tendency of paper and its relationship with changes in the ambient air conditions. No work was done on mechanical factors such as the effect on the sheet of passing it over a sharp edge. There is an introductory paragraph on the nature of curl and on the main causes of curl in the sheet.

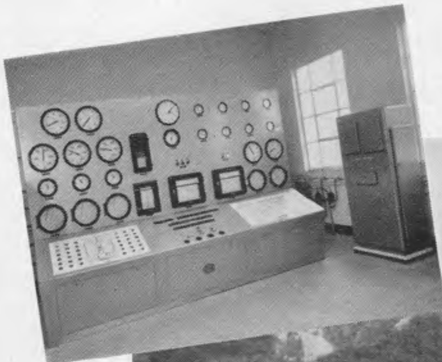
A special apparatus was designed so that the effect of moist air on one side of the test sheet could be studied while the other side was unaffected. This consisted of a lower chamber to hold the sulphuric acid or salt solution affecting the humidity conditions and an upper test chamber with curved walls so that when the test sheet curled no space would be left between the sheet and the walls of the test chamber. The concentration of the salt solution in the base of the apparatus is chosen so that the relative humidity of the air in this part is known and is higher than the relative humidity of the ambient air. The lower and upper compartments are isolated by means of a sliding shutter and the test sheet is placed in the test compartment so that it rests on two bridges at rightangles to the expected axis of curl. The shutter between the compartments is then opened, the damp air comes into contact with the underside of the test piece and the paper curls.

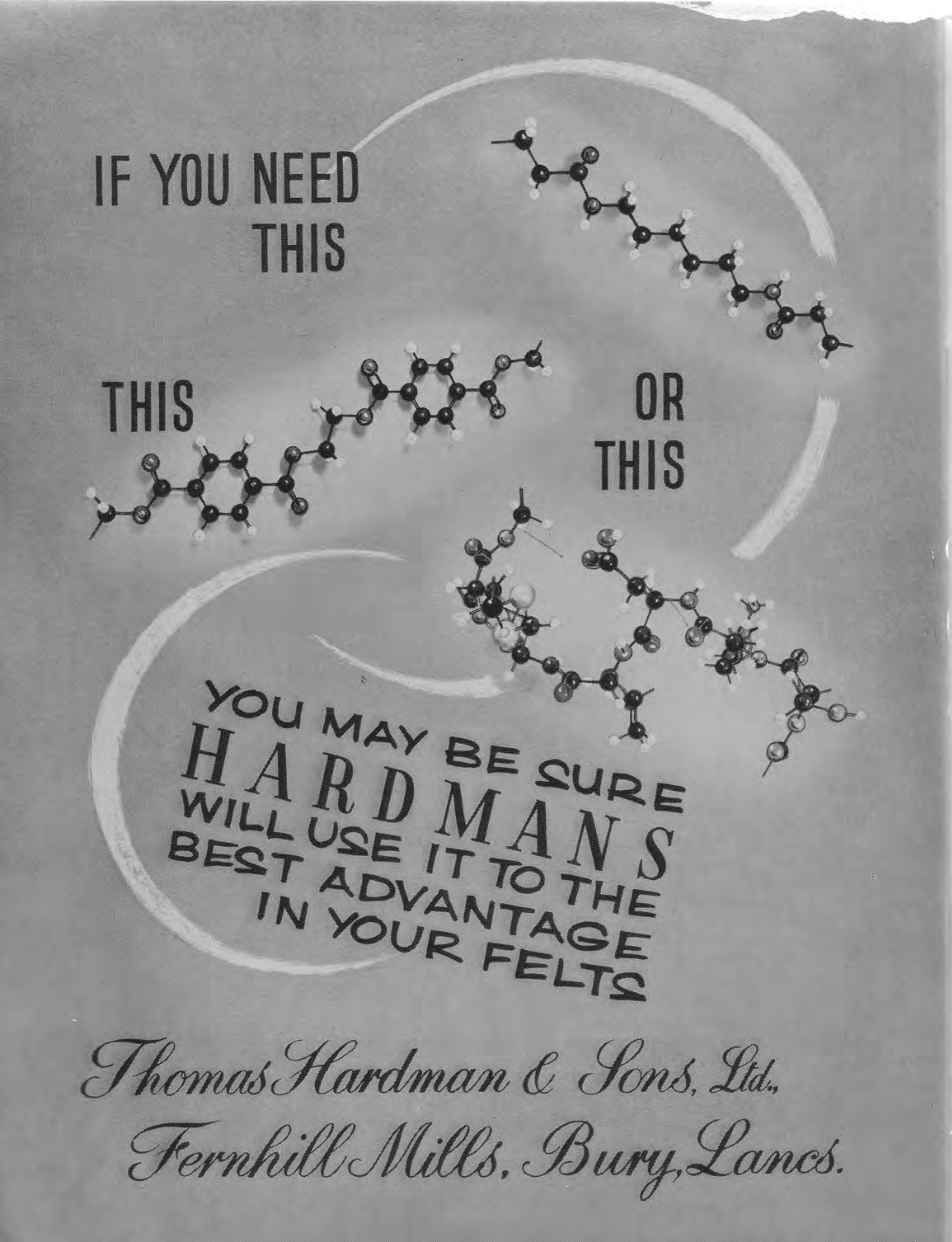
The curling process is followed by taking photographs of the sheet at given intervals and quantitative results are obtained by measuring the 'curl height', that is, the perpendicular distance between the crown of the curled sheet and the original plane of the sheet.

It was found that when the moist air, usually at 95 per cent. R.H., was in contact with only the lower side of the test sheet, the amount of curl was greater the higher the specific wet expansion of the sheet. If there was a difference in wet expansion in the cross- and machine-directions, caused either by fibre orientation or by tension in the machine-direction during drying, the paper tended to curl into the shape of a tube, the longitudinal axis of the tube corresponding to the direction in which the wet expansion is the lesser. With machine-made papers, this is usually the machine-direction.

Investigations on the effect of beating on curl showed that paper made from wet-beaten pulp curled more than paper made from free pulp. There is a

(*continued on page 85*)





greater
stiffnes
Expe
sides o
showed
curl.

The ef
of p
behav
brief

ALT
genera
elonga
applica
conten
these e
lower
meter.
paper
stretch
measu
fractio
ferred
to 200
measu
and e
was c
be qui
An
used
machi
graded
were
relatio
of ap
extend
well a
furthe
stretc
that s
shrink
were
Th
stretc
requi
usual
influe
on th
The

greater tendency for thin papers to curl, since the stiffness of the sheet is low.

Experiments on uniform moisture exchange on both sides of the sheet, using a controlled humidity chamber, showed that only two-sided papers had a tendency to curl.

The effect of the moisture content of paper on its rheological behaviour when subjected to a brief tensile strain

W. Brecht and E. Führlbeck
Das Papier, 1959, **13** (13/14), 293

ALTHOUGH a large amount of work has been done on general paper rheology, there is no information on the elongation or stretch of paper immediately after application of the load or on the effect of moisture content. A special apparatus was built to measure these effects; the main parts are an upper fixed and a lower movable clamp and an induction type extension meter. When the lower clamp is released, the test paper strip is suddenly put under a load and is stretched. The induction type extension meter can measure movement taking place in intervals of fractions of a second and this information is transferred to a recorder graph drum capable of speeds up to 200 mm./sec. The applied force is simultaneously measured at the upper clamp, both at the beginning and end of loading. The sensitivity of the apparatus was checked under free fall conditions and found to be quite suitable for rapid and accurate measurements.

An unbleached sulphite pulp beaten to 50° S.R. was used to make a series of five test sheets on a sheet-machine; the dry solids contents of these sheets being graded from 23 per cent. to 90 per cent. These sheets were then used in experiments designed to find the relationship between load and stretch over the period of applied tensile strain, the measurements being extended to cover repeated and increased loading, as well as the simple case of a single applied load. In further experiments, the fairly moist paper strips were stretched and then, in one case, dried in such a way that shrinkage was prevented and, in the other, so that shrinkage could take place freely. The dried strips were then subjected to a new loading cycle.

The results showed that, when a load is applied, stretching takes place immediately and that the time required for stretching is 0.1 sec. as a maximum, but usually much less. The moisture content has a decisive influence on the amount of stretch, but has no effect on the time required for this stretch to be produced. The same was true when loading was repeated either at a given moisture content or when the moisture content was changed by drying.

On a papermachine, the time spent by the sheet in the various draws is usually 0.1—1 sec. The experimental papermachine ran at a much slower speed and the range in this case was 0.6—10 sec. Now, as the experiments have shown that stretching is more or less complete 0.1 sec. after the load has been applied, it can safely be assumed that, if other conditions are the same, the relationship between tension and stretch of the sheet on a high-speed machine is the same as on a slow machine; in other words, the latter results can be taken not merely as indications, but as absolute values applicable to high-speed machines.

A method for the determination of the resistance of paper to erasure

R. Mörchen
Wochbl. Papierfabr., 1959, **87** (9), 359

VISUAL methods of determining the effect of erasure on the strength of a sheet are unsuitable, so it was decided to use the indirect method of using the bursting strength for this purpose.

The test procedure is to type 8 blocks of capitals on the top side of the test sheet. Each block consists of 6 capital letters in 2 rows of 3 letters and the area covered by a block is approximately 7 mm. square. The sheet is laid on a blotting pad and the letters rubbed out with a standard eraser, the direction of rubbing being changed—diagonally, lengthwise and crosswise. Erasure is carried to a point when the letters have almost disappeared; the test positions are then marked with a pencilled circle and this is then used as the centre of the test area for bursting strength determination. Bursting strength is likewise determined at 8 other, unerased points on the sheet. It is convenient to use a template that ensures the required test areas do not overlap. The average of the results is then calculated, the bursting strength in the original condition being called the *standard value* and, after erasure, the *erasure value*. The difference between the averages for the two different values is the decrease in strength caused by erasure.

It is claimed that this method is both simple and reliable: results obtained with 49 different writing and typing papers are given. As the method stands, inaccuracy may arise from the lack of uniformity in typewriter ribbons, typewriters, key pressure, erasure by hand and from the subjective estimation of when the typing has been erased, but it is useful as a rough method for a comparison of the resistance to erasure of a number of samples.

Determination of the diameter of hardwood fibres using the electron microscope

G. Jayme and E. Koburg
Holzforsch., 1959, **13** (2), 37

THE pulps to be investigated were first of all carefully beaten in water in order to split them into individual cell elements and then formed into thin sheets on glass frits. The preparation was then dried and shadowed with palladium under high vacuum. Direct replicas were made and electron micrographs prepared, using a Zeiss EM 8 III electron microscope and working mainly at 50 kV. This apparatus has a magnification range of 300—17 000 and the electron micrographs discussed here were taken at a magnification of 1 : 14 000.

The results of the measurements on the clearest electron micrograph are given in Table 1.

TABLE 1—DIAMETER OF MICROFIBRILS IN HARDWOOD PULPS

Pulp	*Range of microfibril diameters, Å*
Spruce sulphite (for comparison)	210 – 290
Viscose beech sulphite	120 – 230
Chestnut sulphate	130 – 200
Poplar sulphate	130 – 200
Birch sulphate	120 – 200
Eucalyptus sulphate	120 – 200

It was shown that the diameters of hardwood microfibrils were distinctly less than those of spruce. It is possible that the rather wide distribution of values within the same species is due to variations in growth conditions.

A new apparatus for the treatment of pulps — the 'Hilam'

R. de Saint Hilaire
ATIP Bull., 1959, (3), 156

THE 'Hilam' apparatus has been designed to complement the conventional types of apparatus for repulping waste paper and to provide a method of selective treatment for these pulps. In a normal pulper, a considerable amount of power is consumed in treating pulp that has already been well disintegrated, in order to ensure that the pulp produced is homogeneous. If the well-disintegrated pulp could be separated from the fraction requiring further treatment, then considerable power economics could be achieved. The Hilam apparatus does this by passing the pulp through a vibrating screen in a continuous process and is intended to operate at pulp consistencies of 2—5 per cent.

It has been found in practice that the time in the pulper can be reduced by 50 per cent. and the pulp then passed to the Hilam. Since the power consumption of this apparatus is much less than that of a pulper, the total power consumption is greatly reduced and pulp quality is improved. The Hilam is of special interest for mills making chipboard, tarred brown paper and corrugating medium.

New information on the use of CMC in papermaking

O. Wurz
Wochbl. Papierfabr., 1959, **13** (87), 567

Two papermachines were used in this work, the first being equipped with auxiliary beating apparatus consisting of a ball mill, a Jordan refiner and a hydrafiner and the second relying only on a Hollander for beating. The trim width of the first machine was 2 400 mm. (94½ in.) and made papers of basis weight 36—120 g./sq. m. at speeds up to 240 m. (787 ft.)/min. The second machine had a trim width of 1 400 mm. (55 in.) and made one-sided MG paper of basis weight 40—250 g./sq. m. at speeds of 30—100 m. (98½—328 ft.)/min. In the experiments, various grades of wood-free and mechanical papers were made, including poster paper and various packing papers.

The type of CMC used was a product called Polyfibron, manufactured by an Austrian firm. In the experiments on sizing, it was found that 35—40 per cent. of the rosin size could be replaced by Polyfibron B70, resulting in a reduction of the cost of sizing by approximately 30 per cent. CMC also improved the rosin size retention and this, along with the low cost of CMC, made the process extremely attractive economically.

The filler retention was also considerably increased, it being found that a 1—1½ per cent. addition of Polyfibron B (high viscosity) could increase the ash content of mechanical papers by 25 per cent. Filler retention is also improved with wood-free papers and this is of particular value when expensive fillers such as titanium dioxide are being used.

The addition of CMC to the furnish for MG paper gave an increase in smoothness of 2—3 points as measured on the Bekk instrument and good results were also achieved using a size press with CMC, although it was important in this case to check the viscosity of each charge.

use

MANUTEX

sized paper and board for . .

BETTER VARNISHING

Surface Sizing with Alginate Ensures

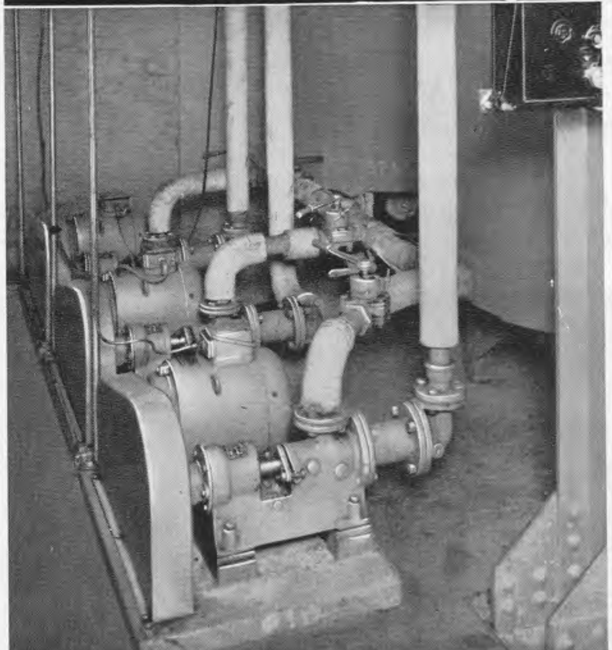
1 **Excellent uniformity with only one varnished coat**
no dull patches

2 **Maximum gloss for minimum of varnish**
due to the excellent hold-out properties obtained

write for details of **MANUTEX** brand sodium alginate and its many applications in the paper industry

ALGINATE INDUSTRIES LIMITED Walter House, Bedford Street, London W.C.2

The MONO pump



HANDLING COATING MIXTURES

The unique principle embodied in the Mono Pump, with its uniform velocity of flow, enables it to deal effectively with viscous compounds such as paper coatings. Inherent self-priming, powerful suction ability and compact construction all contribute towards easy and neat installation, such as that reproduced above from a photograph of three Mono Pumps handling a starch mix at a paper mill of Bowater's United Kingdom Pulp and Paper Mills Ltd.

MONO PUMPS LIMITED

MONO HOUSE, SEKFORDE STREET, LONDON, E.C.1

Tel: CLErkenwell 8911 Grams: Monopumps Phone London

and at: *Belfast Birmingham Dublin Durban Glasgow Johannesburg Manchester Melbourne Newcastle Sydney Wakefield*

MR232

NEWS FROM ABROAD — ABOUT

The S.I.G. THICKNESS TESTER

AUSTRALIA — *"best we've seen"*
CANADA — *"has proved very satisfactory"*
NETHERLANDS — *"preferred to any other"*
GT. BRITAIN — *"far more accurate and reliable"*
GOBI DESERT — *"we've never seen anything like it!"*

For further particulars write to:

Scientific Instruments (Glasgow) LTD.

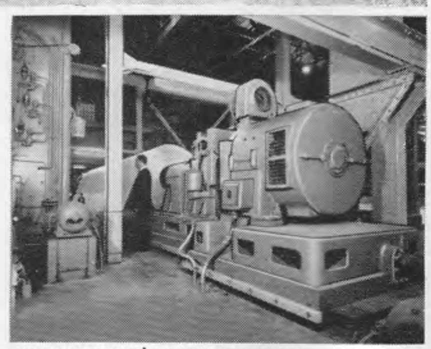
154-156 Grovepark St.
GLASGOW, NW
'Phone: DOUglas **3067**

AEI

WINDER DRIVES

The daily output of 900 tons of newsprint from Bowaters' Kemsley Mills is handled by six winders, all powered by drives manufactured by an AEI Company.

A closed-loop Ward-Leonard amplidyne regulating system is employed which automatically maintains constant paper-tension irrespective of reel diameter, speed, and rate of acceleration from zero speed to maximum.



AT BOWATERS' KEMSLEY MILLS
No. 6 winder which operates at 5,000 ft./min. with parent reels 280 in. wide and 88 in. diameter.

ASSOCIATED ELECTRICAL INDUSTRIES LIMITED

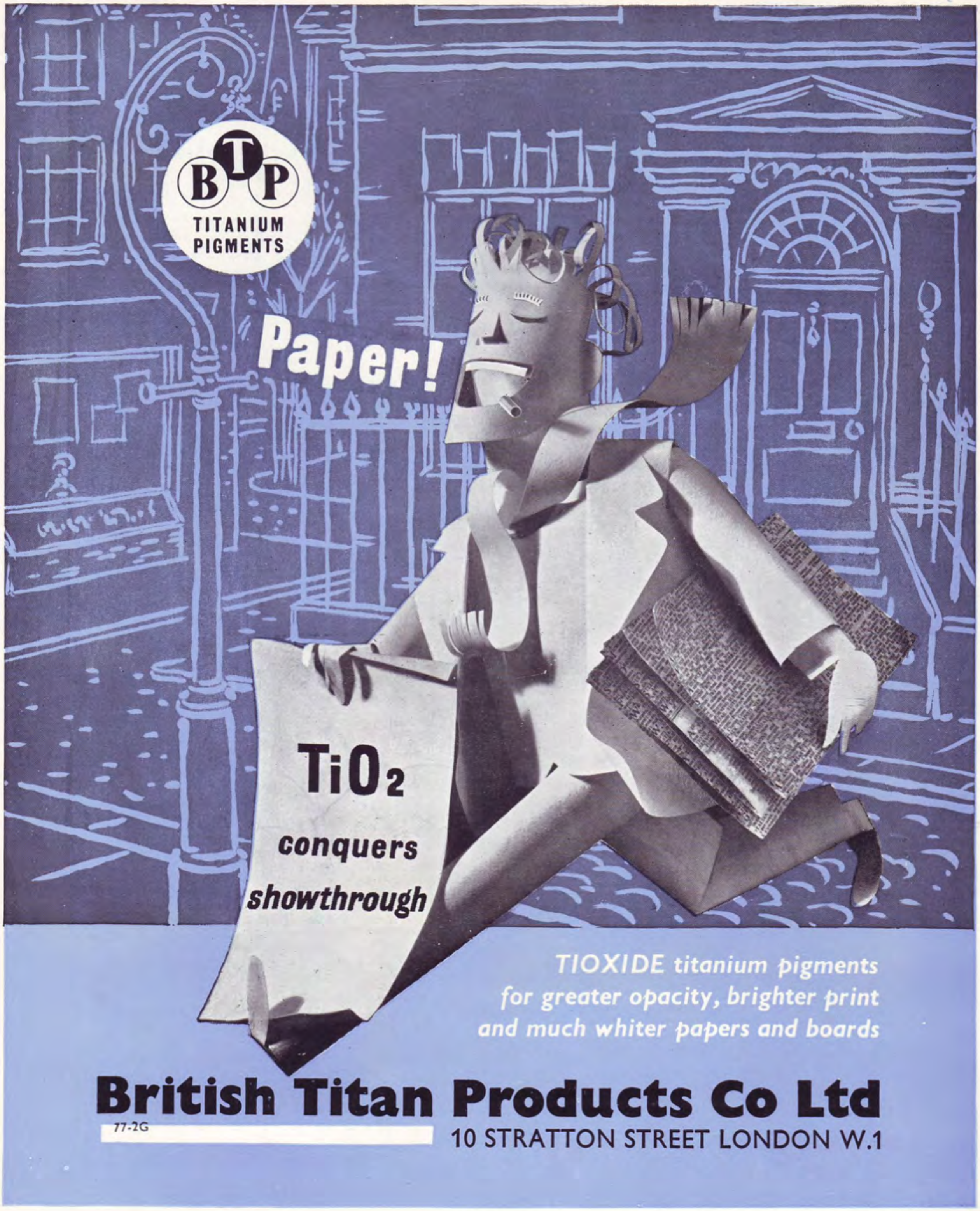
MOTOR & CONTROL GEAR DIVISION RUGBY & MANCHESTER, ENGLAND

BTH INCORPORATING THE MOTOR & CONTROL GEAR INTERESTS OF BTH & M-V

INDEX TO ADVERTISERS

Alphabetical

Classified



BTP
TITANIUM PIGMENTS
Paper!
TiO2
conquers
showthrough
TIOXIDE titanium pigments
for greater opacity, brighter print
and much whiter papers and boards
British Titan Products Co Ltd
77-2G
10 STRATTON STREET LONDON W.1