paper technology

pt

No 3

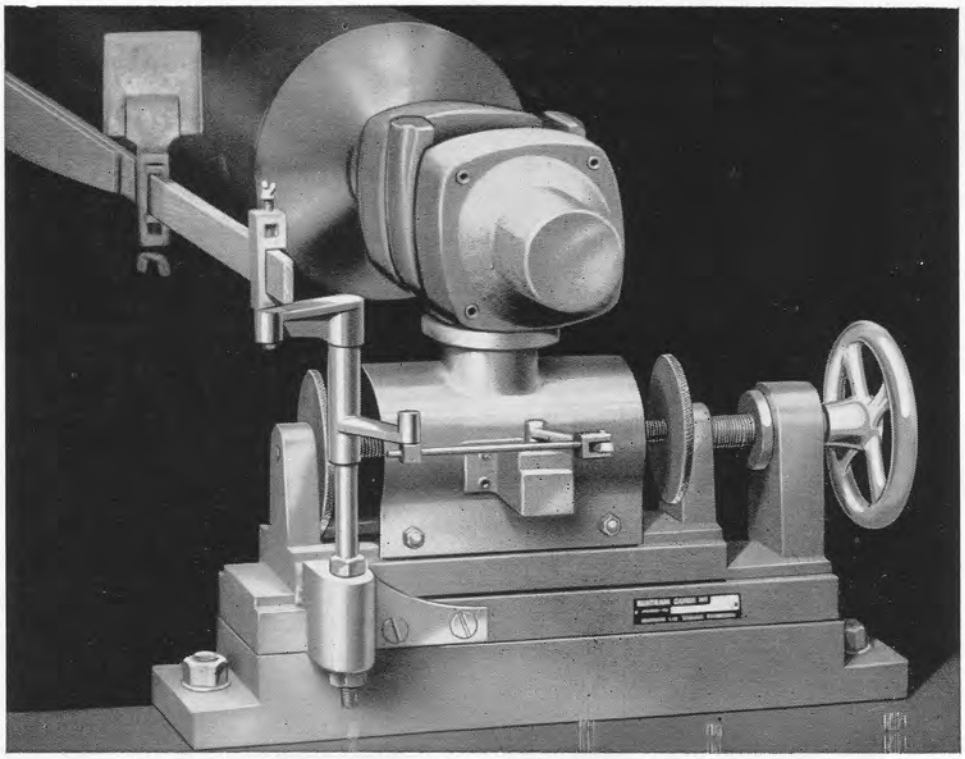
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Journal of the Technical Section
British Paper and Board Makers' Association

INCORPORATING TECHNICAL BULLETIN AND * PROCEEDINGS OF THE TECHNICAL SECTION

June 1960 Vol. 1 No. 3

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Assistant Editor – W. J. Abercrombie

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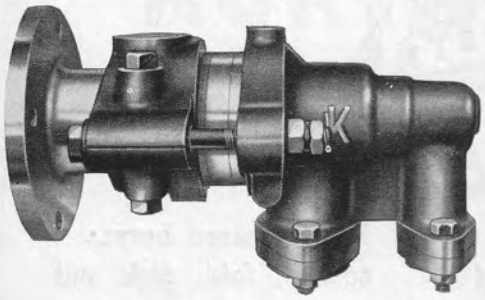
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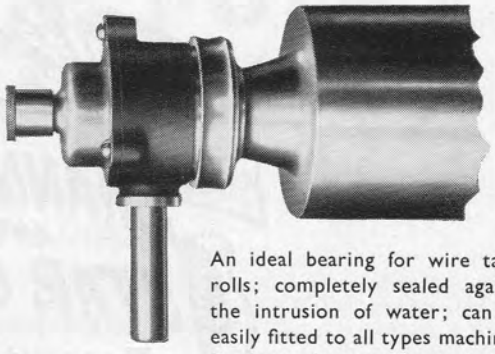
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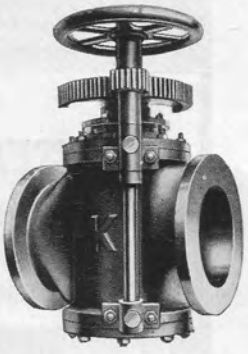
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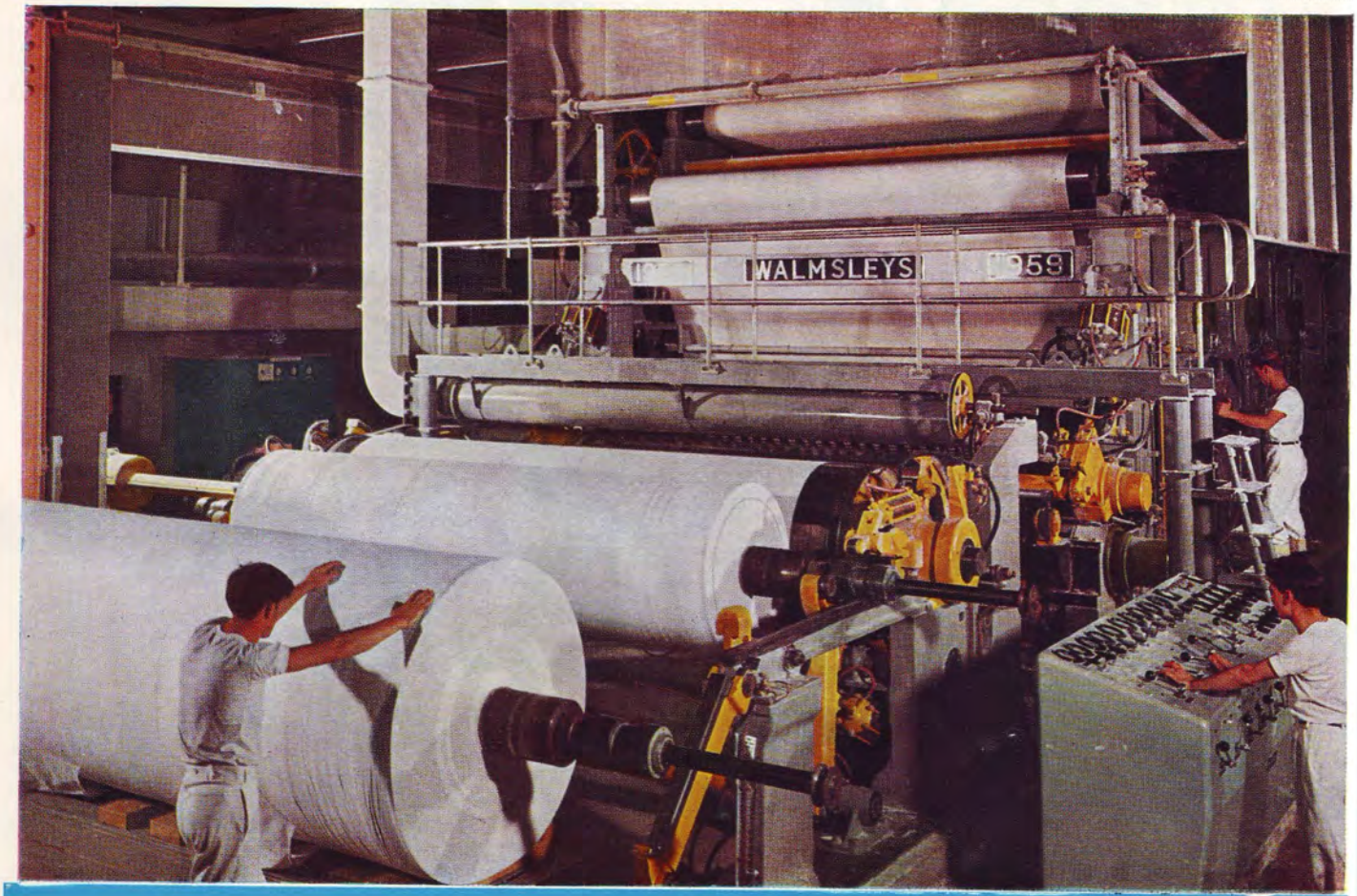
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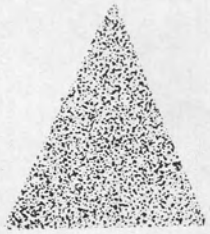
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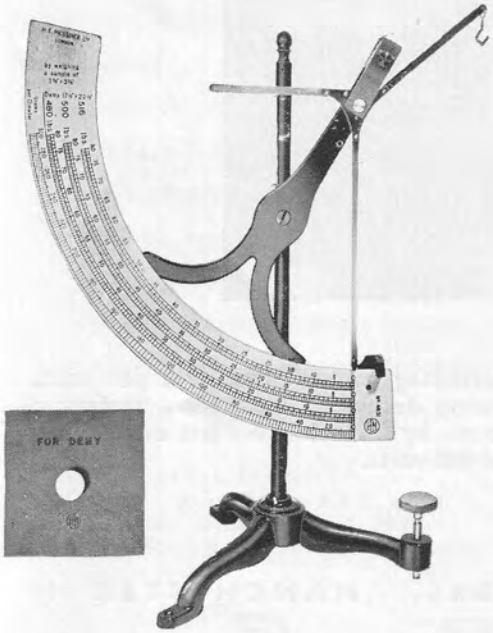
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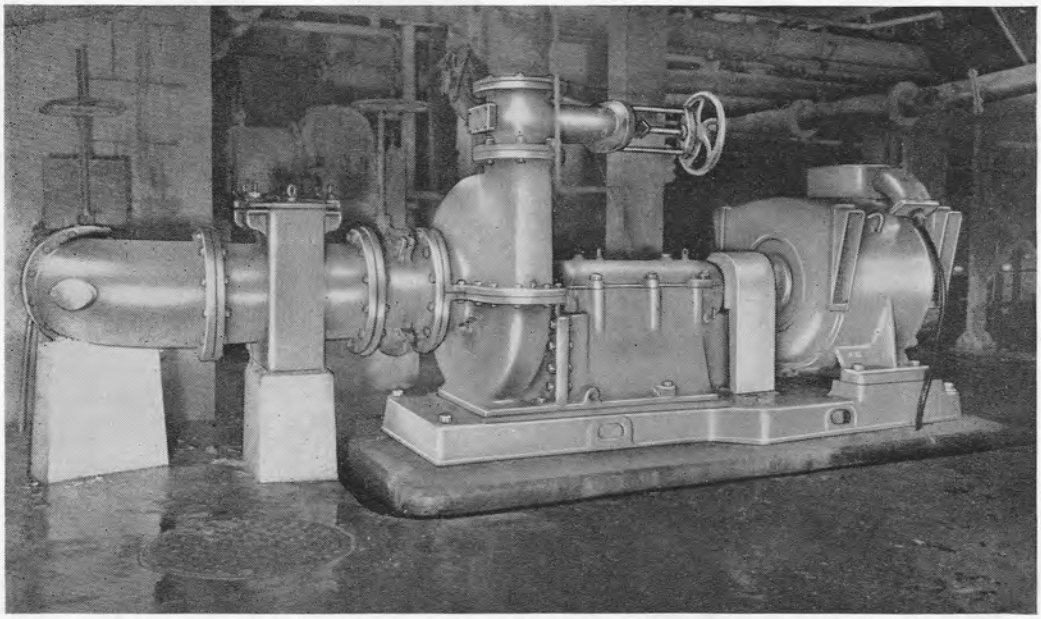
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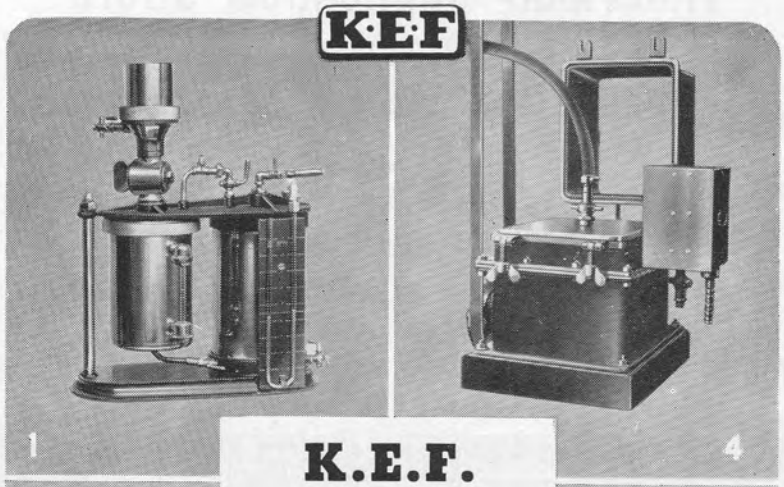
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A. D. Foulerton—*Full*
K. J. Funnell—*Full*
T. C. Gallant—*Full*
L. T. Hems—*Full*
J. W. Illingworth—*Full*
N. F. Kerr—*Associate*
W. J. King—*Full*
T. J. Kirwan—*Associate*
M. Kolker—*Associate*
I. M. M. McCallum—*Associate*
P. C. Monck—*Associate*
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NEWS PAGE

Correction please

ON page 173 of the last issue of this journal, under the heading *Paper Museum*, a correction must be made to the name of the firm providing the museum premises. This should have read Vegetable Parchment Mills (Delcroix) Ltd. Apologies for the inaccuracy are offered to all concerned.



Mr. Underwood delivering his paper at the spring conference—for further details, see pages 219 and 220

Keeping your journal

BINDERS for this journal can be ordered from the Technical Section if there is sufficient demand (*see* page 226)—please send enquiries to the Secretary now.

Similarly, for the bound copies of the year's *Proceedings* papers; prices depend upon demand.

Strawpulp properties

IN the EUCEPA paper by Centola and Borruso printed in this journal, No. 2, a correction must be made to pages 165 and 166: the captions to fig. 8 and fig. 9 should be interchanged.

RUSSIAN PAPER INDUSTRY

No. 1, JANUARY 1960

Page

The pulp and paper industry in 1960— 2

Science and technology

The production of viscose cellulose for tyre cord— B. A. Smirnov 4

It is considered desirable that the U.S.S.R. should produce high-strength tyre cord with a breaking length of 60–70 km. There is not much published information on this subject and a series of experiments have been carried out to investigate the effect of such factors as wood storage and preparation, cooking, washing, screening and bleaching. The purity of the process water is particularly important and satisfactory results can be obtained only when a pure water supply is guaranteed. It is intended to set up a mill to produce tyre cord viscose at Irkutsk in Siberia.

Semichemical pulp—a valuable product for the paper industry— I. Z. Beregitin 8

Semichemical pulp is being made using waste liquor containing 65 per cent. sodium sulphite, which is obtained from chemical works producing phenol. Cooking is carried out at 126–140°c and most hardwoods have been successfully pulped by this procedure.

An electrical method for the determination of sulphates and chlorides in paper and board— A. A. Dolgaleva 12

A new apparatus has been designed to determine sulphate and chloride ions by means of an electrometric titration using a mercury electrode. The method is highly sensitive and there is good reproducibility in the results.

The chemical composition of wood from common pine and Siberian cedar— I. S. Khutorshchikov 15

Practical aspects

Operating conditions for plate heat exchangers— A. M. Ginstling, V. V. Barsov and V. P. Vladimirtsev 16

A mill investigation was carried out to measure the efficiency of the heat exchanger installation at different rates of flowthrough and to estimate the reduction in efficiency caused by deposits accumulating on the plates.

Operation of a two-compartment suction couch roll— N. G. Nikol'ski and A. Ya. Golubev 18

The operation of a Voith two-compartment suction couch roll was causing some trouble, so alterations were made that the suction area was reduced and the vacuum increased. This resulted in a 2 per cent. reduction in web moisture content leaving the couch roll and it was possible to increase machine speed.

Equipment for retaining fibres and liquor during digester blowdown— I. I. Simbyankin and V. A. Sannikov 21

A description of a vane-type screen designed to separate fibres and liquor from steam when the charge is being blown into the blow tank.

The installation of a suspended roof in a machine house without shutting down the machine— A. J. Smirnov 22

An account of how this reconstruction work was carried out.

No. 2, FEBRUARY 1960

Science and technology

Page

The production of boxboard— V. N. Malyutin 4

A survey of equipment used in boardmaking in the U.S.A.

Wet web pick-up and its effect on the operation of a papermachine— J. Mardon 9

Translation from the English of an article on the theoretical and practical aspects of pick-up on the papermachine.

Kraft pulp from logging waste— I. S. Ivanova 13

It was found that to produce pulps with a similar degree of hardness much more active alkali was required with both softwood and hardwood logging waste than with logs of the same wood. For softwood waste, pulp production was 15–17 per cent. lower and, for hardwood waste, 8–10 per cent.

lower than when the wood was in logs. The strength properties of the pulp from waste wood were found to be 10–35 per cent. lower than those of pulp from logs and it is concluded that such waste can only be used for making fibre, building board and the like.

The PVR wallpaper printing machine—
E. A. Zaranovski 15

This is an eight-colour machine for printing wallpaper and it is claimed that it has the advantages of fewer rolls, higher production and simpler maintenance.

Practical aspects

Continuous cooking for sulphate pulp—
D. G. Vyatkin 18

Describes a Kamyr continuous digester installation and some minor modifications that have been made to improve performance.

Improved steam turbine performance—
V. A. Sannikov 21

An account of the operation of a Laval steam turbine.

The preparation of silicate adhesive—
A. Ya. Golubev 23

A description of a horizontal, rotating autoclave for the preparation of silicate adhesives.

The production of bleached pulp from flax waste—
V. N. Gritsulyak 24

The difficulty in using flax waste for papermaking is the high shive content, but it was found that a pulp suitable for making cigarette paper could be obtained by cooking with a mixture of caustic soda and sodium sulphide.

An apparatus for measuring the extent of blunting on chipper knives—
N. P. Rushnov 27

OXFORD

ALL plans for the Technical Section's second fundamental research symposium are nearing completion. This international meeting will be held in the organic chemistry lecture theatre of the Dyson-Perrins Laboratory during the week 24th–30th September 1961.

Residential accommodation has been reserved for registrants at Christ Church and the Randolph Hotel.

Notice about the programme and registration will appear in due course.

The subject of the symposium is ***The structure and formation of paper,*** chosen to follow up the 1957 Cambridge symposium on the fundamentals of papermaking fibres. The transactions of the Cambridge meeting have been in great demand since publication in 1958 and, as this provides essential preliminary reading for intending Oxford registrants who were not at Cambridge, those who have not yet bought a copy are urged to do so while the small stock remains.

Fundamentals of Papermaking Fibres costs—

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Instruction in Statistical Method

THE courses in elementary and advanced statistics that the Technical Section ran in 1954, 1956 and 1958 proved to meet a need that had been thought was now fulfilled. Recently, enquiries about further courses have raised the question whether there is sufficient demand for another series of residential courses in statistics. The Technical Section, through its Statistics Committee, would be prepared to organise such courses, but wishes to know what demand exists for them before doing so. Anyone who is interested should write to the Technical Section so that the position can be gauged.

Existing arrangements under local authorities may well satisfy certain calls for courses in statistics and a list is therefore given of technical colleges and similar institutions that have at one time or another held evening courses in statistics, suitable for scientists and technologists who are interested in the design and analysis of experiments or in other aspects of applied statistics such as quality control. The decision whether a course should be held in any particular session will normally depend on the demand. This does not apply to some of the larger colleges named, especially where such colleges are situated in industrial areas.

Technical Section members who wish to attend this type of course should get in touch with their nearest technical college to enquire whether an appropriate course is to be held. If there is insufficient demand at their nearest college, one of those named below should be able to help them.

Birmingham College of Advanced Technology, Gosta Green, Birmingham 4
Blackburn Technical College, Blackburn, Lancashire
Bolton Technical College, Manchester Road, Bolton, Lancashire
Sir John Cass College, Jewry Street, Aldgate, London, E.C.3
Chelsea College of Science and Technology, Manresa Road, London, S.W.3
Constantine Technical College, Middlesbrough
Coventry Technical College, Butts, Coventry
Derby and District College of Technology, Derbyshire
North-East Essex Technical College, Sheepen Road, Colchester, Essex
South-East Essex Technical College, Longbridge Road, Dagenham, Essex
South-West Essex Technical College, Forest Road, Walthamstow, London, E.17
Ewell Technical College, Reigate Road, Ewell, Surrey
North Gloucestershire Technical College, Cheltenham, Gloucestershire
North Hertfordshire Technical College, Broadway, Letchworth, Hertfordshire
Kingston upon Hull College of Technology, Kingston upon Hull
Kingston Technical College, Fassett Road, Kingston-on-Thames, Surrey
Leeds College of Technology, Calverley Street, Leeds 1
Leicester College of Technology and Commerce, Leicester
Luton College of Technology, Luton, Bedfordshire
Technical College of Monmouthshire, Crumlin
Northampton College of Advanced Technology, St. John Street, Clerkenwell, London, E.C.1
Nottingham and District Technical College, Nottinghamshire
Harris College of Further Education, Corporation Street, Preston, Lancashire
Regent Street Polytechnic, Regent Street, London, W.1
Swansea Technical College, Swansea, Glamorganshire
Welsh College of Advanced Technology, Cathays Park, Cardiff, Glamorganshire
Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton

Conference speakers—
(left to right, standing) N. C. Underwood, D. Attwood, L. LeBreton, D. F. Sutherby and D. E. Mooney
(left to right, sitting) R. Gardner, R. T. Heathcote, B. W. Balls, J. Howarth and W. A. Banks



SPRING CONFERENCE 1960

A RECORD number of 345 members and visitors spent two days considering *The Outlook for Automation in Papermills* at the Technical Section's Seventy Ninth General Conference.

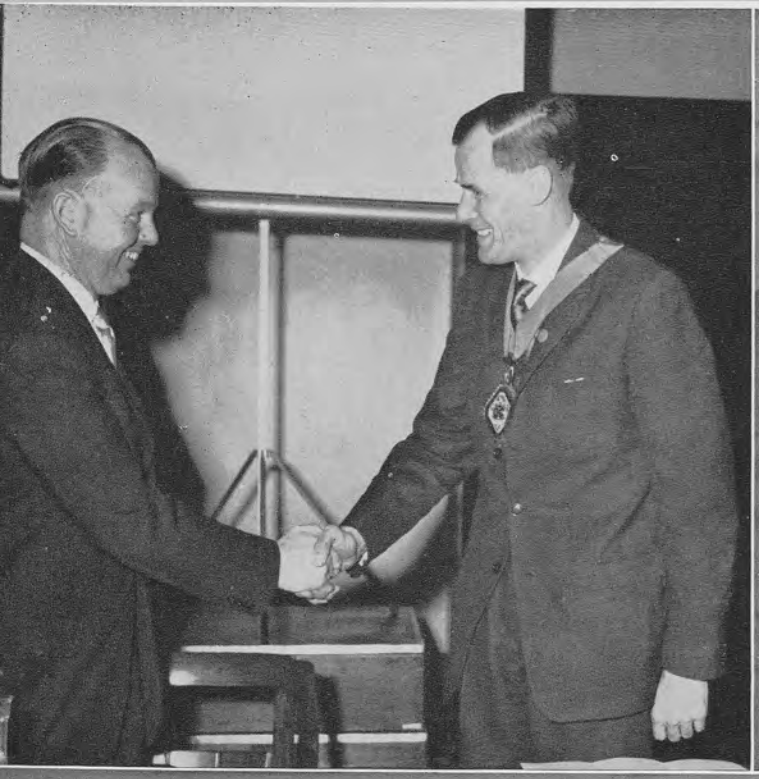
The first paper given was designed to present a review of the most important aspects of automation and automatic control as applied in the paper industry and the ensuing papers were concerned with the more specific problems. These discussion periods threw up an interesting variety of opinions on this controversial subject and the important facts emerging from the two days proceedings were highlighted by Mr. L. Landon Goodman in a final critical appraisal. It was apparent that the application of automatic control in the paper industry has now reached the stage that planned development is necessary and the papers and discussions at the conference will be of major importance in this development.

At the Annual General Meeting on the first morning of the conference, Mr. W. A. Gilmour was unanimously elected to the office of Chairman of the Technical Section and Mr. P. H. Prior accepted election to the Vice-Chairmanship. The retiring Chairman, Mr. K. C. Weedy, in accepting his Past Chairman's badge from Mr. Gilmour, said how interesting and rewarding his two years in office has been and thanked all those who had helped to make it so.

Mr. Arthur Baker then presented the 'Silver Jubilee' medal for 1959 to Mr. R. J. Thomas for an outstanding contribution to the papermaking industry—the development of the Inverform process at St. Anne's Board Mill. In reply, Mr. Thomas said he was proud and happy to accept the award on behalf of all those who had taken part in this work. This is the seventh award of the medal that Mr. Arthur Baker inaugurated in 1945, all of which he has presented personally.

The second special event at the General Meeting was the award of the Marsh Prize for 1959, being the fourth of the awards since the inauguration of the prize. The winner was Mr. J. H. Martin of the Paper and Board Divisional Laboratory, Reed Paper Group for his essay—*The use of glass as a papermaking fibre.*

The Annual Dinner on Wednesday evening in the Burleigh Suite of the Strand Palace Hotel once more proved so popular that it was oversubscribed and it is obvious that, with the ever-increasing numbers attending the Section's social events, still larger accommodation will have to be sought. At the dinner, representatives from Australia, Austria, Denmark, Germany and Italy conveyed greetings from their associations to the British Technical Section; visitors from Belgium, France and Holland were also present.











See also page 213

***Top left**—The retiring Chairman, Mr. K. C. Weedy, congratulating the new Chairman, Mr. W. A. Gilmour, on his election*

***Top right**—The Chairman presenting the Marsh Prize to Mr. J. H. Martin*

***Left**—The Chairman presenting Mr. Weedy with his Past Chairman's badge*

***Bottom left**—Mr. R. J. Thomas replying to Mr. Arthur Baker after being awarded the 'Silver Jubilee' medal*

***Bottom right**—Mr. P. H. Prior accepting election to the Vice-Chairmanship*

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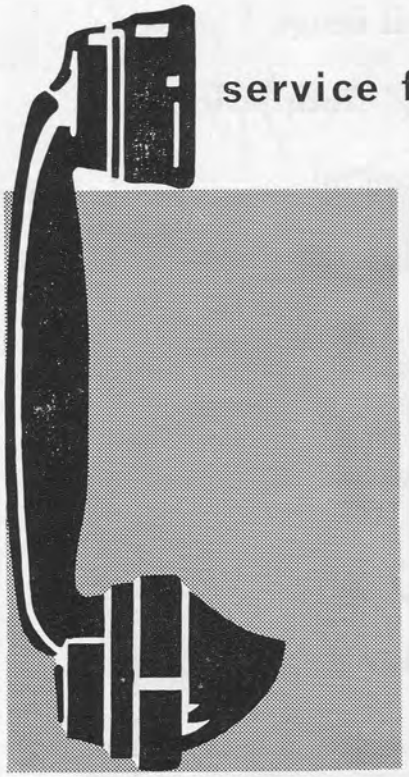
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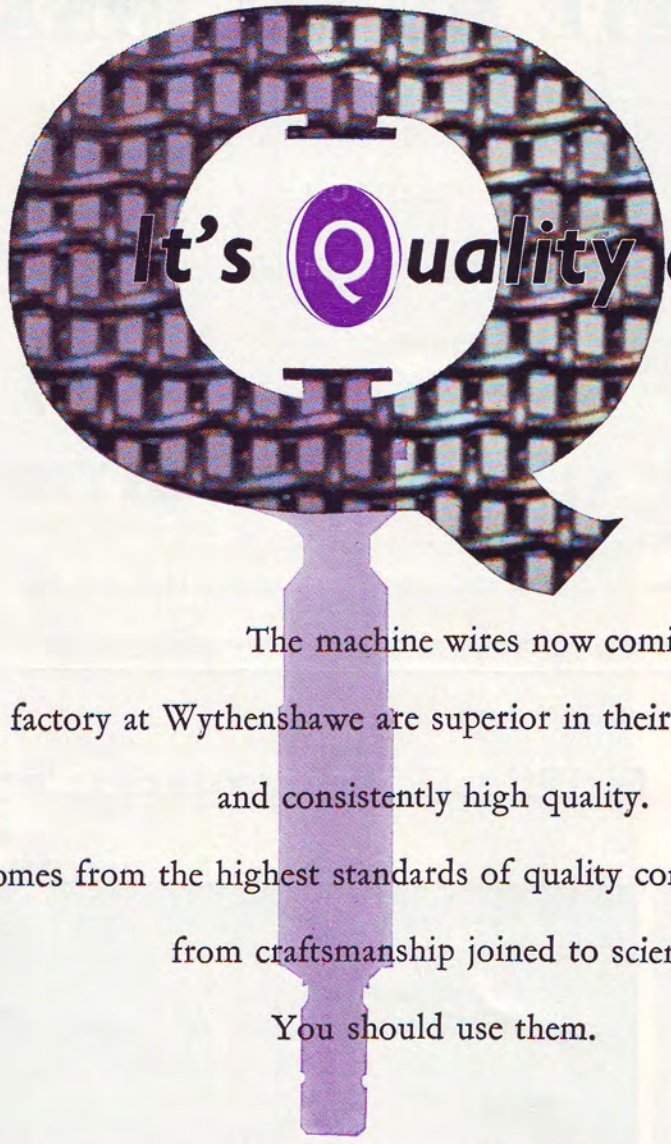
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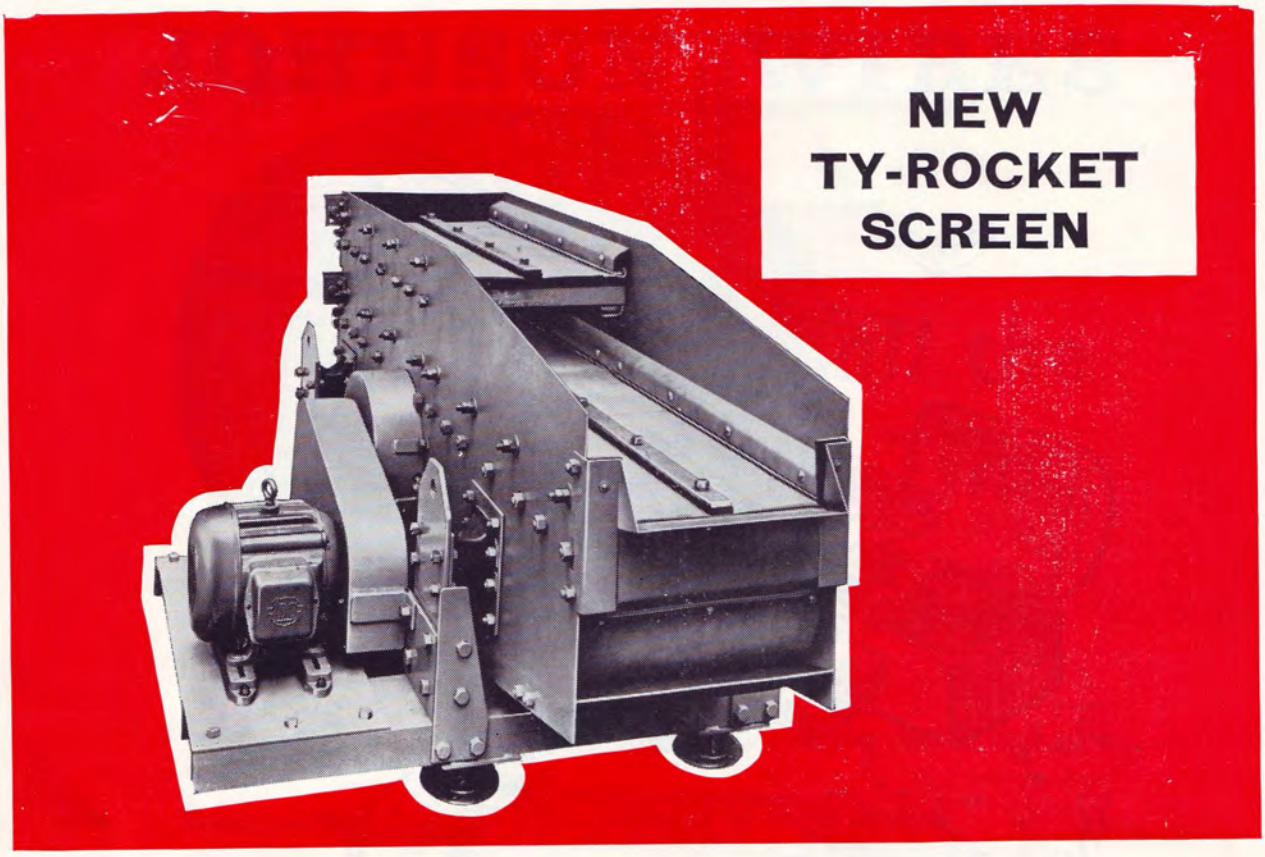
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ATTENTION

This is the third issue of the new journal

PAPER TECHNOLOGY

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

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

(see over)

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

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

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

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

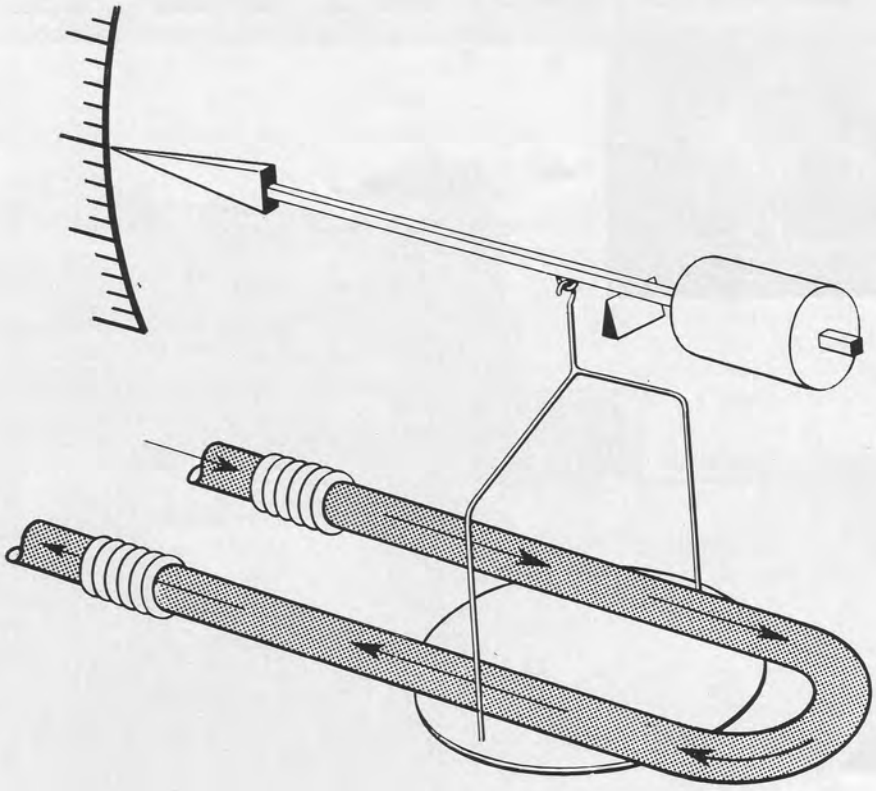
No. 1 in February	No. 4 in August
No. 2 in April	No. 5 in October
No. 3 in June	No. 6 in December

• A number of cloth-board bound copies of the collated *Proceedings* sections from each of the six issues for 1960 can be prepared for special subscribers. The preparation and cost will depend on the demand and members interested in buying the bound volume should advise the Secretary of the Technical Section before 30th September 1960.

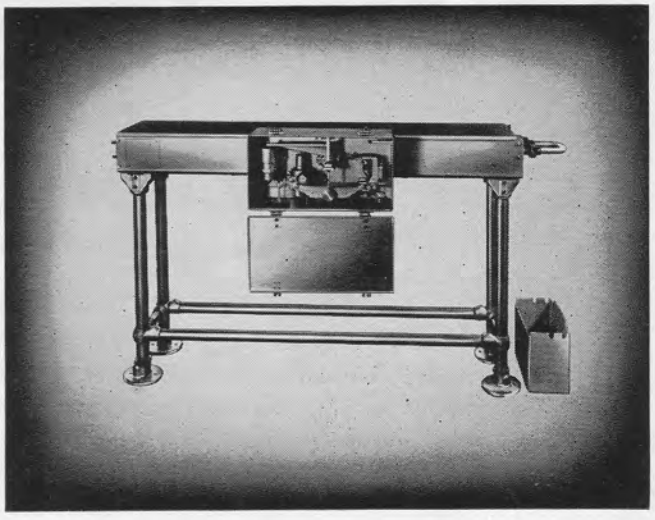
• Binders with gold blocking on the spine can be obtained from the Technical Section at special rate — enquiries are invited. Each binder will hold six issues.

• The register of members will 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.

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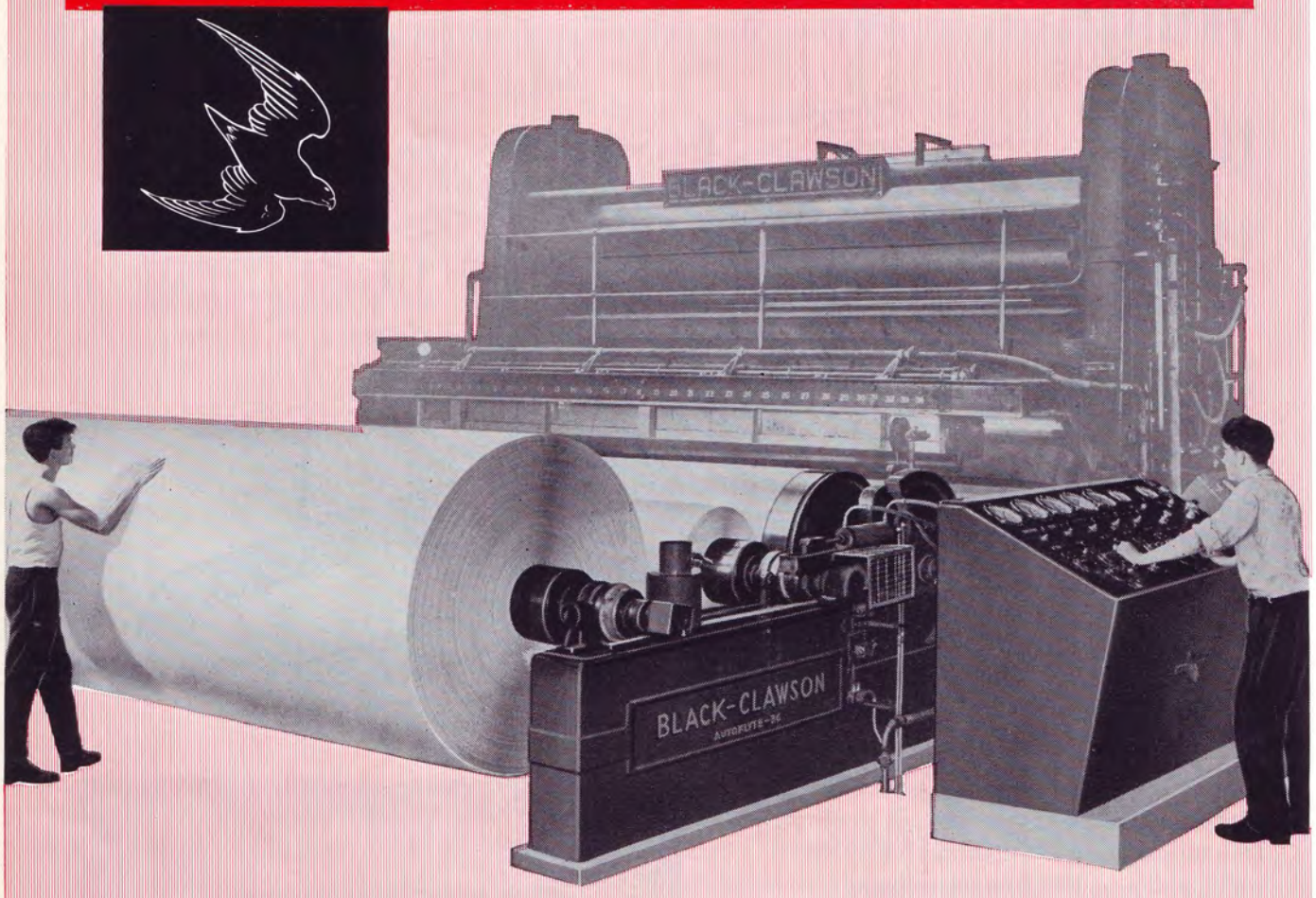
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SUMMARIES from foreign journals

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

*

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

The preparation and papermaking properties of hardwood pulps W. Klauditz, K. Berling and H. Jacobsen

Das Papier, 1959, **13** (13/14), 287–292

IT was found that treating very thin hardwood chips with a dilute caustic soda solution caused the removal of acetyl groups from the polyuronide fraction of the hemicellulose, thus weakening the bonding material in the middle lamella and making it easier to separate the individual fibres.

Several types of machine are now available to chip hardwood only 0.2–0.6 mm. thick and the high specific surface area of these chips makes them specially suitable for the cold caustic soda process. In the experiments, the woods used were beech, birch, poplar, white beech and red oak and the fresh hardwood chips 0.2–0.5 mm. thick, 10–30 mm. long and 5–8 mm. broad were sprayed with a 5–7 per cent. solution of caustic soda, the total amount used being 10 per cent. calculated on a dry woodchip basis. After storage of the treated chips for 4–6 hr. at 20°C or 2–3 hr. at 35–40°C, there is extensive removal of acetyl groups and the fibres are more easily separated. On the laboratory scale, 500 g. of chips were put into a revolving drum and sprayed with the caustic soda, the treatment taking about 15 min. The material was stored at room temperature for at least 3–4 hr., washed in a laboratory Condux mill and then beaten to 60° S.R. in a Jokro mill or some other type of laboratory beater. Test sheets of substance 100 g./sq. m. were then made and the strength properties of these were determined.

The experiments proved that, when hardwood in the form of very thin chips is treated with caustic soda, a uniform reaction takes place and the result is a homogeneously degraded material that is easily beaten. The papermaking properties are similar to those of other hardwood pulps. The process can be used also with mixed woods, in this case a mixture of beech and birch chips was studied, the results being shown in Table 1.

In pilot plant investigations using birch and beech, it was found that there was good reproducibility with the laboratory results.

Fibreboard from hardwood pulp

Although hardwoods have for some time been used for making fibreboard, beech wood seems to have been used little or not at all. In the work carried out in this connection, beech chips 0.5–0.6 mm. thick and 15–20 mm. long were treated with 10 per cent. sodium hydroxide in the cold process, the fibres coarsely separated in a laboratory Condux mill and beaten to 80° S.R. in a laboratory kollergang. The fibreboard made from this pulp was 4 mm. thick and was found to have good strength properties.

Preparation of pulp by the cold lime process

The replacement of sodium hydroxide by the much cheaper calcium hydroxide makes the process more valuable economically.

Calcium hydroxide is poorly soluble in water at normal temperatures, but the thinness of the chips

TABLE 1

Mixture ratio beech/birch	*Freeness, °S.R.*	*Breaking length, m.*	*Double folds*	*Bursting strength, kg./sq. cm.*	*Whiteness (Elrepho filter 6) reflectance, %*	*Tearing strength (Brecht-Imset), g. cm./cm.*
1/1	39	2 270	1	0.7	46	58
1/1	59	3 750	3	1.1	45	80
1/1	69	4 170	4	1.5	44	88
2/1	67	3 600	2	1.2	44	73

TABLE 2—PAPERMAKING PROPERTIES OF TEST SHEET MADE FROM HARDWOOD PULPS PRODUCED BY THE COLD LIME PROCESS

Wood	*Period of treatment, hr.*	*Temperature of treatment, °C*	*Breaking length, m.*	*Double folds*	*Bursting strength, kg./sq. cm.*	*Whiteness (Elrepho filter 6) reflectance, %*	*Tearing strength (Brecht-Imset), g. cm./cm.*
Birch	2	20	3 780	2	1.2	47	78
Birch	4	35 – 40	4 630	15	1.8	43	99
Birch	2	40 – 45	4 281	10	1.8	42	90
Beech	3	35 – 40	3 100	1	1.1	44	58

and the large surface area available for reaction compensate for this disadvantage. The wood/liquor ratio was 1 : 10 and the chips were circulated vigorously in the slaked lime so that the action of the calcium hydroxide is accelerated and to ensure that the solution is kept up to strength, since the mixing process replaces the calcium hydroxide as it is consumed.

It was found that a serviceable pulp could be produced from birch chips with 10 per cent. calcium oxide and a reaction time of 4 hr. at 20°C. The quality of the pulp was improved and the reaction time shortened by increasing the calcium oxide concentration to 15 per cent. and the reaction temperature to 40°C. The excess slaked lime could be recovered by washing the treated chips and the consumption of calcium hydroxide or calcium oxide, calculated on a dry woodchip basis, was about 6 per cent. for the former and 4.5 per cent. for the latter. Some figures for the test sheets made from this type of pulp are given in Table 2.

Configuration of the vanes on the mould of a cylinder mould machine

I. D. Kugushev and G. G. Zhukov
Bumazh. Prom., 1959, **34** (11), 16–17

LABORATORY experiments were carried out to determine the effect of the profile of the vanes or bars inside a cylinder mould. The mould used had a diameter of 300 mm. (11.8 in.) and was constructed with two compartments in which different types of bar could be fitted. In the experiments, the resistance of the pulp web on the wire to the passage of water was imitated by wrapping a felt round the cylinder mould.

Both curved and straight vanes were studied, the cross-section of the former having the shape of a segment of a circle of radius 23 mm. (0.905 in.). The vanes were mounted so that the tangent to the vane coincided with the radius of the cylinder. The straight vanes were streamlined and the ratio of height to width was 5:1.

It was found experimentally that the amount of filtered water entering the compartment with curved vanes remained constant till the point when the cylinder speed was 50 rev./min. There was then a gradual reduction in the amount of water passing through until the 100 rev./min. point was reached and, if the speed of rotation were increased still further, there was a sharp and rapid fall in the amount of water passing through.

It is concluded that any type of vane, but especially straight vanes, improves stock drainage by creating a low pressure region inside the cylinder mould. The creation of this low pressure region also has an effect on sheet formation. Normally, as the mould rises out of the stock, some of the uppermost fibres in the wet web are washed off and fall back into the vat, but this does not happen on moulds fitted with straight vanes as the low pressure zone holds the web on the wire mould by suction.

Tracing paper from hardwood pulp

J. Hancil, J. Moravec, J. Dousa and R. Babulik
Papír a Celulosa (Czech.), 1959, **14** (7), 149

BECAUSE of a shortage of softwood pulp, aspen pulp was used to make tracing paper and it was found that the product was of a quality equal to the best tracing paper made from softwood pulp. As the aspen fibres are short, the pulp must be beaten very carefully and a beater consistency of 7 per cent. was chosen for this work, beating time was 7 hr. and the final wetness of the pulp was 93.5° S.R.

On the papermachine, it was found that drainage of the aspen pulp was better than with conventional pulps and that sheet formation was good. The tracing paper was soft, dimensional stability was equal to that of standard grades and ink adhered well to the paper, showing no tendency to spread.

(*continued on page 309*)

ANNUAL GENERAL MEETING

HELD AT THE CONNAUGHT ROOMS, GREAT QUEEN STREET, LONDON, W.C.2 ON WEDNESDAY, 23rd MARCH 1960 at 9.30 a.m.*

In the Chair—Mr. K. C. WEEDY
succeeded during the meeting by Mr. W. A. GILMOUR

1. NOTICE CONVENING MEETING

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

2. MINUTES

The minutes of the Autumn General Meeting, held on 29th October 1959, had been circularised to all members before the meeting in *Proceedings*, 1959, **40** (3), 275–277. The minutes, unanimously approved as a correct record, were signed by the Chairman.

3. ANNUAL REPORT FOR 1959

Copies of the annual report for the year ended 31st December 1959 had been forwarded to members with the notice calling the meeting. The report was taken as read and neither written nor verbal comments were submitted. Dr. J. Grant moved its adoption, Mr. W. T. Roberts seconded the motion, which was carried unanimously.

The annual report follows these minutes (pages T 58–T 60).

4. CHAIRMAN'S REPORT

The Chairman reported progress on the Technical Section's activities as follows—

'During the past year, the numerical strength and the activities of the Technical Section have continued to expand. As at today's date, we have 1 079 Full, 95 Junior and 659 Associate members, making a grand total of 1 833—an increase of 138 on the figure I gave you at this time last year. When Corporate and Overseas members are taken into account, our total membership now stands at 2 221.

As regards activities, it is invidious perhaps to pick out any aspect for special attention, but I feel that I should draw to your notice the very real success of the efforts of the Statistics Committee. On 29th October last year, they organised a one-day meeting dealing with the subject of evolutionary operation. Encouraged by the interest shown, they arranged a further one-day symposium in February this year on the handling of non-numerical data. Both these meetings were held in London and proved to be extremely popular—so popular, in fact, that we were forced to turn away many applicants, owing to our accommodation being limited to a seating capacity of only 120 persons.

The healthy state of activity prevailing in the Divisions and Discussion Groups can best be judged from the printed report of their year's proceedings and I think you will agree that all Divisional and other committees should be congratulated on the enthusiasm and vision with which they have fulfilled their function.

I am pleased to be able to tell you that the Paper Museum Committee, charged with the task of founding our national paper museum, has arranged for the setting up of a trust fund in terms that have received the consent of the Inland Revenue authorities to its recognition as a charitable fund. This has been made possible by the response to our appeal to the paper and allied industries for donations, either outright or under covenant. The result has been most heartening and over £1 000 has now been subscribed.

Arrangements have been completed with the Vegetable Parchment Mills (Delcroix) Ltd. for the use of premises at St. Mary Cray and work is being put in hand for the adaptation of these buildings to suit them for housing the museum. The cost of this is to be defrayed from the Museum Trust Fund, the three trustees of which are Messrs. H. R. Balston, R. Barcham Green and P. H. Prior.

Our plans for a visit to Canada in August and September of this year are making good progress and a detailed itinerary has now been agreed with the Canadian Technical Section. Our party at present numbers 32 persons and, while this is reasonably satisfactory, it is essential that members interested in joining it should not delay in advising the Secretary of their intentions, as block bookings based on final numbers will have to be confirmed with the Canadians,

* These draft minutes are due to be presented for approval at the Autumn General Meeting on 28th October 1960

the air lines and the surface transport companies in the very near future. Full details of the itinerary are being released to the press and are also available on application to the Secretary. I would urge you most strenuously to study them, for it seems to me that our Canadian friends have indeed organised a most interesting and instructive tour.

We have produced the first issue of *Paper Technology* during the year under review and I am pleased to say that the great majority of reactions that have been conveyed to me have been favourable. This new journal incorporates both our previous journals (namely, *Proceedings* and *Technical Bulletin*) and it is received by all members of the Technical Section, thus extending the service that we offer.

Coincidental with the discontinuation of the production of *Proceedings*, we are now very nearly up to date with the production and printing of indexes covering the volumes hitherto uncatalogued. Two such indexes to *Proceedings* were published before the war, covering the years 1920–1936 and now three further indexes are complete. Two of these, covering the years 1936–1946 and 1947–1957 have recently been published and are available on sale at the book-stall; the third for 1958–1959 is now printing and will be ready shortly.

In a few moments, we shall be proceeding with the election of a new Chairman of the Technical Section and I would like to take this opportunity of thanking not only the regular staff, but also the members of the Executive Committee and, indeed, all members of the Section with whom I have come into contact during my two years of office. Everyone has accorded me most generous and friendly assistance at all times, with the result that I can now look back over two years, every moment of which I have thoroughly enjoyed. Perhaps the most heartening factor of all for me as the retiring Chairman and for my successor-in-office is revealed by the bookings for today's conference. We have received 328 applications, an increase of nearly 22 per cent. on the previous 'best ever' attendance established last year. Thank you all very much indeed.'

5. SPECIAL REPORTS FOR YEAR 1959

The annual reports from the chairmen of the standing committees and the honorary secretaries of the Divisions and Discussion Groups were in the hands of members, appended to the annual report (*see* pages T 60–T 68). Adoption of the reports was moved by Mr. G. Thompson, seconded by Mr. L. A. Lawrence and unanimously approved.

6. AUDITED ACCOUNTS FOR 1959

The audited statement of accounts for the eight months of the year ended 31st August 1959 and the certified balance as at that date were submitted as part of the annual report circularised to members.

Mr. C. G. Wallace moved the adoption of the accounts and, seconded by Mr. P. H. Prior, the motion was carried unanimously and the balance sheet was signed by the Chairman and Vice-Chairman.

7. ELECTION OF CHAIRMAN FOR 1960–61

The Chairman, in retiring from office, moved that his successor for the ensuing year be Mr. W. A. Gilmour. Mr. C. G. Wallace seconded the motion and, there being no other nominations, the motion was carried unanimously.

Mr. Gilmour was invested with the badge of office by the retiring Chairman and then took the Chair. He said he was very sensible of the honour done to him by his election to office and he made his first function the presentation of a Past Chairman's badge to Mr. Weedy.

8. ELECTION OF VICE-CHAIRMAN FOR 1960–61

Mr. G. Thompson proposed on behalf of London Division the nomination of Mr. P. H. Prior as Vice-Chairman for the coming year. Mr. Arthur Baker seconded the motion and, with no other nomination, Mr. Prior was unanimously elected to office.

9. 'SILVER JUBILEE' MEDAL

The Chairman announced the award of the 'Silver Jubilee' Medal for 1959 by reading the citation—

> The 'Silver Jubilee' Medal for 1959 is awarded to Reginald James Thomas in recognition of the outstanding contribution made to the technology of paper manufacturing by the team which, under his guidance and direction, originated the Inverform process and brought it from a theory to a practical industrial reality.

Mr. Arthur Baker, in presenting the medal, said, "We are living in momentous times. This is an age in which science and technology are having an ever-increasing influence on our lives as individuals, on this country's position and power—indeed, on the whole world.

It is the engineer who sooner or later translates into action every discovery of science and it falls to them therefore to see themselves as part of a service to mankind.

Our industry, is to be congratulated on having broadminded members like Mr. Thomas, distinguished in business, but not unmindful of the industry's interests as a whole and, indeed, of the national interest. Mr. Thomas, your firm developed the Inverform process out of its own resources and, apart from this great achievement, the industry should realise that, in addition to the personal support you have always given the Technical Section, you have been most helpful also in the work of the Research Association, your firm being particularly generous with facilities for the pilot scale investigations on the pulping of esparto.

Mr. Thomas, may I say how pleased I am to present you, personally, with this medal and to wish you many, many happy years of enjoyment."

Mr. R. J. Thomas responded, "I am deeply conscious of the honour the Technical Section has bestowed on the Inverform development team at St. Anne's Board Mill and it gives me the greatest pleasure to receive this award on their behalf. If the requirements for solving some of the outstanding problems are renewed vigour and enthusiasm, then this award will provide just those very things."

10. MARSH PRIZE

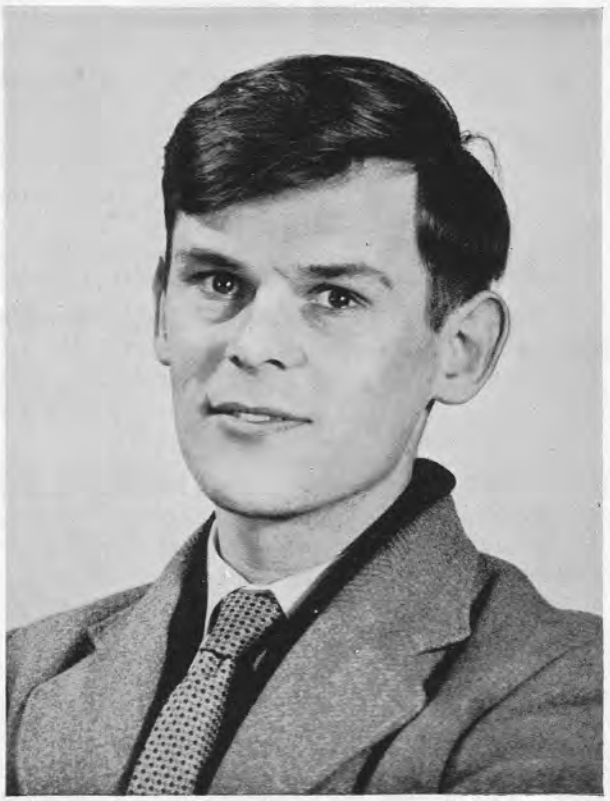
The 1959 essay competition was won by Mr. J. H. Martin for his essay *The use of glass as a papermaking fibre*. The Chairman presented Mr. Martin with books to the value of £20 and a cheque for £20.

11. RULE 44

A matter referred to the meeting by the Executive Committee was to lengthen the period of time provided by rule 44 from the call for nominations to the receipt of marked ballot papers. It was proposed that the new schedule of dates be—

(*a*) Nomination notices to be despatched during 13th–20th November and nominations to be received by 5th December.

(*b*) Nominations to reach the Secretary of the Technical Section by 10th December.



Mr. J. H. Martin, Marsh prizewinner 1959

(*c*) Ballot papers to be despatched during 10th December – 6th January.

The reason for making these changes was that the increasing postal delays and rush at the printers over Christmas require longer time to meet the dates in the Constitution. No fundamental change was being made in the Constitution, it was purely one of administrative detail.

Mr. K. C. Weedy proposed that these amendments in dates be made to rule 44. Mr. G. Thompson seconded the motion, which was carried unanimously.

The meeting then ended.

ANNUAL REPORT

FOR THE YEAR ENDING 31st DECEMBER 1959

Annual General Meeting

The Annual General Meeting was held in London on 25th March 1959.

Election of Officers

At the Annual General Meeting, Mr. K. C. Weedy was unanimously re-elected Chairman of the Technical Section and Mr. W. A. Gilmour was elected Vice-Chairman.

Autumn General Meeting

At the Autumn General Meeting, held in Bristol on 21st October 1959, the Chairman gave a brief résumé of the chief activities of the Section during the previous six months. He mentioned that the Technical Section was faced with the problem of finding new office accommodation and expressed appreciation to the Research Association for its hospitality since the war.

Reference was made also to the forthcoming visit for Technical Section members to Canada in September 1960.

The Technical Section's financial year was changed to end 31st August 1959 and then to run 1st September – 31st August each year.

Staff

The Technical Section staff at the end of 1959 consisted of—

Mr. Francis Bolam, B.Sc., A.R.I.C. (Secretary and Editor)
Mr. W. J. Abercrombie, B.Sc. (Assistant Editor)

Miss S. V. Machell (Cashier and Registrar, handling accounts and publications sales)

Miss J. M. Pettet (Secretary to Mr. Bolam, handling office management, S.P.E.A., library and advertising)

3 shorthand typists
2 office juniors

Membership

Membership of the Section at 31st December 1959 is shown below, together with the comparative figures for the previous year.

	1958	*1959*
Corporate members	177	174
Honorary members	4	3
Full members	976	1 041
Associate members	585	622
Junior members	69	84
Overseas Associate members ..	203	205
Total ..	2 014	2 129

1959	*London Division*	*Northern Division*	*Scottish Division*	*Western Division*
Corporate members	52 (—1)	62 (—1)	39 (n.c.)	21 (—1)
Full members ..	440 (+39)	272 (+10)	190 (+13)	139 (+3)
Associate members	285 (+15)	234 (+23)	75 (—4)	28 (+3)
Junior	38 (+6)	21 (+5)	14 (—2)	11 (+6)

(Fluctuation in membership over the last year is shown in brackets)

Conferences

The Seventy Seventh General Conference was held in London on 25th and 26th March 1959. The title of the conference was *Technical planning of major capital papermill projects* and the individual papers were as follows—

The modern mill conception—G. R. Roberts

The forward planning of a large construction project—E. Asquith

Trends in papermachine design and their application to the modernisation of existing Fourdrinier and MG machines—W. J. Binns and B. Priestley

Modernising a papermachine: a case history—J. Tweedie

Problems of steam and power supply modification—R. S. Bennett

Developments in water treatment for high pressure boilers—H. A. Matthews

On 21st October 1959, the Seventy Eighth General Conference was held in Bristol. This was the first occasion that an autumn conference had been held in Western Division. The general title for this conference was *Packaging trends in paper and board* and the following papers were presented—

Packaging requirements and modern trends in the use of paper containers in the chemical industry—P. F. Gay

An account of a new paper and board making process—L. A. Lawrence

Package testing—C. H. Bulmer
Corrugated board and its role in packaging—F. A. Paine

gional meetings

1. London Division	Seven meetings
2. Northern Division	Seven meetings
3. Scottish Division	Seven meetings
4. Western Division	Six meetings
5. Wye Valley Discussion Group	Six meetings
6. North East Discussion Group	Seven meetings
7. North East Scotland Discussion Group	Six meetings
8. South Wales Discussion Group	Seven meetings
9. North West Discussion Group	Seven meetings

Six local meetings of the London Division were ccessfully arranged in the Kent area at Gravesend, idstone, Ashford and Sittingbourne.

The Chairman and Secretary again attended a mber of meetings of the Divisions and Discussion oups, also local meetings.

blications

The last issues of *Proceedings* and *Technical lletin* have now been published with the close of 59.

All members will receive in 1960 the first issue of new journal *Paper Technology*, which incorporates material previously published in *Proceedings* and *hnical Bulletin* and which is being issued free to mbers. This is a marked forward step in extending service to members, without any alteration in scription rates.

Sales during the year of the main publications ve been—

Fundamentals of Papermaking Fibres	309
Paper Making	507
British PBMA Methods	1 012
Proceedings reprints	40
Proceedings—annual subscriptions	117
Proceedings—sundry sales (separate issues)	128

arsh Prize

The third of the Marsh prizes was awarded to . I. J. Samuel, who put his prize towards a travelling olarship and visited pulp and paper mills in Sweden.

brary

The Technical Section library has issued 585 books d journals on loan during the year, an increase of re than 100 over 1958: 42 photocopies of articles ve been supplied. The library now possesses a photocopying machine and it is expected demands on this service will increase in future, once its benefits are widely known.

Translations

The translations service covers the six languages Dutch, French, German, Italian, Polish and Russian. English translations of 24 articles have been prepared in 1959 (representing 42 900 words); 145 copies of translations have also been supplied.

Assistance to students

The Technical Section again helped to arrange mill visits for National Association of Paper Merchants students. Very sincere appreciation is extended to those mills that were able to co-operate in receiving these groups of students.

Enquiries

There have been 189 recorded enquiries during the year—38 were concerned with literature references; 48 with details of suppliers of equipment and materials; 34 with paper tests; 10 with education; 14 with mill and industrial operations; 17 with specialities; 2 with specifications; 26 were miscellaneous.

City and Guilds of London Institute Examinations in Papermaking

The examinations in papermaking technology, under the auspices of the City and Guilds of London Institute, were held with Mr. H. W. Emerton, Mr. H. R. Hutley, Mr. W. F. E. Robinson and Mr. S. V. Sergeant acting as the examining panel.

During 1959, 60 candidates (+ 7 overseas) qualified in the Final Grade, compared with 51 (+ 6 overseas) in 1958; 185 candidates (+ 18 overseas) passed in the Intermediate Grade, compared with 124 (+ 34 overseas) in 1958.

British Paper and Board Makers' Association

The Technical Section is again very happy to acknowledge with gratitude the financial support given by the B.P. & B.M.A. during the year. In addition, its action to provide new office accommodation for the Technical Section in 1960 is greatly appreciated.

Trade press

The Section records with appreciation the publicity afforded by the trade press during the year and is happy to report continued good relations.

Attendances at Executive Committee meetings

Ten meetings of the Executive Committee have been held during the year, attendances being as follows—

Ex officio members—

Mr. W. R. M. Watson Mr. J. Barcham Green
Mr. J. H. Black

Mr. Arthur Baker[b]	6	Mr. O. J. Horne	1
Mr. D. R. Barbour[f]	0	Mr. L. A. Lawrence	6
Mr. D. C. Bellingham	3	Mr. D. McNeill	3
Mr. N. P. Brown	1	Major R. Marsh[b]	2
Mr. I. G. Burns	1	Dr. V. G. Morgan	7
Mr. G. A. Cade[a]	0	Mr. P. H. Prior	5
Mr. R. H. Clapperton[b]	4	Dr. H. F. Rance[a]	1
Mr. F. A. Craig[a]	0	Mr. W. T. Roberts[a]	0
Mr. P. H. Dixon	6	Mr. W. F. E. Robinson[c]	4
Mr. A. J. M. Draper[f]	0	Mr. P. Sadler	0
Mr. G. Duxbury	7	Mr. W. F. Saunders[a]	0
Mr. P. A. Duxbury[d]	5	Mr. S. V. Sergeant	4
Mr. W. A. Gilmour	7	Mr. W. Speir	3
Dr. J. Grant[b]	2	Mr. G. Thompson	8
Dr. H. Ainsworth Harrison	8	Mr. A. F. Tout[c]	4
Mr. L. G. S. Hebbs[b]	6	Mr. B. H. Turner[a]	2
Mr. J. B. Henderson[e]	2	Mr. G. F. Underhay[b]	6
Mr. R. S. Hesketh	3	Mr. C. G. Wallace	7
Dr. N. R. Hood[b]	0	Mr. K. C. Weedy	9

(*a*) Retired in March 1959 when two meetings had been held.
(*b*) The maximum number of attendances for a co-opted member was nine.
(*c*) Elected by London Division as one of its six Executive Committee members in March 1959, after which seven meetings were held.
(*d*) Elected by Northern Division as one of its six Executive Committee members in March 1959, after which seven meetings were held.
(*e*) Elected by Scottish Division as one of its six Executive Committee members in March 1959, after which seven meetings were held.
(*f*) Elected by Western Division as one of its six Executive Committee members in March 1959, after which seven meetings were held.

Obituary

It is with regret that the Technical Section records the death during the year of several of its members, among whom are a number who joined in the Section's early days. The year of joining the Section is shown in brackets—

J. F. Berger	(1952)	T. A. McMahon	(1948)
L. G. Cottrall	(1924)	W. H. Millspaugh	(1953)
H. Currie	(1922)	T. F. Nicol	(1948)
L. C. Green	(1933)	R. J. Paterson	(1944)
T. Hamer	(1951)	H. Thomas Thorpe	(1926)
A. E. Lee	(1937)	J. A. Warwick	(1950)

Mr. Cottrall's death was a great loss both to the industry and to the Technical Section. He had served the Section over a considerable time in many capacities, technical, administrative and advisory, especially as Chairman 1946–48. He was elected an Honorary member in 1958.

REPORTS OF COMMITTEES, DIVISIONS AND DISCUSSION GROUPS FOR THE YEAR 1959

PUBLICATIONS AND LIBRARY COMMITTEE

Presented by the Chairman, Dr. J. Grant

Membership of committee

Dr. J. Grant (*Chairman*)
L. A. Lawrence (*Vice-Chairman*)

R. H. Clapperton	G. Thompson
P. A. Duxbury	*B. H. Turner
Dr. H. Ainsworth Harrison	G. F. Underhay
D. McNeill	C. G. Wallace
S. V. Sergeant	

F. M. Bolam (*Secretary*)

* *Resigned during the year*

The first preoccupation of the Committee during the past year has been matters arising in connection with the new journal *Paper Technology*. This is the publication resulting from the merging of the *Proceedings* and *Technical Bulletin*. The result of this work will appear in the first issue, published in February 1960.

Other matters dealt with are the reprinting of Technical Section papers by other journals, consideration of Regional Officers' recommendations regarding the publication of papers read before their Divisions and the refereeing of the papers.

During the year, Mr. G. F. Underhay became temporary Vice-Chairman of the Committee in succession to Dr. Binns who had to resign this position. Mr. Underhay has since been succeeded by Mr. L. A. Lawrence.

Membership of the library sub-committee is as follows—

L. A. Lawrence (*Chairman*)
R. H. Clapperton
S. V. Sergeant
F. M. Bolam (*Secretary*)

Note—The Chairman and Immediate Past Chairman are *ex officio* members of all Standing Committees. The Vice-Chairman is an *ex officio* member of the Publications and Library Committee.

PAPER AND BOARD TESTING COMMITTEE

Presented by the Chairman, Mr. G. Thompson

Membership of committee

G. Thompson (*Chairman*)
C. A. Chester (*Vice-Chairman*)

W. E. Bennett	L. F. Hopkins
F. Bridge	Dr. F. L. Hudson
R. R. Coupe	L. A. Lawrence
T. H. Farebrother	A. F. Tout
G. F. Glover	H. G. Tyler
E. Halson	G. F. Underhay

F. M. Bolam (*Secretary*)

The work of the Paper and Board Testing Committee during the year 1959 has been a continuation of the programme agreed on during 1958, which was based on comments received from the industry following the circulation of the Technical Section memorandum (TS 2289) and, as a result, further sub-committees were set up during the year dealing with dirt count, fluff, curl and top and bottom side of paper.

During the year the revised burst test was published simultaneously by the Technical Section and the B.S.I. and PT 19 dealing with the determination of the permeability to water vapour was also published as British Standard 3177:1959. Methods for the determination of conductivity, chloride and sulphate in paper, thickness and smoothness (or roughness) are in draft form and should be published shortly.

As a result of the ISO conference in Stockholm in May 1958, a considerable amount of redrafting and editing by the appropriate sub-committees has taken place in line with the decisions reached on the methods which were considered; all this work has been channelled through the British Standards Institution, with whom once again we have worked in very close collaboration during the year and with whom we have very good relations. Also as a result of the ISO conference, an ISO working group party composed of representatives from France, Germany, Holland, Sweden and the United Kingdom and chaired by the Chairman met in London during November to consider the programme of work on optical properties of paper.

During the year, the Chairman visited Darmstadt and discussed with Prof. Brecht and other prominent German paper technologists ways and means of collaboration at industry level on paper testing matters in the hope that some form of agreement on test methods at industry level could be reached so that, when methods at ISO level came up for consideration, the procedure would be simplified and expedited. As a result of discussions with Mr. Laroche, the past President of EUCEPA, an invitation was extended again to the Chairman to put the same views before the October meeting in Paris of the presidents of associations attending the EUCEPA conference. This has resulted in a note indicating the lines suggested having been circulated to all EUCEPA member countries for consideration and comment.

During the year six meetings were held; the Test Group personnel and chairmen of the sub-committees are as follows—

1. GENERAL AND STRUCTURAL PROPERTIES

E. B. Price—Thickness and bulk
(outstanding)—Basis weight
C. A. Chester—Conditioning
T. H. Farebrother—Moisture content
C. R. G. Maynard—Smoothness
A. F. Tout—Sampling
Miss E. J. Pritchard—Fluff
G. K. Abercrombie—Curl

2. MECHANICAL PROPERTIES

G. F. Glover—Tearing test
N. C. Underwood—Bursting test
R. G. Knapman—Folding test
W. E. Bennett—Tensile test
B. H. Browning—Wet strength
W. F. Saunders—Stiffness

3. OPTICAL PROPERTIES

L. F. Hopkins—Gloss
E. S. Brazington—Colour and brightness
Miss S. S. Cameron—Opacity
(outstanding)—Dirt count

4. PERMEABILITY TO FLUIDS

F. Bridge—Water vapour permeability
W. E. Bennett—Air permeability
R. R. Coupe—Sizing properties
D. M. Wyllie—Absorbency of bibulous paper
D. J. B. Miller—Oil absorption and grease resistance

5. CHEMICAL PROPERTIES

R. R. Coupe—pH and acidity
C. G. Hampson—Sulphates and chlorides
L. F. Fuller—Nitrogenous treating agents
C. G. Hampson—Waxes for paper
E. Halson—Ash content

6. BOARD TESTS

L. A. Lawrence
T. R. Johnson
Dr. G. J. Murdoch
W. F. Saunders
H. G. Tyler

7. DRAFTING GROUP

A. F. Tout, E. S. Brazington, Dr. F. L. Hudson, F. M. Bolam

(*Group Chairmen's names in italics*

EDUCATION COMMITTEE

Presented by the Chairman, Dr. J. Grant

Membership of committee

Dr. J. Grant (*Chairman*)

Arthur Baker	R. Robertson
I. G. Burns	*A. Hugh Rutt
*G. Campbell	W. P. Scott
R. H. Clapperton	S. V. Sergeant
Dr. G. A. Cramond	S. F. Smith
Dr. F. L. Hudson	G. F. Underhay
M. Lambert	K. C. Weedy
G. E. H. Newton	J. Winterburn

F. M. Bolam (*Secretary*)

* *Resigned during the year*

There is little new to report as compared with last year; however, further, if somewhat slow progress has been made by the two editorial panels dealing with the manuscripts of the two completed monographs (on stock preparation and on wires and felts) and by the sub-committees responsible for completing the monographs on the wet end of the papermachine and the nature and uses of paper.

It is fitting to pay tribute to the work of the late Mr. L. G. Cottrall on the stock preparation monograph. Mr. Cottrall carried the main burden of the responsibility of organising and collating the contributions to this monograph and it was hoped that he would have been able to see it through to the printing stage. His death is therefore a sad loss to this work.

The work on the compiling of material for the library of illustrations and lantern slides is completed, but the slides themselves have yet to be made.

Other matters dealt with include correspondence courses, the educational needs of 'mill floor' men and technical information sheets on papermaking subjects.

PULP EVALUATION COMMITTEE

Presented by the Chairman, Mr. L. G. S. Hebbs

Membership of committee

L. G. S. Hebbs (*Chairman*)

A. F. Tout (*Vice-Chairman*)

W. E. Bennett	J. L. Gartshore
C. Brown	*Dr. H. Ainsworth Harrison
*Dr. G. A. Cramond	A. Ross
J. P. Firrell	G. Thompson

F. M. Bolam (*Secretary*)

* *Resigned during the year*

With regret, we have to record that the Committee has lost the services of two members by retirement due to the heavy pressure of work in other directions—Dr. H. Ainsworth Harrison and Dr. G. A. Cramond. Dr. H. Ainsworth Harrison was closely connected with the early development of the standard sheet-machine and pulp evaluation in general and his support has continued over many years. Dr. G. A. Cramond took an active part during all those years when he could attend meetings in London, but, as this has not been possible recently, now wishes to retire from this Committee. The guidance and staunch support of these members of so many years' standing will be greatly missed by the Pulp Evaluation Committee.

The sheetmaking equipment sub-committee has continued its contacts with the new manufacturer of the equipment and consolidated the position further. A production engineer has been consulted about possible modifications to the existing design in the hope that its construction can be simplified without detriment to its performance; so far, however, no specific recommendations on these lines have been made.

During the year, no new laboratory investigations were started by the chemical and physical properties of pulp sub-committee. The first specification to be issued by the International Committee for Cellulose Analysis (ICCA 1:59—Kappa number) was considered and is recommended for adoption in British laboratories—providing an improved method for the determination of cooking degree or bleachability, free from the defect of a break in the curve, which characterised most of the test procedures earlier in use. Methods under consideration for adoption as standards in other countries were received for comment and, whenever possible, the sub-committee has deprecated the introduction of modifications, whilst keeping the empirically defined names unchanged as, for instance, in the TAPPI proposals for kappa number and alpha-cellulose determination.

The sub-committees dealing with laboratory beating and with fractionation and shive content of groundwood have not had occasion to meet during the year, but a close watch is being kept on various investigations that it is hoped will enable useful standard methods to be formulated in due course.

Facilities for approval testing of the standard pulp evaluation equipment purchased through the Technical Section have continued to be provided by the Research Association at Kenley and we wish to record our thanks to the Director and his staff for the considerable time and care put into this important standardisation work.

The membership of the Pulp Evaluation Committee's sub-committees is as follows—

CHEMICAL AND PHYSICAL PROPERTIES OF PULP

L. G. S. Hebbs

E. C. Allison
A. W. Elkington
I. F. Hendry
J. More
Dr. H. F. Rance
J. R. Simmons
R. Tripp Smith
H. A. B. Wilson

FRACTIONATION AND SHIVE CONTENT OF GROUNDWOOD

A. F. Tout

J. R. Ainscough
B. H. Browning
J. M. Dixon
J. L. Gartshore

LABORATORY BEATING

J. L. Gartshore

C. Brown
H. W. Emerton
D. H. Page
A. Ross

SHEETMAKING EQUIPMENT DRAINAGE AND FREENESS

G. Thompson
E. C. Allison
W. E. Bennett
C. Brown
J. P. Firrell
G. F. J. Mansell

(Chairmen's names are in italics)

STATISTICS COMMITTEE

Presented by the Chairman, Mr. A. F. Tout

Membership of committee

A. F. Tout (*Chairman*)
W. E. Bennett (*Vice-Chairman*)

*C. R. Baines
F. C. Butcher
D. L. Cooper
*Miss E. M. Dean
I. F. Hendry
Miss P. Marsden
D. A. H. Thomas
D. J. Waller

F. M. Bolam (*Secretary*)

* *Resigned during the year*

In accordance with the plans which were described last year, the Committee held the first of its symposia on 29th October. The amount of interest aroused by this exceeded the most optimistic forecasts and, though the accommodation was trebled, many applicants were unable to be accepted. Approximately 120 people heard Mr. G. A. Coutie of Imperial Chemical Industries Ltd. give a lucid and comprehensive account of the principles and practice of evolutionary operation with suggestions as to how this technique might be applied to some aspects of papermaking. The meeting lasted all day, was divided into three sessions and closed with a period of questions and lively discussion. A further symposium is planned for 29th February 1960 and will be devoted to methods of handling subjective data. Information on existing courses in statistics has been collected with the co-operation of the Ministry of Education: its collation is proving rather difficult, but is in hand. In view of evidence of demand for a residential course in elementary statistics, the Committee has under review its decision not to organise any more one week courses and is contemplating arranging a course for 1964.

A symposium devoted to statistical methods in the pulp and paper industry is being organised by EUCEPA in Finland from 16th to 18th May 1960 and the Committee, which has been responsible for liaison between the United Kingdom and the Finnish organising committee, is pleased to report that it has been responsible for five of the papers that will be presented.

Work on publications devoted to sampling and to analysis of variance has continued, albeit slowly, because of the immense amount of work involved in reducing the subjects to reasonably small compass. Other publications on quality control and on regression and correlation have been started.

Seven meetings have been held during the year: in February, the Committee was joined by Mr. D. L. Copper and Miss E. M. Dean, though the latter has recently resigned on leaving the paper industry. The Committee has also with regret accepted the resignation of Mr. C. R. Baines, which was anticipated when he left Kenley for Aberdeen, but is very appreciative of the fact that he has continued to accept responsibility for drafting the publication on regression and correlation.

FASTNESS TO LIGHT COMMITTEE

Presented by the Chairman, Mr. J. G. Grundy

Membership of committee

J. G. Grundy (*Chairman*)

J. R. Ainscough
W. E. Bennett
E. A. Bradford
F. Bridge
Dr. W. Carr
Dr. V. G. Morgan

F. W. Bailey (*Honorary Secretary*)

The fastness trials mentioned in the report for last year, using both the wool standards covered by B.S. 1006:1955 and the latest experimental paper standards, have been completed and the results analysed. A report on the work has been drafted and should be in the hands of committee members in the near future.

Anomalies were obtained in the assessment of certain patterns irrespective of the set of standards used, but in general, the tests indicated—

(*a*) A greater agreement in assessments using the latest experimental paper standards compared with the wool standards covered by B.S. 1006:1955.

(*b*) Experienced observers are more reliable in making assessments than inexperienced observers.

ENGINEERING COMMITTEE

Presented by the Chairman, Mr. G. R. Roberts

Membership of committee

G. R. Roberts (*Chairman*)

N. J. M. Bennett	Major R. Marsh
W. J. Binns	G. E. H. Newton
J. S. Curtis	R. G. Oliver
G. Duxbury	W. Speir
J. Howarth	*W. Spence
J. J. Kelly	T. Sutherst
A. C. McLaren	J. Winterburn
F. H. Maddox	

F. M. Bolam (*Secretary*)

* *Resigned during the year*

The Engineering Committee has continued to press forward in its objective of encouraging and stimulating interest by engineers in the work of the Technical Section. The Committee has met on five occasions during the year and has been responsible for arranging a discussion meeting at Gravesend on 20th January, at which the attendance was extremely gratifying. A subsequent similar discussion meeting was held in Bury on the 2nd April, which emulated the success of the Gravesend meeting. The Committee also supported Mr. A. A. Ives' paper on vacuum pumps given in front of the London Division on the 12th November. In addition, the Wye Valley Discussion Group held a successful meeting on engineering matters on the 18th November and a paper on ventilation was given by Mr. R. G. Sands in Maidstone on the 10th December.

The programme for this year is now virtually completed and the Chairmen of the Divisions have been kept fully informed of the work of the Engineering Committee and the help which they can receive from that Committee in the submission of papers and engineering participation at the discussion group level. During the year, meetings have been held with the Chairman of the Technical Section and the Chairman of the Engineering Committee, the main result of which has been that the activities of the Engineering Committee are now co-ordinated throughout the Technical Section at Division and Discussion Group level.

FUNDAMENTAL RESEARCH COMMITTEE

Presented by the Chairman, Dr. H. F. Rance

Membership of committee

Dr. H. F. Rance (*Chairman*)

P. H. Dixon	Dr. N. R. Hood
H. W. Emerton (*Programme Secretary*)	H. R. Hutley
Dr. J. Grant	P. H. Prior
Dr. H. Ainsworth Harrison	G. F. Underhay

F. M. Bolam (*Secretary*)

During 1959, the Fundamental Research Committee has continued to promote the sales of the Transactions of the 1957 conference. At the time of writing (January 1960), about 821 copies have been distributed and the Transactions account shows a satisfactory balance, which will be utilised for the 1961 conference.

Plans for the 1961 conference on the formation and structure of paper have advanced satisfactorily during 1959. The subject of the programme has already been elaborated and most of the potential contributors have already been approached. The conference will be held in Oxford and plans for accommodation and practical details for the formal and social aspects of the conference are well in hand.

PAPER MUSEUM COMMITTEE

Presented by the Chairman, Mr. J. Barcham Green

Membership of committee

J. Barcham Green (*Chairman*)
R. H. Clapperton (*Vice-Chairman*)

H. R. Balston	J. C. Marsden
D. McNeill	J. Mason

F. M. Bolam (*Secretary*)

Committee business was reported to the Executive Committee.

Three trustees were appointed in May to administer the Museum Trust Fund—Mr. H. R. Balston, Mr. Rémy Green and Mr. P. H. Prior. Considerable time was necessary to prepare the Trust Deed so that donations to the Fund could qualify for refund of tax. The Deed was finally drawn up in April and official recognition of the Trust Fund as a charity was accorded in October.

An appeal letter was approved in May and the covenant form to accompany it was subsequently

prepared. Arrangements are being made by the Trustees for the Technical Section's bankers to handle all the clerical work, including claims for refund of income tax. Once these details have been agreed, the appeal letter will be despatched.

During the year, more old machines and apparatus have been earmarked for the museum. The experimental Inverform machine may be offered to the museum.

CANADA COMMITTEE

Presented by the Chairman, Mr. G. F. Underhay

Membership of committee

G. F. Underhay (*Chairman*)
P. H. Dixon (*Vice-Chairman*)

I. M. Carmichael	L. A. Lawrence
P. A. Duxbury	G. Thompson
W. A. Gilmour	*J. Turner
H. R. Hutley	C. G. Wallace

F. M. Bolam (*Secretary*)

* *Resigned during the year*

The Canada Committee, to organise the second official visit of the Technical Section to Canada, was formed early this year after the Canadians had sent an invitation for the visit to take place in the autumn of 1960.

During the year, the plans have advanced to the point when a public statement is to be issued to the press giving details of the itinerary, the approximate cost and inviting applications to join the party.

The visit is being planned to take just over three weeks, the departure date by air being 26th August and the return date from Montreal about the 19th September (the exact date depending on whether air or sea travel is preferred).

The planning has been arranged to enable the party to attend the Canadian Technical Section's summer meeting, which, this year, takes place at Banff, 6th–9th September. The subject chosen for the conference is *Towards the better use of our manpower and raw material resources*, to which we are invited to contribute.

LONDON DIVISION

Officers

Chairman	*G. THOMPSON, M.Sc., A.R.I.C.
Immediate Past Chairman	R. CARTER, B.Sc., F.R.I.C.
Honorary Secretary	*D. C. BELLINGHAM, B.Sc.

Committee

E. A. Bradford	Dr. H. F. Rance
W. J. Carter	*W. F. E. Robinson
G. F. Glover	W. F. Saunders
F. W. Hayward	*S. V. Sergeant
I. F. Hendry	J. Tate
*P. H. Prior	*A. F. Tout

(* *Members of the Executive Committee*)

Meetings held during the year—

8th January	Some fundamental properties of wet felts—R. Ginn
12th February	Annual General Meeting Some techniques for absolute and relative speed measurements— N. C. Underwood, M.Sc. and D. Attwood, B.Sc.
9th April	Creep and creep recovery of paper— A. H. H. van Royen
14th May	Film show and cocktail reception—*Just an idea, The house of Walmsley, The twilight forest, The titanium pigment story*
15th October	Brains trust
12th November	Suction couch operation on paper machines—Influence of air permeability and basis weight of sheet on air extraction by vacuum pumps— A. A. Ives, A.M.I.Mech.E.
8th December	Annual dinner Prospecting for pulp— J. Grant, M.Sc., Ph.D., F.R.I.C.

Local meetings were held in Gravesend, Ashford, Sittingbourne and Maidstone as follows—

20th January	Gravesend: Chairman—E. T. Baker, M.A., Organising Secretary—W. Holden, A.R.I.C.; Engineering meeting—Brains trust
27th January	Gravesend: Chairman—E. T. Baker, M.A., Organising Secretary—W. Holden, A.R.I.C.; Paper and print—W. J. Steers
27th February	Ashford: Chairman—T. C. Davidson, Organising Secretary—F. W. Hayward, B.Sc., F.Inst.P.; The Cleaning of stock for fine papers—D. A. Knight, B.Sc.
3rd November	Gravesend: Chairman—E. T. Baker, M.A., Organising Secretary—W. Holden, A.R.I.C.; Some less common methods of flow measurement—J. R. Parker, M.A.
27th November	Sittingbourne: Chairman—A. S. Linforth, Organising Secretary—F. W. Hayward, B.Sc., F.Inst.P.; Focus on groundwood—C. W. King, A.R.I.C. and F. J. Pyle

10th December — Maidstone: Chairman—J. R. C. Sheldon, M.A., Organising Secretary—G. E. H. Newton, A.M.I.Mech.E., A.Inst.F.; Engineering meeting: Papermill ventilation—Its problems—R. G. Sands, M.I.Mech.E., F.R.S.A., M.Inst.F.

The London Division during the past year held seven meetings in London, the December meeting as usual being the occasion of the annual dinner. All meetings were well attended.

In 1959, for the first time, a ladies' evening was introduced, taking the form of a cocktail reception in the Norfolk Hotel, following the annual film show in May. This event proved to be a great success and it is hoped to repeat this in future programmes.

Six local meetings were held during the year, three at Gravesend, one at Ashford, one at Sittingbourne and one at Maidstone. These meetings continued to be attractive and well attended, so much so that at Maidstone it is now necessary to use a larger hall than previously.

One of the Gravesend meetings was the first meeting organised by the newly formed Engineering Committee and, later in the year, the Maidstone meeting was again under its auspices. Both these were very successful and attracted many engineering members and friends.

During the year, the number of Corporate members has decreased by one, but Full members have increased by 39, Associate members by 15 and Junior members by 6, a net increase of 59. The Divisional membership therefore is now—

Corporate members	52
Full members	440
Associate members	285
Junior members	38
	815

NORTHERN DIVISION

Officers

Chairman	*P. A. DUXBURY, B.Sc.Tech., Assoc.M.C.T.
Immediate Past Chairman	(B. H. TURNER, resigned)
Honorary Secretary	*V. G. MORGAN, B.Sc., Ph.D., A.R.I.C.

Committee

W. J. Binns	E. J. B. Mowat
F. A. Craig	N. G. Rackley
*P. H. Dixon	Dr. M. N. Strachan
*G. Duxbury	F. Walker
C. G. Hampson	J. Winterburn
*Dr. H. Ainsworth Harrison	W. C. Whittaker

(* *Members of the Executive Committee*)

Meetings held during the year—

9th January	Some properties of papermakers' felts—A. McGuiness
6th February	The fundamentals of pitch troubles and pitch control—Dr. E. Back
6th March	The application of starch products in the size press—A. Harsveldt
10th April	Research in industry—J. Wardley Smith (D.S.I.R.)
2nd October	Questions session Panel—P. H. Dixon, M.A., F. Bridge, Assoc.M.C.T., F.R.I.C. and J. Winterburn, A.M.I.Mech.E.
6th November	The use of plastics in papermill construction—Dr. J. H. Wilson and E. M. Elliott
4th December	General factors concerning MG machine operation—J. Chapman, M.Sc., A.M.I.Chem.E.

Interest is being well maintained in the Northern Division, the attendance figures and the quality of discussion at lectures being high. The summer outing was once again an outstanding success and took the form of a visit to Transparent Paper Co. Ltd. in the morning, followed by social activities at Southport.

During the year, we regretfully accepted Mr. B. H. Turner's resignation from office. The Northern Division wish him well in his new sphere and place on record their full appreciation of his excellent service as Secretary and Chairman.

SCOTTISH DIVISION

Officers

Chairman	*C. G. WALLACE
Immediate Past Chairman	*I. G. BURNS
Honorary Secretary	*N. P. BROWN

Committee

*I. G. Burns	J. A. Miller
T. Clapperton	A. Ross
Dr. G. A. Cramond	R. Scorgie
W. A. Gilmour	*W. Speir (transferred to London Division in December)
*J. B. Henderson	
*R. S. Hesketh	R. M. Thomson
J. Horsburgh	

(* *Members of the Executive Committee*)

Meetings held during the year—

28th January (Glasgow)	A show of films, including film and talk: The supply of steam of medium pressure on a line about 1 000 yd. long across open country to a boardmill—J. D. Crozier & Partners Ltd.
25th February (Edinburgh)	Annual General Meeting Demonstration of instruments used in a papermill laboratory

8th April (Edinburgh)	Divisional Dinner More net profit—W. Tait, C.A.
30th September (Edinburgh)	Young idea
7th October (Aberdeen)	Instrumenting a papermachine— R. C. Gardner, A.M.I.Mech.E., A.M.I.E.E., M.S.I.T.
5th November (Glasgow)	Film and talk: *Wood today*, *Pulp tomorrow*—T. Lassenius
2nd December (Edinburgh)	Mechanical drives — K. R. Suttie A.M.I.Mech.E., A.H.-W.C., Electrical machine drives—S. J. Holloway, B.Sc., A.M.I.E.E. and Electronic sectional papermachine drives—P. D. House

It is very encouraging to report once more an increase in the average attendance at meetings, which rose from 82.1 in the previous year to 88.7.

The papers and films presented again covered a wide aspect of papermaking and included three papers on engineering subjects.

Again, the fifth annual dinner meeting was a successful function, as applications exceeded the available accommodation. Mr. Tait's talk led to a very lively discussion.

The membership of the Scottish Division at the end of 1959 stood at 318, an increase of 7 over the previous year.

WESTERN DIVISION

Officers

Chairman	*L. A. LAWRENCE, B.Sc., F.R.I.C.
Immediate Past Chairman	*K. C. WEEDY
Honorary Secretary	*D. R. BARBOUR, A.M.I.Plant E.

Committee

J. W. Bodey	L. A. Lawrence
*A. J. M. Draper	*P. Sadler
J. A. Higgins	T. Sommerville
*O. J. Horne	R. A. Traill
J. J. Kelly	J. Tweedie
P. King-Smith	E. J. Worlidge

(* *Members of the Executive Committee*)

Meetings held during the year—

30th January	1958 Through the eyes of a papermachine designer— W. J. Binns, A.M.I.Mech.E.
27th February	Annual General Meeting Brains trust
3rd July	Paper additives to the beater and size press—A. V. Turner, C. Roberts and R. J. B. Millar
25th September	Effective use of instrumentation in stock control—B. W. Balls, B.Sc., M.I.Chem.E.
23rd October	Corrosion protection in the papermill—D. W. Marshall and J. A. McWilliam
27th November	River pollution—L. Gill

The Western Division again held six meetings, which have all been well attended. The subjects given at these meetings have again been divided, as far as possible, between the various aspects of the paper trade.

A co-ordinating committee has also been formed to work in conjunction with the Engineering Committee. This committee is under the guidance of Mr. J. J. Kelly.

WYE VALLEY DISCUSSION GROUP

Officers

Chairman	M. W. JACKSON, J.P.
Honorary Secretary	H. G. TYLER, M.Inst.F.

Meetings held during the year—

14th January	Quality control— I. F. Hendry, M.A., A.I.S.
18th February	Planned maintenance—W. Tait
1st April	Instrumentation— W. F. E. Robinson, C.G.I.A.
21st October	Accident prevention in the mill— R. Bramley Harker
18th November	An introduction to papermill engineering—G. R. Roberts, M.I.Mech.E.
9th December	Paper impregnation with synthetic latex—M. Clasper, A.R.I.C.

Once again, the Group has had a successful year; the average attendance has been maintained and the papers have covered a wide field.

NORTH EAST DISCUSSION GROUP

Officers

Chairman	A. E. CRANKSHAW
Vice-Chairman	D. MASON
Honorary Secretary	C. A. CHESTER

Meetings held during the year—

30th January	Questions night
27th February	Developments in the colouring and optical whitening of paper— F. Parrott and K. W. Grundy
3rd April	Visit to Team Valley Paper Mills, Gateshead

24th April	Annual General Meeting Film show
23rd September	The manufacture of titanium dioxide Visit to British Titan Products Ltd., Billingham
23rd October	Some practical aspects of sizing— C. Tosh, B.Sc.
20th November	The effective use of instruments in stock preparation— B. W. Balls, B.Sc., M.I.Chem.E.

At the Annual General Meeting, Mr. R. A. Patterson retired from the Chair after completing his two years' service and was replaced by Mr. A. E. Crankshaw. Mr. C. F. Maidwell has retired from the committee on leaving the district and Mr. J. Colton was elected to fill the vacancy.

Due to poor support for the annual dinner in the past two years, it has been decided to suspend this function for the time being.

NORTH EAST SCOTLAND DISCUSSION GROUP

Officers

Chairman	G. A. GEDDES
Honorary Secretary	W. BARNETT

Meetings held during the year—

7th January	Air systems in papermills—D. J. H. White
4th February	Additives at the size press— R. J. B. Millar
4th March	Growth of timber in relation to fibre characteristics—R. Dinwoodie
7th October	Instrumenting a papermachine— R. C. Gardner, A.M.I.Mech.E., A.M.I.E.E., M.S.I.T.
11th November	Colour in everyday life—F. Parrott
9th December	Engineering brains trust

The meetings continue to be well attended and we have again to record a very successful joint meeting with the Scottish Division on 7th October. A record number of people from the south travelled to Aberdeen for this meeting.

SOUTH WALES DISCUSSION GROUP

Officers

Chairman	C. O. ASKWITH
Honorary Secretary	C. CAPPS, B.Sc.

Committee

M. B. Baggallay
S. Brennan
R. Chittenden
R. Keay
J. Lawson
J. J. Morris
A. Rowlands
R. L. Williams
D. M. Wilkinson

Meetings held during the year—

21st January	Safety and law in papermills— E. I. Wilson, B.Sc.
18th February	Woodpulp—T. H. Frankel, Ph.D.
18th March	Visit to Sudbrook Pulp Mills
7th October	Brains trust—D. M. Wilkinson, B.Sc., J. A. Higgins, A.M.I.Mech.E., A.R.T.C., A. Sidebottom, B.Sc.Tech., Assoc.M.C.T.
23rd October	Visit to Black-Clawson International Ltd., Newport
11th November	Film show, Bridgend
2nd December	Stock preparation—New batch/continuous system— C. A. Rowlands

At a committee meeting on 9th April, Mr. C. O. Askwith was elected Chairman and Mr. C. Capps Secretary. Mr. A. Rowlands of Black-Clawson International Ltd. joined the committee.

The Discussion Group has had a very successful year and the attendances were almost double those of the previous year, the average being about 70.

The papers given proved very interesting and covered many aspects of papermaking. Works visits to Sudbrook Pulp Mills and Black-Clawson International Ltd. were very well supported.

NORTH WEST DISCUSSION GROUP

Officers

Chairman	N. G. RACKLEY
Honorary Secretary	H. S. AINSWORTH, A.M.Tech.I.

Committee

T. F. Brown G. Cullen C. G. Lawrence

Meetings held during the year—

23rd January	Beater additives—R. J. B. Millar, A. V. Turner and C. Roberts
20th February	Queries and theories
20th March	Wires and felts—F.C.Ray & J.Whitworth
24th April	Visit to Star Paper Mills, Feniscowles
23rd October	Film show—*Cornish china clay; The Papermakers*
20th November	Observations on a recent visit to some papermills in Canada and the U.S.A.— J. Allsup
18th December	Building techniques and planning— G. Harwood Modern methods of stock cleaning— G. Stuart

The meetings have been well attended. The average attendance throughout the year was 90, the mill visit again proving most popular.

THE OUTLOOK FOR AUTOMATION IN PAPERMILLS

Towards automation	T 71	*N. C. Underwood, D. Attwood and R. T. Heathcote*
Instrumentation of a Papermachine	T 82	*R. Gardner and L. LeBreton*
Instruments for automation	T 92	*B. W. Balls*
Speed control of drives in the papermill	T 102	*I. M. M. Maccallum*
Machinery for automation	T 112	*J. Howarth and W. A. Banks*
Trends in automation in the paper industry	T 123	*D. E. Mooney and P. F. Sutherby*
General discussion	T 128	*with panel of speakers*

Towards automation

N. C. UNDERWOOD, M.Sc.,
D. ATTWOOD, B.Sc. and R. T. HEATHCOTE

GIVEN AT THE SEVENTY NINTH GENERAL CONFERENCE: CONNAUGHT ROOMS, LONDON, W.C.2
ON 23rd MARCH 1960, Mr. W. A. GILMOUR IN THE CHAIR

Introduction

GENERALLY speaking, it can be said that the paper industry used prior to the Second World War only very simple and sometimes crude forms of continuous measurement and automatic control, although extensive laboratory testing of the finished product had helped the manufacturer to provide the customer with uniform quality. There is no doubt, however, that this testing, whilst of great value, suffered from the fact that it could only operate on a limited periodic sample basis and it therefore largely served as an intermittent check and to some extent as a post-mortem service. Such continuous measuring and control as there was was confined mostly to devices dealing with consistency, stock proportioning, chest levels, flow measurement and pH.

After the war, measurement and control instruments began to appear in greater variety and many installations were put in, often on a trial basis. The equipment was inserted with as little interference as possible with production, since at that time the industry was, of course, very short of productive capacity. Many papers of general interest appeared in the literature on this subject.[1–13] In this atmosphere, it is not surprising that some of these installations were of low accuracy and reliability and were often measuring parameters that could be permitted to vary over a wide range without affecting the saleability of the product.

In this period, many new pulp preparation units and papermachines were being designed and built and, as these came into operation, their instrument schemes were described, usually separately from the machine.[14–21] It is apparent that facilities for obtaining accurate measurements had been built into the system and the instrumentation was integrated with the construction of the machine, so that the whole would operate in a novel manner. Previously, in pulp preparation, for example, most beaters were filled in by hand, after water had been added to a mark on the wall of the beater; in modern batch hydrapulpers, the water is added by batch tanks in which the backwater is level-controlled. The control system cannot be considered separately from the plant, either in cost or operation, for the technical advantages of batch tanks would be lost without the control system and automatic operation would be impossible. On the other hand, such a control system would be inapplicable without the batching tanks and backwater supply that go with it.

The equipment manufactured by the instrument industry naturally has improved over the years. Straightforward measurements of pressure, temperature and their derivatives, differential pressure, flow and thermal conductivity have been made more accurate and reliable under plant conditions. This is especially true of pneumatic transmission systems, in which all measurements are transformed to a 3–15 lb./sq. in. air signal at the point of measurement or to an electric current in the latest electronic systems.[22] The advantages of improved speed of response over long distances, increased power for operating recorders and controllers and the interchangeability of all recorders and controllers have generally outweighed the increased cost of the method.

New recorders and indicators, often miniaturised with a minimum of moving parts, have permitted graphic panels to be built[23,24] without reaching undue size. The presentation of the final measurement has received considerable attention, although (in the opinion of the authors) further improvements to the final read-out in some instruments is still desirable. This applies to the visibility of the reading and to pen, ink and chart systems.

Controllers appear to have developed along two divergent paths: on one hand, there are combined recorders and controllers mounted on the control panel

Mr. Underwood is Research Co-ordinator and Mr. Attwood is Head of Papermachine Technology Department, The Bowater Research and Development Company Limited

Mr. Heathcote is Instrument Engineer, Engineering Division, The Bowater Paper Corporation Limited

and, on the other hand, there are separate controllers, often of the stacked diaphragm type, which may be mounted either at the point of measurement or behind the control panel.[25] Both systems have advantages—panel mounting centralises maintenance, but mounting near the measuring device and control valve speeds the system response by reducing transmission lags.

The final control valves have also been improved in materials of construction and in more linear characteristics, both in the inherent design and by the use of valve positioners.

The instrument air supply has now become divorced from the general mill air supply by the use of dry compressors, so preventing oil from entering the air lines; efficient aftercooling and drying have improved reliability very considerably.[26]

A few new principles have been developed, notably the beta-gauging method, which has changed from an undergraduate laboratory experiment through some rather questionable early instruments to complex scanning and control methods.[27–37] A move towards simpler circuits and the dissemination of full information to the customer would surely be a forward step.

The magnetic flowmeter is again an ingenious application of a known fundamental principle and with its unobstructed measuring tube will permit flow measurements where orifices and venturi methods have not been considered suitable.[38,39]

Moisture meters still rely on the correlation of electrical resistivity or dielectric constant with the moisture content of the sheet. Drying cylinder temperatures have been measured by thermocouple and thermistor methods[40] and the sensitivity of the infra-red photocell is being developed rapidly into the temperature range useful for this type of application. Each new moisture meter tries to make weight and furnish changes have the smallest possible effect on the reading and many installations are now operating.[41–43] Improved engineering in the instruments and their installation has aided this application, but part of the success is also due to a closer control of basis weight, furnish and additives, so that changes shown up by the instruments are more likely to be true moisture changes.

One of the few fast acting control system applications is in papermachine drives and, with modern systems relying wholly or partially on electronics, their design has now reached a stage that precision can be obtained much better than 0.1 per cent. of top speed and accuracy almost to this figure.[44]

Digital methods for measuring papermachine speeds have been developed—indeed, digital methods of presentation will probably be used extensively in the future for other measurements.[45]

Summing up, there has been a great increase in numerical measurement, coupled with a realisation, which is not yet complete, that equipment that may be suitable for laboratory work cannot stand up to mill operating conditions. It must be asked how these mill installations have been used, what are their advantages and defects and along what lines further development will take place.

The advantage of having numerical readings for all stages of the process with automatic control of some parameters is now widely established and is essential on high speed machines. On these machines, it is not possible to operate without some of this control gear—it is most difficult to decide what is essential and what is not, so all new machines have sufficient equipment to ensure their correct operation and this has necessitated several changes in the plant, not usually obvious.

The installation cost of instruments on existing machines, owing to machine modifications, is often greater than the cost of the instruments themselves. On new machinery, the cost of the whole job is considered as the new controls have become essential, although some data in cost breakdown has been given.[46]

The present position

REMEMBERING that all measurements are intended to increase production, improve quality or cheapen production without sacrificing quality, it is seen that the information, if outside the desired limits (which may or may not be closely defined), must be sent back and used at an earlier stage in the process to make corrections. This feedback control is used in all papermills whether they are equipped with instrumentation or not. We believe that the concept of each operation in terms of feedback control is vitally important for any discussion of automation and we make no apology for the following elementary discussion.

Consider the problem of a machineman controlling the basis weight of a making by adjusting the stuff gate. If we start our study when a reel has just come out of the machine, we shall see the dryerman taking some samples from the reel and weighing them. He then signals the results to the machineman, who goes to the stuff gate. In his mind, he has considered whether the readings are reliable, whether they are within an acceptance band around the desired value and he has considered how much the stuff gate should be moved.

In coming to a decision, a good machineman can take account of many factors—machine speed changes, consistency changes, flow box head, level across the slice, retention of stock on the wire, pressing and drying changes. Provided he has information about all these factors and provided he can interpret it correctly, the machineman is in an ideal position to make changes to his stuff gate. This is a complex feedback loop.

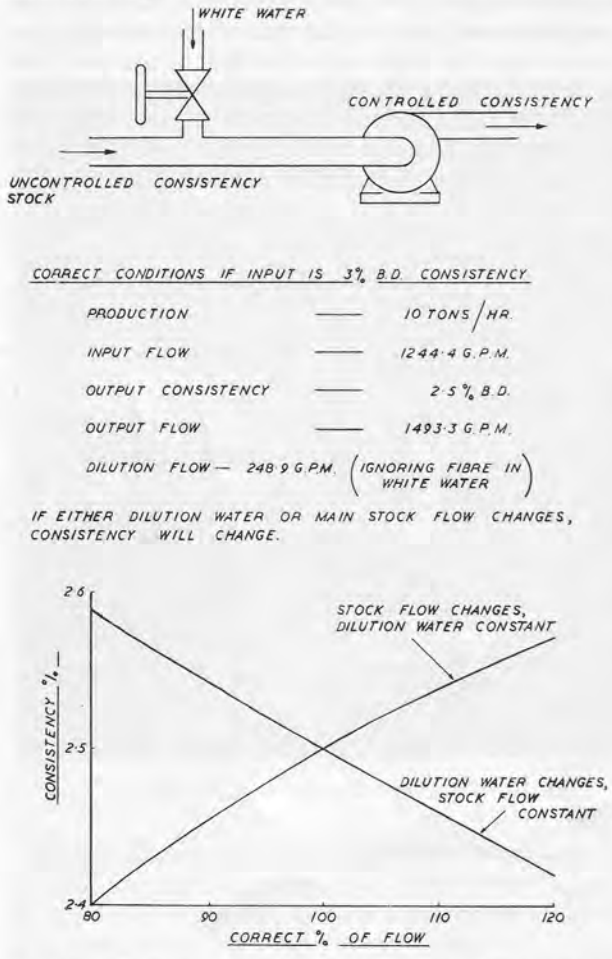


Fig. 1—Graph showing how the flow rates of stock and whitewater influence a consistency control system

Now look at a consistency controller and let us assume that it is capable of measuring consistency with a linear scale. It suddenly detects some difference from the desired value and opens the dilution valve to let whitewater run into the thick pulp. This is a typical simple closed feedback loop. Now, the correcting change in consistency that the movement of the dilution water valve produces depends on several factors, the main ones being the pressure in the dilution water line, the consistency in the dilution whitewater, the flow of thick stock through the pump and the consistency of the thick stock (Fig. 1). If good performance is required, the important supply side factor of dilution water pressure must be kept constant, as well as the demand side factor of thick stock flow rate. If these factors vary, the performance of the controller will be poor. We have also several techniques in the controller such as the combined use of proportional and integral control to overcome the inherent inability of either control to give perfect control by itself.[47]

To sum up so far, it can be said that automatic control can act in a repeatable manner within limited circumstances, whereas manual control is able to be influenced (for better or for worse) by a wide range of factors depending on the skill and enterprise of the operator.

The main reasons for process control are to improve the uniformity of the product and to permit the tolerances around the required properties to be reduced. It is axiomatic that no controller will produce a perfectly uniform product and there are several ways in which the performance of a system can be judged[48]—

1. Maximum deviation from desired value—This is the criterion that can be applied to a basis weight control system when it is undesirable for the weight to move more than 5 per cent. away from specification. This leads to the idea of the deviation reduction factor, which is the ratio of the change in a measured variable for a given supply side change without the controller to the change in a measured variable with the controller in operation.

2. Minimum time integral of the square of the error—In many chemical reactions in which the reaction is controlled by temperature, large deviations can be permitted so long as they are controlled quickly.

3. Minimum number of oscillations after an upset—As it is well known that most control systems respond to a sudden change by executing a series of damped oscillations, it is desirable that these should die out as quickly as possible, especially if the product passes to another controller.

There is little in the technical literature on the quality of control required in process operations, except in the most general terms. So the supplier has only his general experience to guide him and often puts in a more expensive system that he is certain will work.

Before defining and discussing automation, let us now look at some of the more pressing problems of process control that are not universally solved.

First is the concept of inherent stability. Various formal definitions have been given, but consider a Yankee drying cylinder as an example. This is inherently stable, because an increase in steam pressure will cause the surface temperature to rise from one value to another somewhat higher value, at which the heat flow to the sheet and losses to atmosphere account for the extra heat being brought in by the steam. The change in temperature due to unit movement of the steam valve is known as the *potential value*, assuming that all steam supply pressure and enthalpy conditions upstream of the control valve, sheet conditions of basis weight and moisture, as well as conditions of heat transfer in the dryer remain constant. This potential value is one of the basic factors of control engineering and dynamic changes in the controlled variable are compared with it.

On the other hand, consider a stock chest fed from a line and at the same time being used as a supply to a positive pump. If the input rate is either above or below the pumping rate, the level in the chest will either rise or fall until the chest floods over the top or is pumped dry. Such a system has no inherent stability. Though such a system is controllable, it is desirable to have a system with maximum inherent stability. The Poirier consistency control uses a system in which an increase in viscosity results in a reduction in flow to the machine, so keeping the quantity of stock constant. The authors consider that this principle has much to commend it.[49]

Secondly, some of the more difficult process control systems are extremely non-linear. This means that a unit change in the control valve position causes a change in the controlled variable that is not the same at all parts of the scale. Alternatively, the primary measuring element may be non-linear in scale. In many instances that require only approximate control, this does not matter or can be compensated by a reset control mode. On the other hand, in moisture control installations in which a dielectric or resistivity measurement is used in cascade with a steam temperature or pressure controller, this non-linearity can be serious.

Thirdly, there is the necessity to design for dynamic instead of steady state conditions. Most plants are designed to operate at a certain rate with set stock and paper flow rates and from these are derived chest levels, pump sizes, etc., but little attention has been paid to the way in which this steady state condition is approached at start-up or immediately after a break. The consistency build up of a wet end system has been described,[50] as well as equipment for automatic start-up.[51] A simple example is the automatic reduction of the set point of a steam temperature controller when the break detector operates. There is scope for the use of control systems whose action is modified when extreme conditions occur.

The way in which control systems behave when rapid changes occur has not been investigated very fully in this industry and the technique of frequency response analysis is hardly known. The basic theory has been described[48] and equipment is available from several manufacturers. The method consists of applying a sinusoidal variation to the input of a process and comparing the amplitude and phase of the waveform present at the output. From the results, some idea of the controllability of the process can be obtained and an indication of controller characteristics given.

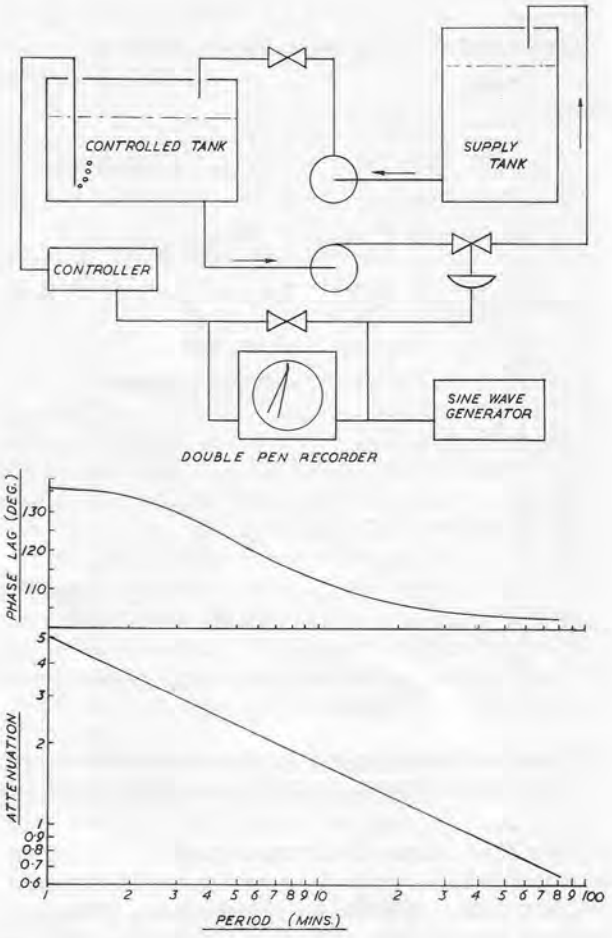


Fig. 2—Phase attenuation diagram for a water circulation control system (as the system has no inherent stability, the attenuation is not normalised)

Fig. 2 shows the frequency response of an experimental water circulation system.

While the basic ideas underlying frequency response methods are most helpful in understanding the principles of control, their practical value yet remains to be demonstrated in papermaking, except as a pointer in the design of new plants. Whereas the method is used extensively on fast electrical servos for gun and rocket control, most process control systems are tuned up empirically after installation or by observing their response to simple step, ramp or random noise inputs.

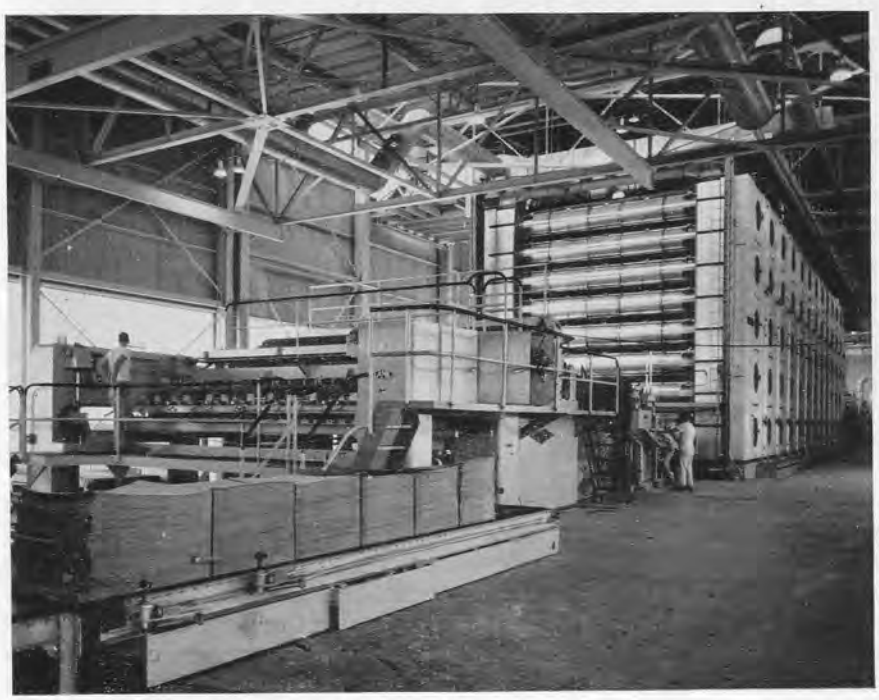


Fig. 3—Automatic conveyor between slitter and baling press

Even in the most technically advanced plants, there is still considerable scope for improvements and extensions to orthodox process control, whilst some other plants have only begun to enter the field.

Automation

IT is not easy to differentiate between process control and automation, as the two merge together. It is difficult to find a formal definition of automation, but it is broadly applied in three different ways[52]—

1. To transfer machines used between unit operations.
2. To complicated operations previously programmed, with or without feedback.
3. To self-optimising processes, in which the desired properties in the final product are obtained only when other simpler properties are in a suitable combination.

The first type, the transfer machine, grew in the motor car industry,[53] where heavy parts had to be moved from one operation to the next, possibly between two machines working at different rates. Such an operation can be regarded as inherent in the design of even the oldest papermachine, with no storage between operations as the sheet passes from one section to the next. Indeed, the paper industry can claim to be in the forefront of automation with the inventions of Gamble and the Fourdrinier brothers: but this took place so long ago that it anticipated the new terminology. Transfer operations are also carried out by conventional cranes, conveyors and powered vehicles. The rate of output of machine reels from even the fastest papermachine does not necessitate radical changes from techniques used at present. One typical example is the pulp baling machine shown in Fig. 3. Here, a number of pulp laps being delivered simultaneously are collated on a conveyor and are delivered serially to the press and wiring machine. The operation is controlled by a system of photocells.

Transfer operations of this type are often carried out by electric, pneumatic or hydraulic actuators and *automation* is often used to describe this equipment. In the paper industry, many ancillary adjusting mechanisms are now coming into this category. Press and calender compounding systems, with their lifting gear, stream flow valve control mechanisms are typical examples and expenditure on this type of equipment for a machine often exceeds that on the closed loop controllers. The range of these remotely controlled mechanical devices is large and is not easy to fit into the formal definition.

The second idea of automation is demonstrated most clearly in some modern pulp preparation plants.

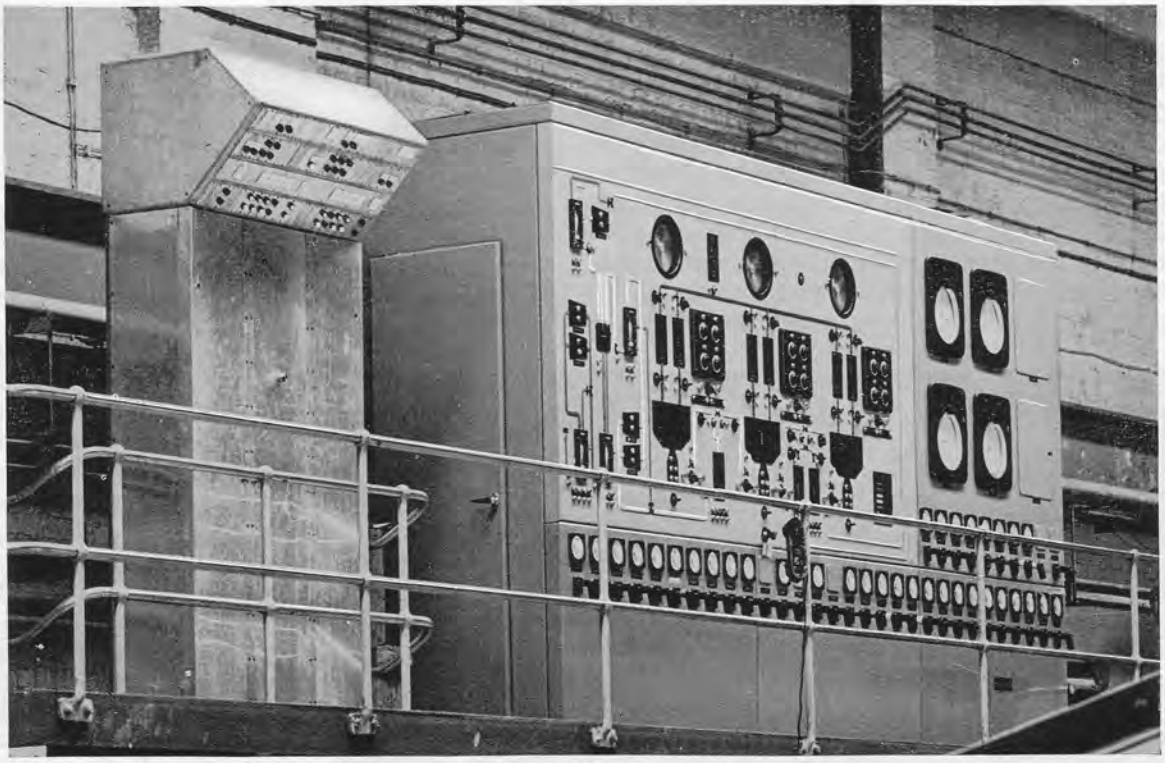


Fig. 4—Pulp preparation control panel with monitor unit on the left

A system typical of modern practice with which the authors have been concerned is shown in Fig. 4. The basic principle is that of a timed programme for slushing baled groundwood and chemical pulp in two separate systems. The timer allows water to be added to a hydrapulper from batching tanks. After a certain fall of the level in the batching tanks, the water stops flowing into the hydrapulper and the tank refills by means of level controls. Pulp is now added to the hydrapulper by a conveyor and agitation continues for a set time. At the end of this time, the stock is pumped, with the addition of a tankful of dilution water, into the dump chest. If the dump chest is already so full that it will not accept the whole charge, however, the hydrapulper continues to slush the pulp until the dump chest is sufficiently empty.

Fig. 5 shows that the control scheme is a mixture of open and closed loops and, in particular, there is no means of knowing if the operations called for by the timer have in fact been carried out. The authors suggested that a monitor should be built to detect whether operations called for by the control panel were carried out in some 15–30 sec. If not, an alarm sounded to alert the operator. This equipment was of some assistance, though it was found that the few plant failures that occurred were easily detected by the operator and that the correction feedback loop was closed through him. This shows that the reliability of open loop controls can be very high and that a small amount of human supervision can be much more economical than the complicated fault detection equipment that is otherwise necessary.

The third concept of automation—that of the self-optimising plant—presents the greatest novelty, although it can only be realised in a limited way with our present knowledge. The idea is in two parts.

Firstly, it is supposed that a specification is drawn up in terms of the purpose of the product rather than in terms of most present tests, which have little or no relation to the usage and are applied mainly because they are simple to perform in themselves. For example, a bag paper might be specified as having a certain tensile strength provided that the stretch reaches a certain figure with a given tear. If the stretch is more than this base value, the strength can be lower and yet still fall within the specification. This concept (but with different tests) applies also to printing papers, because here the properties for good

printability are very much interrelated.[54–56] Having set up a specification for the product, the next stage is to relate this specification to manufacturing conditions on the papermachine and it must be realised that by the time this system may be in use the papermachines may have changed quite radically from their present construction, although it is probable that the same basic processes will still be employed. Much work remains to be done on the relationship of machine factors such as the preparation of the fibres, chemical additives and machine conditions and their effect on such parameters as stretchability, dimensional stability, tearing strength and anisotropy for papers that are subjected to mechanical stresses. For printing papers, there is limited knowledge of the papermachine conditions that give good smoothness, desirable compressibility characteristics and similar properties on both sides of the sheet, as well as how different pulps can give paper of the same specification.

When the machine parameters that determine the desirable properties in the sheet are known, it is supposed that measurements taken either on the machine or in the control laboratory will be fed back in a known manner so as to alter the machine conditions. This presupposes that the equations of the machine are known and that a small deviation in smoothness can be corrected by control action, which, for example, may be applied to the flow box, to the draws of the machine, to the drying or to the calendering. Now, it is most unlikely that these equations will be found with sufficient precision; in any case, the effect of different pulps or wear in the machine cannot be expected to help the equations to retain their accuracy and it is most likely that some other avenue of approach will be sought.

Evolutionary operation offers considerable promise.[57] Small changes in operating conditions are made during normal operation and the effect is noted on the product. If a favourable response is found, a further step is made in that direction until an insensitive optimum is found. In more practical terms, one might imagine that the draw of a wet end section is changed automatically and the effect on the breaking stretch of the product is then evaluated. This, in conjunction with several levels of speed of the papermachine, would permit the best conditions of draw to be obtained at the particular operating speed. By this technique, there is no need to know the exact relationship between machine operating conditions and the properties of the product, for the machine operating conditions are continuously being varied in small steps and the effect on the product is found. Thus, the operating conditions move steadily towards the optimum, when they are not so critical. Complex controllers are now being developed for this purpose. The whole technique is necessarily a guess into the future and the authors will be particularly interested to re-read their paper in ten years' time to find whether this technique has been applied.

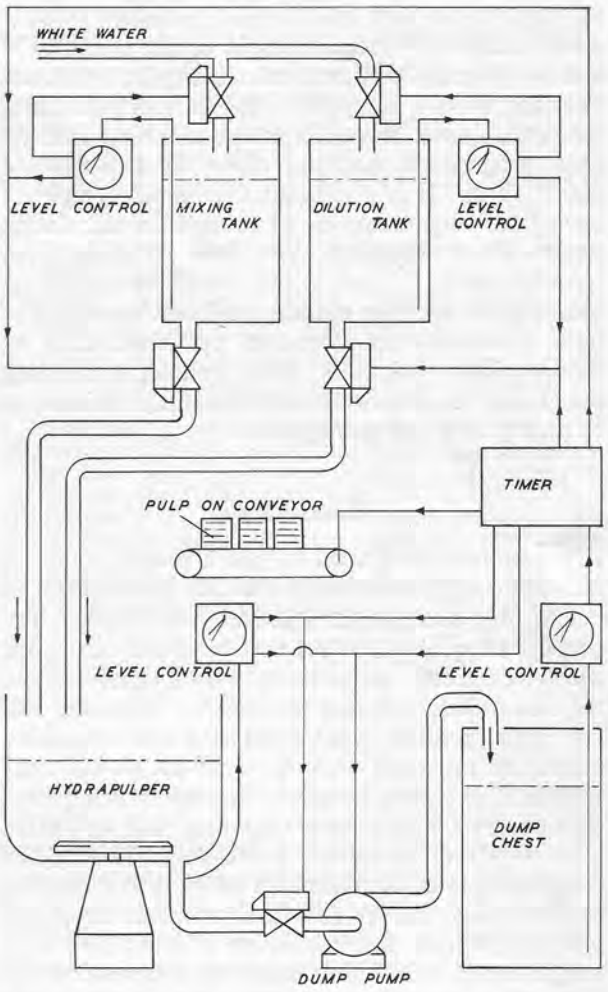


Fig. 5—Schematic diagram of pulp preparation system

No paper on automation would be complete without some mention of computers and the large complex equipment usually comes to mind.[58,59] Digital computers are, of course, already gaining ground for mechanised accounting, pay roll and, in some cases, for programming of production. Their value in research is undoubted and several organisations are now using computers for analysis of papermachine

records, particularly in basis weight analysis[60] for splitting the basis weight variability into the machine-direction, cross-direction and random components and similarly related projects such as the Fourier analysis of cyclical variations.

There are two other types of computer that must not be forgotten; one is the analogue computer, which is of considerable use to the research worker in the industry. It has been used for such problems as basis weight analysis,[61] calculations in drying cylinders[62] and for the analysis of mechanical vibration problems. The other form of computer is not yet in extensive use, but probably will be seen in greater numbers. It is the fixed programme machine, either in analogue or digital form. It is envisaged that small computers having set programmes could be used for calculating many of the operations now done manually from recorder charts. These include water, fibre and heat balances and machine operating efficiencies. Many of these operations are at present performed daily or weekly; but, with very little trouble, a running calculation could make data continuously available to operating staff and management.

Conclusion

THE authors have tried to give a broad picture of the fields of process control and the development in it that may occur in the relatively near future. The concept of quality control will be greatly extended with much greater emphasis on control engineering in the initial design of new machinery. There are still too many occasions when measuring and controlling means are requested after the final design has been settled. The cost of installing the control equipment then becomes much greater than usual and very often the set-up is not completely satisfactory. This applies particularly to measurements of forces in wire tension, press loading and to flow measurements in piping systems. Besides, the installation of traversing basis weight, moisture and gloss heads could be made much easier, if they were considered in the initial design of the machine.

We see no revolutionary change that might be called complete automation in the immediate future, rather a steady development along the recognised lines of process control, but there is no doubt whatsoever that the success or otherwise of equipment described by ourselves and other authors will depend very much on the men who construct, install, operate and maintain it.

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discussion

MR. G. SYKE: The control system of a complex plant like the papermachine tends to consist of many controllers to maintain relevant variables individually at a substantially constant, preset level. Their cumulative residual errors, as well as fluctuations due to uncontrolled variables, might be corrected by one superimposed general control loop. It has, for instance, been suggested in some quarters to control machine speed over a small range from the error signal of a substance gauge, in order to reduce the residual substance variations arising from all causes. The choice of the controlled variable for this loop, however, is a very controversial matter.

My second point concerns computers. One is often confronted with interdependent plant variables, which necessitate the computation of control instructions from several measured variables. Bearing in mind current developments on tandem rolling mill control in the steel industry, I feel that the right trend in such cases might be to employ relatively simple special purpose analogue computers or computer-controllers, which continuously receive analogue information from several measuring stations and produce one or more analogue control signals.

Computers embodied in automatic control systems may tend to be analogue; to provide data for use or evaluation by human beings, however, we may find that digital computation and display techniques are generally preferable.

MR. N. C. UNDERWOOD: Concerning basis weight control, we thoroughly agree that one first has to

investigate the small closed loops at the wet end of the papermachine, which may be contributing to rapid short term variations. It is desirable to track down this type of variation at source, since one cannot hope to control it by a beta-gauge at the dry end of the machine, because of the distance velocity lag between the control valve and the measuring instrument. There is no theoretical reason that either machine speed or the stuff gate should not be altered by a dominating general control, provided one does not expect too rapid a speed of response from this system.

I think the point emerging from this is that we are being asked to look into more and more difficult control applications. The very first question to the very first paper is concerned with the interaction of several variables and, as we move ahead into more and more complicated systems, I think it impossible to give a complete answer, unless in terms of a particular machine.

The fixed programme computer is a most interesting development and has not yet been applied in the paper industry so far as we know. Whether it should be an analogue or a digital system is not quite certain, but it is up to people like Mr. Syke to advise us.

MR. F. W. HAYWARD: Mr. Syke has suggested that basis weight should be controlled in the first place by the control of consistency, moisture, etc. and, finally, by varying the speed of the machine. I think that this would be impossible on a high-speed newsprint machine running at 2 000 ft./min. The inertial mass would be so great that it would be difficult to prevent *hunting*. It seems essential to control the speed of the machine and all the other factors, such as consistency and moisture, affecting substance separately. This emphasises the importance of finding better methods of measuring consistency and moisture.

MR. UNDERWOOD: We have to bear in mind that not everybody is concerned with high-speed newsprint machines; on slower machines, a case can probably be made for changing the speed of the drive to control the basis weight, although one is assuming that the normal variations in the speed are very small—as, indeed, they are in most modern electronically controlled installations.

MR. D. ATTWOOD: One other method to control basis weight is to adjust the consistency. There are thus three factors—the consistency of stock going to the machine, the speed of the machine and the position of the stuff gate; we have, in fact, considered all three. The reason that control with a beta-gauge is necessary is that there is no such thing as a consistency regulator. All known consistency regulators work on flow properties and, as such, cause the basis weight to vary.

The usual idea of adjusting speed to control basis weight is to get a very swift response, but this is ruled out on papermachines by the very long time it takes for the sheet to get down through the machine. On a newsprint machine, for instance, it takes well over 30 sec. for the sheet to travel from the wet end to the beta-gauge at the dry end. This means that we are never going to take out very fast variations in basis weight using the beta-gauge. This is why consistency controllers, speed controllers and flow controllers are a preliminary requisite to beta-gauge control. With these controllers, only long term variations in weight are left and the beta-gauge can easily keep these variations under control.

MR. LANDON GOODMAN: Experience with other applications teaches that speed variation is not desirable for corrections of the type mentioned by Mr. Attwood. A simple example is continuous weighing, in which it is very difficult to obtain high accuracy by varying the speed of the conveyor belt.

You state, '. . . mounting near the measuring device and control valve speeds the system response by reducing transmission lags.' I presume you are only referring to a pneumatic system. It should be stressed that electrical control systems can tie in much better than the pneumatic type with computer control.

Do you visualise that controllers will be placed round a plant and that there will be a central controller, probably regulating the band width of individual controllers or a central controller operating actuators at various points? A decision on this will govern the direction of research.

A small analogue computer that has been used with great success in the sugar industry is on the market. Has this type of controller any applications in the paper industry?

What are the possibilities for punched card or paper tape control? There are mills abroad operating with fast starting times on punched card control. What research is being carried out on such control here?

MR. UNDERWOOD: During the past ten years, research and development teams have been helping in the rapid expansion of the paper industry, using control equipment commercially available, mainly pneumatic. We are investigating all systems of control equipment, especially electrical and electronic, but

electrical systems until recently have had the one weak point that the actual control valve has been either hydraulically or pneumatically operated. Our experience with directly operated electrical valves has not been too good.

We have no direct experience of a small multiplying computer at present, but we are actively looking into the factors affecting the performance of all controllers. From the practical side, for example, we know of no controller for which the band width or the integral or derivative terms can be set remotely, which leads to difficulty when one control needs to have an emergency condition. Then, the setting of the proportional band should be different from the normal operation.

At the moment, we envisage a central controller (or small computer if you wish to call it that) primarily to alter the set points of individual controllers, assuming enough inherent stability in the plant to make it unnecessary to alter the band width or the integral and derivative terms of the controllers operating on individual closed loops.

Much of our production is the same, week after week, therefore applications of punched cards would be to ancillary equipment such as grinding machines, though maybe to improvements in efficiency at start-up and for accounting, research and for large scale computations such as with basis weight variations on the papermachine.

MR. B. W. BALLS: A paper by J. E. Samson* describes a pneumatic control system for the air compressors supplying a jet engine test bed. This proves that, if need be, the speed of response in a pneumatic system can be made extremely fast. One can overemphasise speed of response, particularly in control problems in the papermaking process.

MR. K. C. WEEDY: In the mid-fifties, practically everywhere you went on the continent and in America you saw weight control or weight recording done by passing the whole sheet over a roll. There were two models on the market, both manufactured by scale manufacturers and these were particularly popular in Scandinavia and America. It strikes me that, for practical purposes of the type of machine that perhaps falls in the 300–900 ft./min. speed range, giving you a general picture of sheet weight is a better proposition than the beta-gauge controller. I should like to ask Mr. Underwood to comment on that type of measuring instrument and to say if, in his opinion, it has been completely superseded by the beta-gauge method of substance determination.

MR. UNDERWOOD: We have no practical experience of this equipment, but we are familiar with a tension measuring device, in which the paper passes over a roll. The beta-gauge has developed into such a reliable instrument that it is generally easier to install it on an existing papermachine than a system for which the run of the sheet has to be changed to pass it over a roll.

MR. C. R. G. MAYNARD: A previous speaker said that simple mathematics could show that basis weight control by means of the speed of the machine was not possible or not very easy to achieve. Our company has been interested in basis weight control by means of altering the machine speed and I wonder if the previous speaker could indicate briefly the mathematics involved in this system.

MR. GOODMAN: It is a question of inertia and response together with the hunting period between the two.

MR. G. F. UNDERHAY: Has there been any attempt to take a signal at the wet end of the papermachine as a means of controlling basis weight. Some years ago, I saw a continuous measurement being made between the first press and the drying cylinders: despite the possible variations in moisture content at that point, the equipment appeared to be promising. Is there any advantage in pursuing this idea now to reduce somewhat the lag from taking the signal at the dry end?

MR. ATTWOOD: Whilst I have never seen such an installation, I have seen a preparation for one at a mill in Belgium, for installing a fully traversing beta-gauge at the wet end; however, the time saved is not so great. On our own installation, the time is that, $2\frac{1}{2}$ min. after you move the stuff gate, you see a change of weight at the beta-gauge at the dry end. Cutting down by 30 or 60 sec. by going up to the wet end, there is still left this long delay of $1\frac{1}{2}$ min.

On our newsprint machines, the basis weight must be integrated for at least 1 min. to average out the random fluctuations—only one adjustment every integrating time plus delay time, which can come out as long as 5 min. By measuring at the wet end, you could get an adjustment every 4 or $3\frac{1}{2}$ min. I think the advantage would not outweigh the disadvantage of not knowing the moisture content at the wet end.

* *The control of axial flow compressors*: Joint Symposium on Instrumentation and Computation (Institution of Chemical Engineers, 1959)

T 82

Instrumentation of a papermachine

R. C. GARDNER and L. LeBRETON
Albert E. Reed & Co. Ltd.

GIVEN AT THE SEVENTY NINTH GENERAL CONFERENCE : CONNAUGHT ROOMS, LONDON, W.C.2
ON 23rd MARCH 1960, Mr. W. A. GILMOUR IN THE CHAIR

Synopsis

The No. 13 machine Aylesford is designed to produce newsprint and mechanical printings at high speed, extensive use being made of instrumentation and automatic control to ensure uniform conditions throughout the process. The paper describes the particular applications at various stages of the stock preparation and machine systems. A central control room contains most of the recording and controlling instruments.

The hydrapulping stage is semi-automatic to eliminate variations in consistency between successive batches. The type of consistency control is described in some detail.

A stock proportioning system regulates the groundwood to sulphite pulp ratio, also the broke and china clay proportions.

The dryer section is equipped with pressure controls and a condensate extraction system to utilise as much as possible of the available heat in the steam.

A paper break detection operates an automatic broke disposal system and the dry end broke is also regulated automatically.

The water and drainage systems are controlled and measured to enable a close check to be made on water consumption and effluent conditions.

Introduction

FOR many years, recording and controlling instruments had been applied in increasing number to the twelve machines at Aylesford; consequently, with the advent of a proposed new machine (No. 13), it was a logical step to take advantage of the experience gained on the other machines and to design the machine and stock preparation plant for automatic control.

Quite early in the design stage, it was appreciated that considerable benefits would be obtained by centralising the records and controls. Since from experience of other machines of a similar size, the new machine was expected to be extremely noisy, it was decided to provide a soundproofed, air-conditioned, central control room. Fig. 1 shows this room containing the controls and records of all process variables not immediately concerned with the direct operation of the machine; further local control panels and desks are provided at strategic points along the machine aisle. Extensive interlocks ensure adequate automatic protection at critical parts of the plant.

All process (pneumatic, hydraulic and electric) controls are mounted on common panels or desks. The control panels are the graphic type, carrying a flow diagram of the system.

The main control room panel is 42 ft. long, carrying 62 recorders, 36 controllers and associated equipment. The dryer control room panel is 10 ft. long, carrying 12 recorders, 4 controllers and associated equipment. The main panel alone embodies 600 relays, 290 signal lights and 240 push-buttons, requiring over six miles of internal wiring.

Local controls are provided adjacent to operating points throughout the mill, two identical panels being mounted near to the hydrapulpers. Control of local operations of the machine, supercalender and reeler is from twelve desks located at convenient points.

Over 15 miles of small bore tubing and over 60 miles of wire were required for interconnecting controls and site mounted equipment.

All pneumatic instruments are supplied from an instrument compressed air system, equipped with an absorption dryer. The steady air demand is approximately 130 cu. ft./min., one 180 cu. ft./min. oil-free compressor being installed. A line pressure of 130 lb./sq. in. is required for pneumatic cylinder-operated equipment.

It is convenient to describe the equipment employed by following the process from the raw pulp through to the finished paper.

Stock preparation

THE pulp is received from the pulpyard and fed into either of two 20 ft. hydrapulpers, together with water and additives, to be reduced to a slush pulp condition.

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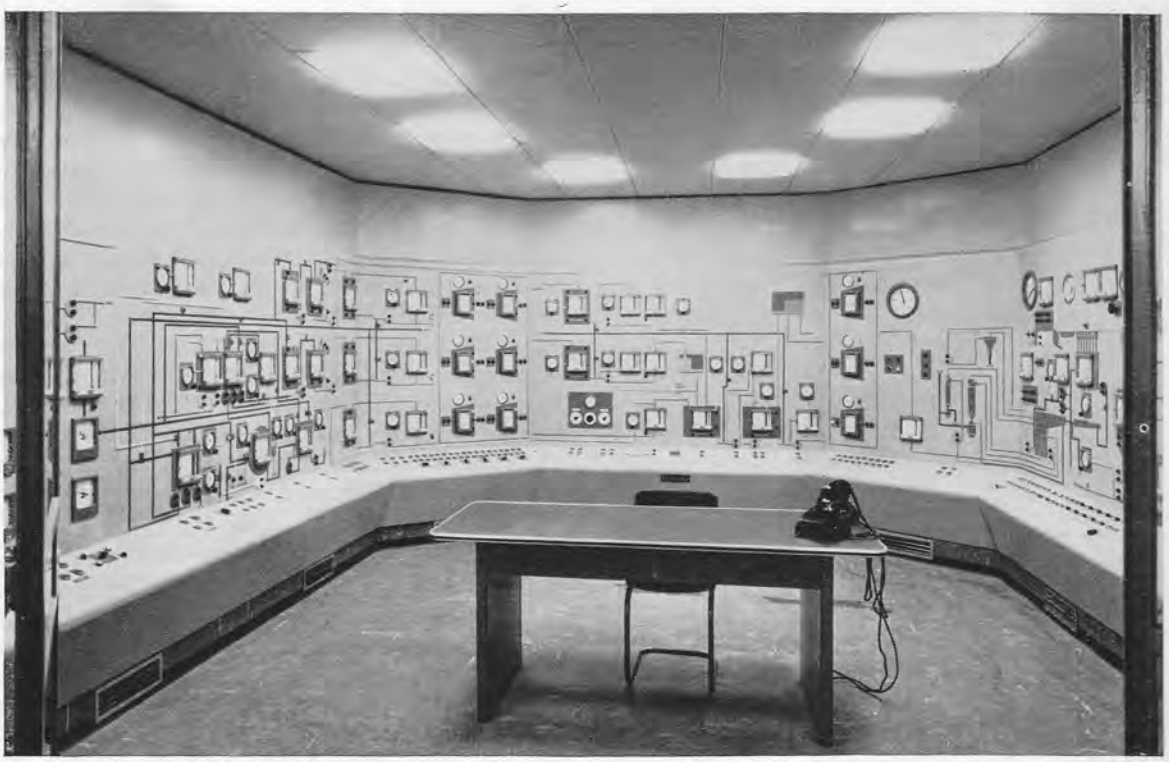


Fig. 1 — The main panel in the soundproofed and air-conditioned control room

To ensure that successive batches are of even consistency, the hydrapulpers are first partially filled with a measured quantity of water, to which a counted number of bales of pulp are added and reduced to an even slush pulp of approximately 7 per cent. consistency. At this stage, china clay slurry and alum solution are introduced. To enable this batch to be pumped away to storage chests, a further quantity of water is added to reduce the consistency to 6 per cent.

Since the hydrapulper requires an initial charge of approximately 12 000 gal. to be introduced in 3 min., it is necessary to accumulate backwater during the pulping phase of the cycle and to transfer it to the hydrapulper quickly at high flow rate. Fig. 2 shows how the necessary control is achieved by using a measuring tank of 15 000 gal. maximum capacity, arranged to fill automatically to a preselected level, at which point the control valve closes. The operator then presses the *fill* button, which opens a 12 in. pneumatic cylinder-operated, plate type valve, allowing the measuring tank level to fall to a preset value, at which point the 12 in. valve closes. The closing of this valve automatically releases the water inflow valve, which then opens to refill the tank to its original level. After approximately 15 min. pulping time, the operator presses the *dilute* button, which again opens the 12 in. discharge valve, allowing the tank level to fall to the second preset value, at which point the 12 in. valve closes and again releases the inlet control system. The discharge system is interlocked with the level control mechanism to ensure that both valves cannot be open at any time in the cycle of operation.

Simultaneously with the filling of the hydrapulper, a quantity of china clay slurry is introduced, the required quantity is obtained by setting a process timer dial to the required time interval and the slurry transferred by a positive displacement pump, which is run for this preset time, hence delivering a constant volume of slurry each cycle. Similarly, alum solution is added via a preset, positive liquid meter by setting the required gallonage on the meter dial; in this case, the solution is fed from a head tank through the meter and controlled by a diaphragm-operated valve.

The hydrapulper is discharged through a 16 in. pneumatic cylinder-operated, plate type valve by means of a pump. It is arranged by solenoid-operated valves for the discharge valve and pump to operate simultaneously from a common push-button station.

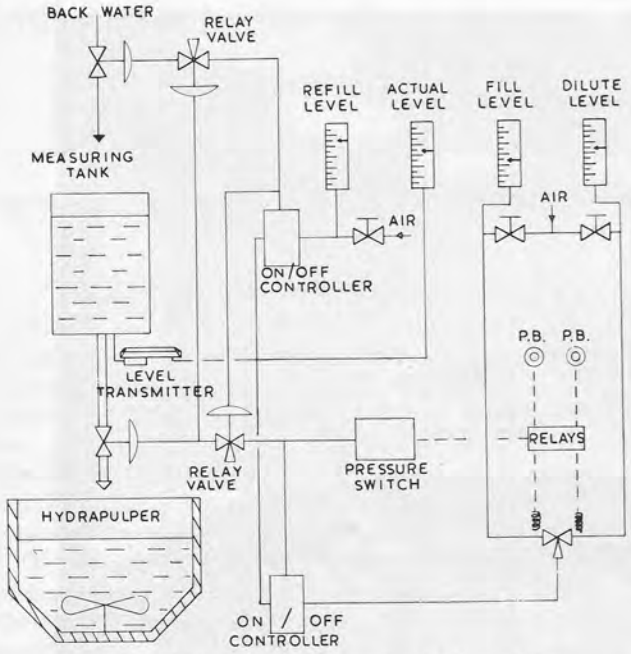


Fig. 2 — A simplified schematic diagram of the hydrapulper water measuring system

adding sufficient water at the pump inlet to reduce the consistency from the approximate figure of 6 per cent. in the storage tank to $5\frac{1}{2}$ per cent. at the pump outlet.

The power consumption of each hydrafiner is recorded in the control room and is adjusted manually by means of push-buttons operating a pilot motor geared to the rotor and arranged to adjust the relative position of the rotor and stator axially to vary the amount of 'work' done on the pulp. Since it is required to know the pressure of the pulp fed to the refiners, the inlet is fitted with a pneumatic pressure transmitter of the diaphragm type, having its measuring diaphragm arranged flush with the pipe surface to avoid blockage by the pulp. The refined stock passes through a control valve into a storage chest, the level of which is recorded and maintained constant by means of a two-term controller.

Stock proportioning

Up to this point in the plant, there are two parallel pulping systems (as described), each starting with a hydrapulper and finishing in a storage chest, to allow different treatment to be given to the two types of pulp used, groundwood and sulphite. The finished pulp is received from the above system into a dump chest, equipped with a level recorder. The level is measured by an air reaction system, the pressure of which is fed to a pneumatic transmitter, whence a 3–15 lb./sq. in. signal is taken to a receiver recorder in the control room and a receiver indicator on the hydrapulper operating panel.

The pulp is pumped from the storage tank to hydrafiners for further treatment. A sample of pulp is taken from the pump outlet and passed through a consistency measuring and controlling system, control being effected by

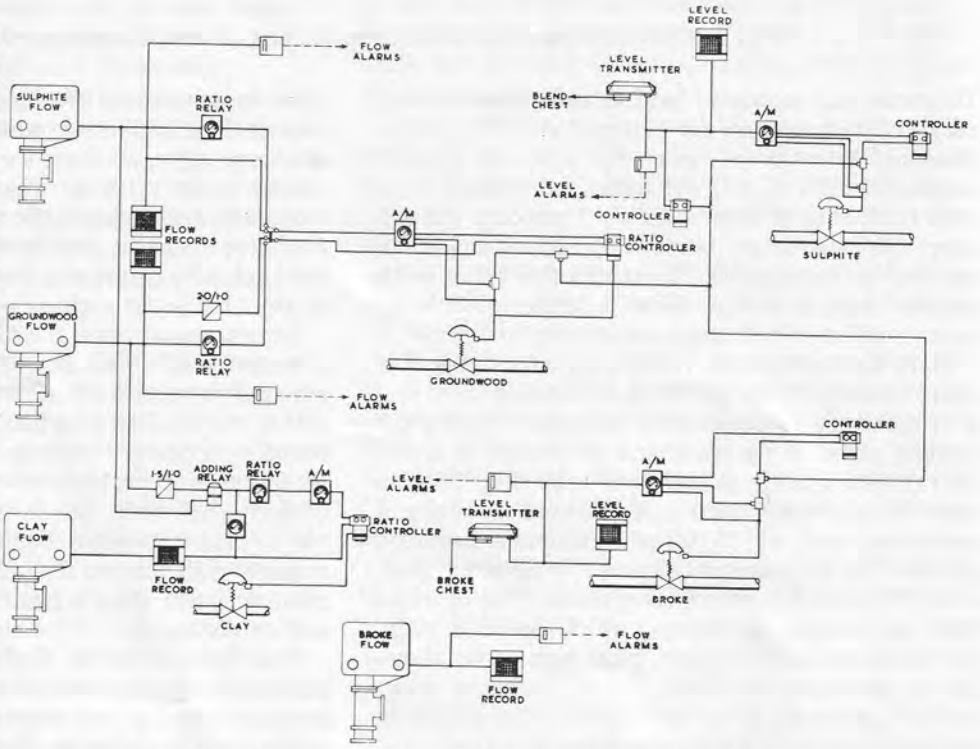


Fig. 3 — Diagrammatic layout of the stock proportioning system

paper can vary from 15 per cent. sulphite pulp and 85 per cent. groundwood to 50 per cent. sulphite and 50 per cent. groundwood. It is required to blend these two pulps in the required ratio together with dyes and further additives. At this point also, the broke from later parts of the process is reintroduced into the system. The broke-pulping system will be described later.

Since it was found necessary to accommodate a wide range of sulphite pulp to groundwood ratios, it was convenient to divide the range into a low sulphite range (newsprint) and a high sulphite range (mechanical printing), either range being selected by a switch. The stock flow in each system is controlled for consistency at each transfer pump and passed through variable area flow meters. The sulphite stock flow is governed by level control of the receiving blend chest,

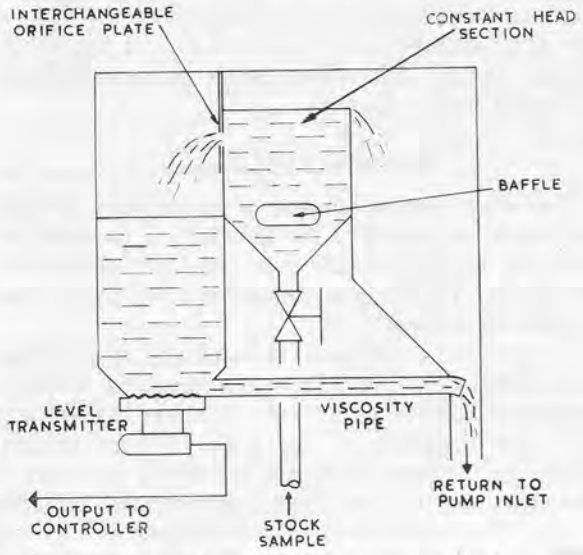


Fig. 4 — Diagrammatic cross-section of a consistency sample box

this flow in turn monitoring the groundwood flow rate to the selected proportion. A similar system measures the china clay slurry flow to the blending chest and maintains this flow in the required ratio to the total of groundwood and sulphite pulp flows, ensuring that the blended stock contains the correct proportion of china clay. Dyes are also added at this point through manually adjusted metering pumps to obtain the correct shade. Interlocks are provided to stop the flow of all components into the blend chest at high level and to give alarms at abnormally high or low flows of any component. The system is shown diagrammatically in Fig. 3.

The blended stock is then pumped to the machine chest, again receiving a consistency adjustment, the level in the machine chest being automatically controlled by a valve on the input pipe and a conventional control loop. Size is added to the machine chest by means of a manually adjusted metering pump to obtain the required paper quality.

After receiving a further consistency adjustment, the prepared stock is then pumped through Jordan refiners to the machine head box, maintained at a constant level by an overflow back to the machine chest. The Jordan refiners are equipped in an identical manner to the hydrafiners.

Consistency control

THE form of consistency measuring equipment used at Aylesford is of the viscosity pipe type, shown diagrammatically in Fig. 4.

The stock sample enters the centre chamber through a valve adjusted to maintain a steady overflow to the righthand section, resulting in a constant head of stock above the orifice plate.

Since the flow of stock through an orifice is substantially independent of viscosity over the range met in practice, a constant volume of stock passes into the lefthand section, from which it must flow along the viscosity pipe. The force required to pass this volume of stock is the head built up in the chamber and this head will vary with viscosity changes such that it is just sufficient to force along the viscosity tube a volume of stock equal to the volume metered in through the orifice.

To accommodate a wide range of furnish and consistency, the orifice plate is interchangeable, a set of five plates from 1 in. to 3 in. (in $\frac{1}{2}$ in. increments in diameter) are used together with three sizes of viscosity tube—$2\frac{1}{2}$ in., 2 in. and $1\frac{1}{2}$ in. diameter. Having established the most suitable combination of plate and tube, minor changes in consistency are made by alteration of the level at which the lefthand chamber is controlled.

It can readily be seen that variations in consistency will cause variations in the level in the lefthand chamber, the level being measured in a conventional manner such as a diaphragm type transmitter, the usual range being 0–20 in. water gauge. A pneumatic control loop is used to add more or less water to the stock to maintain the level in the measuring chamber constant and hence maintain constant consistency by correcting for any tendency to depart from the desired value.

The pneumatic controller is of the recording type with proportional and integral control action. A second record pen, range 0–20 lb./sq. in. arranged to record the controller output to the control valve, is invaluable in assessing the performance of the control system. It is particularly advantageous to have the charts printed with bold lines at 3 lb./sq. in. and 15 lb./sq. in. to show the control limits. If the controller output reaches either of these limits, it is quite clear to the process operators that the stock is too thick or too thin, enabling them to take corrective action.

Machine inlet

THE machine head box is fitted with a remotely operated plate valve (or stuff gate), which meters the flow of stock into the papermachine system, this flow being measured by a differential pressure transmitter and orifice plate and recorded in the control room. Remote operation of the stuff gate is obtained by an air impulse motor system, operated by push-buttons on the control room panel and on the control desk adjacent to the machine flow box. Dial indicators and a recorder show the stuff gate position.

The flow of stock to the flow box is also measured by means of an orifice plate and differential pressure transmitter and recorded in the control room, the flow rate being remotely adjusted by means of an air motor-operated 22 in. diameter valve. The temperature of the stock to the machine is measured and recorded together with the pressure at the flow box slice. The pressure in the flow box is maintained constant by controlling the pressure of air maintained above the stock level in the totally enclosed flow box. Remote adjustment of the slice is provided by push-button control of the air motor-driven mechanism. An interlock is provided with the machine water pump motor, arranged to close the cylinder-operated stuff gate cutoff in the event of a stoppage of the machine water pump.

A sample of stock is taken from the flow box and passed through a continuous flow electrode system to determine its pH value; automatically controlled to the desired value by a control valve regulating the quantity of alum added at the machine water pump inlet.

The vacuum in the first three flat boxes is maintained at the desired value by means of a pneumatic control system, arranged to open a vacuum valve or an air inlet valve as required. The vacuum in the other four flat boxes is regulated by self-actuated controllers.

The vacuum in each of the suction boxes and rolls is measured by means of a pneumatic transmitter, the output of which is recorded in the control room. The nip pressure at the presses is adjustable by $\pm$ 20 per cent. of that due to gravity by the application of a controlled air pressure to 16 in. diameter cylinders. These cylinders are also used for lifting the top roll when necessary by application of high pressure air to the lifting side of the piston.

The dryer section is fitted with photoelectric break detection, which, on a break, causes the cross-cutter to run to the front side, the web then being doctored off the first press. Simultaneously, the deluge pump and broke conveyors are started and a valve opened to the conveyor deluge showers. The broke is conveyed to the couch pit, whence it is pumped under level control to the broke chest.

If the pick-up vacuum is off, the deluge water is automatically diverted to the wire showers to remove the sheet directly into the couch pit. If the deluge pump should fail, fresh water is automatically delivered to the showers.

Steam and condensate

THE dryer section consists of 59 cylinders, divided into four sections of 3 low pressure, 7 intermediate pressure, 39 high pressure dryers and 10 high pressure felt dryers. The steam is supplied at 15 lb./sq. in. from a pass-out turbine.

A pneumatic pressure transmitter, proportional controller and 12 in. diaphragm-operated butterfly control valve provide pressure control of the steam at the inlet manifold of the high pressure section. Similarly, the pressure to the felt-drying cylinders is controlled by a 6 in. diaphragm-operated butterfly valve. The intermediate pressure section is supplied with flash steam from the high pressure condensate separator, together with some make-up steam through a 6 in. valve and pressure control system. The low pressure section steam is entirely flash steam from the intermediate and felt section separators. The low pressure separator is evacuated by a vacuum pump to 20 in. mercury. Level controllers and diaphragm-operated valves control the condensate level in each separator.

Steam and condensate flows to the drying cylinders, felt dryers and other auxiliaries are recorded and integrated by electrical flow meters. All dryer records and controls are grouped together in a control room at the dry end of the machine.

The pneumatic pressure controller of each dryer section is provided with a normal working pressure

desired value dial and a ratio setting dial, the latter being arranged to have an output equal to the desired fraction of the former. Solenoid-operated, three-way valves are connected to the break photoelectric system previously mentioned and arranged that the pressure controllers at a paper break are reset to control at the desired lower value, until the sheet is restored through the machine; the control then reverts automatically to the original setting.

The machine is provided with a Pope type reel, the support arms of which are operated by pneumatic cylinders, controlled from a desk adjacent to the reel; provision is made for increasing or decreasing the natural load of the reel by application of a controlled air pressure to either side of the cylinder piston.

Broke disposal

To deal with the broke made when feeding the sheet through the machine calender and reel, a continuous repulping system is provided immediately below the calender and reel drum, into which the sheet falls directly from the machine, the pulper bowl being the full width of the machine. The system is shown diagrammatically in Fig. 5.

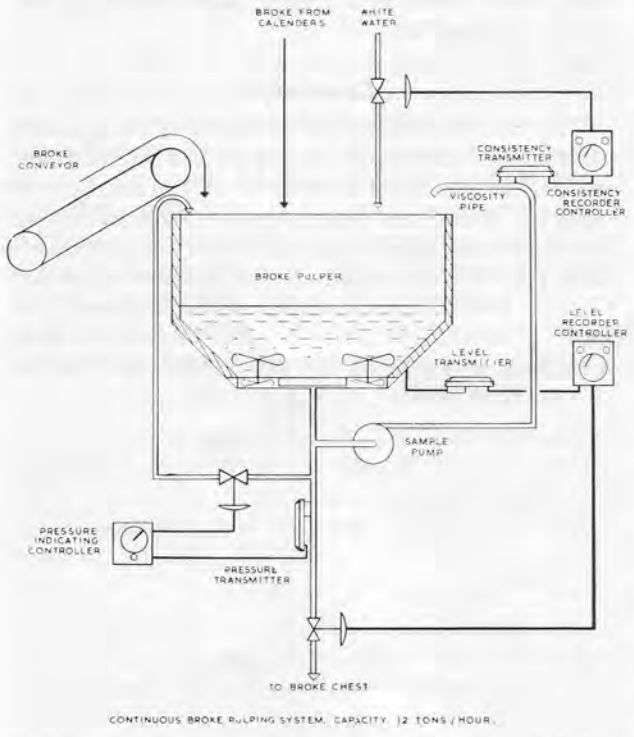


Fig. 5 — The automatic broke pulping system with a pump and viscosity pipe type consistency measurement

The pulper rotors are run continuously, with a controlled minimum level of pulp in the bowl. A continuous sample is taken through a consistency control system that automatically adds water when the consistency rises by the addition of broke; this produces in turn an increase in level, causing the level control system to allow pulp to be pumped away to the broke chest.

A belt conveyor is provided to enable the broke from supercalender and reeler to be fed into the broke pulper.

Water and effluent

THE water from the wire pit overflow is contained in the whitewater surge tank located below the machine, from which it is pumped to the measuring tanks for the hydrapulpers; to consistency control valves; to the deluge sprays; via a saveall to the clarified whitewater chest. To maintain the level in the whitewater surge tank reasonably constant, the level control system is arranged to raise or lower the saveall speed with a rise or fall in level, thus changing the demand for water. Simultaneously, a control valve closes or opens, to admit less or more clarified whitewater back into the surge tank.

The saveall is essentially a filtering device and is provided with a liquid level control system to maintain constant level in the tank by regulation of the water inflow. The throughput of the filter is adjusted by variation of the speed of rotation of the filter discs, achieved by a variable speed motor controlled from a phase-shifting induction regulator, the position of which is controlled pneumatically by the whitewater surge tank level controller.

The mill is provided with three drainage systems—clean water, clean fibre and dirty water drains—the latter flowing directly from the mill to the existing site drainage system, through a 10 in. magnetic flow meter.

The clean water drains flow to a sump (collecting the water from air compressor cooling, bearing cooling and other non-contaminating uses) and is pumped under level control back into the freshwater system at a point after the tapping for cooling water, thus returning to the system the heat extracted from heat exchangers.

The clean fibre drains receive the overflows from chests, whitewater surge tank, clarified whitewater chest and other sources of fibre-laden water. The clean fibre is pumped out under level control to the input side of the saveall and to the De Nöel decanter. The recovered stock from the decanter is pumped to the

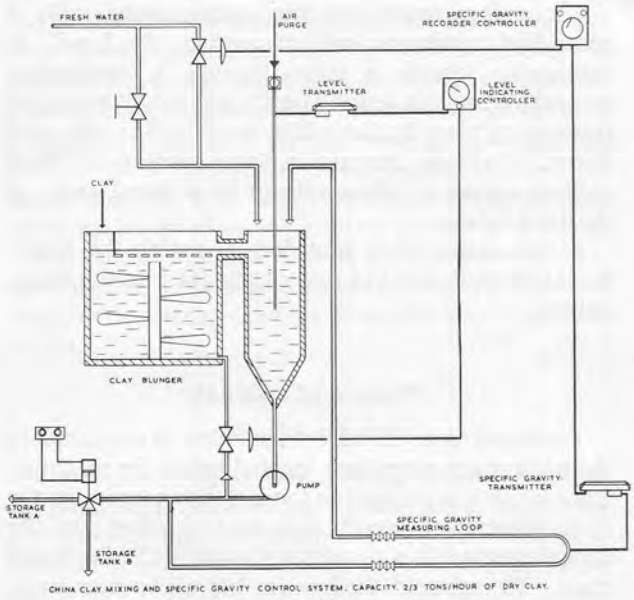


Fig. 6 — The automatic clay mixing system

broke chest, the decanted water being passed through an orifice type flow meter to the site effluent plant.

Freshwater flow to the mill is recorded and integrated, as also are the effluent flows, to enable a close check to be made on water consumption and effluent conditions.

China clay preparation

As considerable quantities of china clay are included in the paper furnish, it is convenient to add the clay by volume measurement of a slurry prepared in a central plant and distributed to the machines by pipework. It is obviously essential to ensure that specific gravity of the slurry is constant, if measurement of volume is to be used to ensure uniformity in the furnish.

It is most economic to buy the china clay in bulk and, to facilitate the preparation of a consistent slurry, the system shown in Fig. 6 has been used. The lumpy clay of 8–10 per cent. moisture content is dispersed into a slurry in a type of mixer extensively used in the pottery industry.

The clay is fed into the mixer below the gridplate that allows the slurry to flow into the take-off chamber and into the pump suction. Since the storage tanks are situated some 20 ft. above the mixing plant, the control valve shown will allow more or less slurry to circulate through the mixer as the level falls or rises and the valve quickly takes up such a position that the volume transferred to storage is equal to the volume entering the mixer.

As clay is added, the specific gravity tends to rise, sensed by the specific gravity transmitter carrying a sample of the slurry and corrected by the automatic addition of more water. This, of course, causes a level increase, which is corrected by the level controller.

It is interesting to note that this type of mixer is usually operated on a batch system and is rated at 15 cwt./hr., but it has operated satisfactorily in the continuous system at 4 tons/hr. and is in continuous use at 2–3 tons/hr.

Conclusion

THIS comprehensive instrumentation undoubtedly assisted the successful start-up of the machine and enabled it to achieve a speed of 5 per cent. over its designed maximum. The use and value of the installation was readily appreciated by the production staff and full use made of the facilities provided. Current and future instrument developments on this machine, including electronic speed, yardage and gloss measurement are being actively pursued with the full co-operation of the production staff.

discussion

MR. P. H. DIXON: Is difficulty found in training machine operators when working with a highly centralised control system? I was given the impression that some of the control mechanism shut on failure—you mentioned a stuff cock. Surely, this is an expensive way of operating, although it may be the cost of elaborate control and lack of training for machine crews to operate the machine by hand.

MR. L. A. LeBRETON: To train operatives, the crews were introduced to the scheme in the early stages. The controls in the system are used in varying forms throughout the mill and a graphic panel was introduced to simplify their interpretation.

With a machine stoppage, the stuff gate quick shut-off valve ensures that no further stock is delivered to the inlet of the machine water pump and the control valve, which is adjusted for basis weight correction, is operated from the local control panel.

MR. R. GARDNER: The only major shutdown due to instrumentation on the machine was when the machine operators thoroughly hosed out one of the control panels. In general, the failure of any instrument in the system does not shut the machine down. The interlocks are provided for mechanical or electrical failures in various parts of the system. All of the controls are supplied with manual facilities and a plug-in facility for a quick change; the operators are trained to recognise a fault and change over to manual control while the equipment is attended to.

MR. J. S. K. INSKIP: Has Mr. Gardner come across difficulties in centralised control imposed by the limitation of the manufacturers on the distance at which indicating and recording equipment is placed from the pick-up points?

MR. GARDNER: We did run into difficulty on the automatic broke pulping system, which was rather remote from the control room. It was quite easily overcome by shifting the particular controller to a point nearer to the pulper: by reducing the distances, we eliminated time lag in the control loop.

MR. N. C. UNDERWOOD: Who decides the position of the set point on the controllers of this installation?

MR. LeBRETON: In each of the machine shift crews, one panel operator, aware of the machine's requirements, makes adjustments under the guidance of the machine foreman. The actual operation of those set points is wholly the papermaker's responsibility.

MR. GARDNER: I must add one correction—we no longer have a panel operator: it was found that the machine crew could attend to all that was required, without wrecking the controls. Any adjustments of instruments and control action settings are done by an instrument mechanic.

MR. G. F. UNDERHAY: How do you calibrate the 10 in. magnetic flow meter in operation for measuring the effluent discharge?—and what accuracy is achieved? Furthermore, as I understand the operation depends on maintaining full bore conditions all the time, is there any problem in the sedimentation of solid particles in the effluent under these circumstances? Finally, is the quantity of stock in the effluent also measured automatically to give the total stock losses?

MR. GARDNER: The calibration of a 10 in. magnetic flow meter is entirely in the province of the manufacturers. We satisfied ourselves with a smaller meter that the paper stock was, in fact, being accurately measured: the 10 in. effluent meter we have had to take on the manufacturer's calibration.

We took out a venturi type meter from the effluent system and substituted the magnetic flow meter to eliminate trouble from blockages. It must have a full bore (by putting it in a depression in the pipe run) to ensure that the magnetic flow meter is always full. We are interested in automatic measurement of the effluent consistency, but we have not found any accurate means of measuring it.

MR. F. W. HAYWARD: In his paper Mr. LeBreton quoted a figure of 85 per cent. utilisation of the instruments installed on No. 13 machine at Aylesford. What are the reasons for not using the remaining 15 per cent. ?

MR. GARDNER: I think it is true to say that the instrumentation was used 100 per cent.; 15 per cent. represents the *plant* that was not used. Parts of the stock preparation plant were designed on a basis that proved to be a little unsound and, in fact, some of the plant is not used for the production of paper; we found it a very useful pilot plant for testing instruments. I reckon that all the instruments supplied at the original commissioning of the machine are in use and we have probably added 10–15 per cent. after start-up—things nct foreseen or not thought sufficiently important at the time.

MR. K. C. WEEDY: How does this magnetic flow meter work?

MR. UNDERWOOD: The principle of the magnetic flow meter is that of a conductor cutting lines of force and so generating an e.m.f. of a few millivolts, which is measured without drawing any current and so, provided the conductivity exceeds a certain limiting value, the flow measurement does not depend upon it. All aqueous liquids that one meets in papermills come into this category and the result is independent of pH value.

MR. G. R. HYDE: One slide showed what looked to be a variable area flow meter in use on stock—could Mr. Gardner comment on its suitability for stock flow measurement and state the consistency involved?

Secondly, would he elaborate on the experience gained with the stock proportioning system on fully automatic control?

MR. GARDNER: The stock proportioning system was designed to make use of variable area flow meters—the only type available at the time the machine was designed. Magnetic flow meters had been heard of, but not seen. The variable area flow meter works very successfully on papermaking pulp and, in this particular case, it takes 4 per cent. stock quite comfortably. It does object to occasional bale wire and the like.

The unused part of this plant was employed as a testing ground for meters; one of these experiments was for calibrating the two types of meter in series using a volumetric measuring system. The accuracies obtained were quite within the 2 per cent. commercial limits required.

The fundamental design error in the proportioning system was that to pulp groundwood and sulphite separately and to soak them for a considerable time does not reproduce slush stock conditions—the stock degenerates quite badly. The stock proportioning system worked well initially, but normal stock chest agitation could not completely blend a ratio of 15/85 per cent. of the two pulps. We reverted therefore to blending on the conveyor belt into the hydrapulper, leaving some spare chests and capacities in the system.

The proportioning system is still used to blend the required furnish from clay, broke and mixed furnish. We do not blend groundwood/sulphite pulps in a blend chest and we may revert to blending separately within the next twelve months. The machine speed will be increased beyond its present design limit and, owing to capacities in the system, we may have to use separate stock preparation, but dispense with soaking time.

MR. L. BAILEY: Could Mr. Gardner and Mr. LeBreton give any idea of the capital costs involved in such an elaborate scheme with a central control room? Secondly, how are the savings in labour offset by the additional maintenance (or preventive maintenance) involved and how many instrument mechanics are required to keep this system operating satisfactorily?

MR. LeBRETON: The capital cost of the instrument installation on machine No. 13 ran at approximately 3 per cent. of the total capital cost, which included the machine and its auxiliaries.

It is rather difficult to assess the advantages of reduction in manual labour, because this is the first machine of its type that we have. We estimate that the day-to-day labour is reduced by one man per shift—not very much, but the advantages of automation are not wholly centred round the reduction of labour, rather in the reduction of human drudgery and we have gone a long way in this respect.

MR. GARDNER: This machine took us 5 hr. running time from start-up to produce a saleable sheet, which we attribute to control over the stock preparation and the machine.

We have a fairly sizeable instrument department for the whole of the mill, but I estimate one instrument mechanic occupied almost full time on No. 3 mill, No. 13 machine and its auxiliaries, that includes chart changing, inking of pens and general routine maintenance, without attending to breakdowns or suspected breakdowns.

MR. HAYWARD: The advantages of instrumentation were discovered in successive stages over a long period and analysis of the production figures showed that the machines were running more efficiently, reducing running costs as well as human drudgery. I suggest that this should be the approach, particularly in a mill with little or no instrumentation. The first step could well be the installation of a consistency controller or level recorder. In this way, the apparently high capital cost of complete instrumentation will not obscure its advantages.

THE CHAIRMAN: When you want complete uniformity of products then instrumentation becomes essential. That is one aspect of it I would strongly advise you to keep very much in front of you so far as propaganda is concerned.

MR. G. THOMPSON: How far are the authors in a position to say as a result of some two years' experience with this machine what their forward thinking now is and how far they would modify the instrumentation on a new machine?

MR. GARDNER: We would probably reduce some of the instrumentation to completely blind systems to eliminate some of the space requirements of the equipment. We are developing further equipment to incorporate in a new machine—moisture measurement, gloss measurement, substance possibly at lower consistency ranges. I think a machine today would be very similar to No. 13, possibly reduced in presentation and increased a little in scope. The machine has been running for only two years, not long in which to make a great deal of improvement or extension of the techniques used.

MR. A. G. ELLIS: In view of the experience gained with No. 13 machine, have any factors shown up that, in a similar project, would affect the design of the papermachine itself rather than the instrumentation?

MR. GARDNER: In view of the interferences that we found on examining records for interactions, we would probably modify such things as the water extraction system from the machine, the whitewater filtration plant, which we found influenced machine operation to an unexpected extent. Secondly, we would redesign the machine with smaller capacities to minimise both the storage in the system and the time to effect changes on the machine. We would probably modify some of the stock preparation plant to get away from batch hydrapulping to a continuous sytem.

MR. WHITELEY: With the continuous repulping of the broke, what arrangements are made for the continuous consistent supply of repulped broke back into the system?

MR. GARDNER: The broke is very intermittent and the system was designed to take intermittent and random quantities of broke. The pulping arrangement runs continuously and is self-regulating: it will consume 110 per cent. of the machine output, taking the complete sheet from the machine at the dry end plus 10 per cent. for odds and ends fed back just at the wrong time.

If there is no broke, in fact, the consistency will arrive at its controlled value, the water will turn off and the pulper will continue to freewheel with a small quantity in the bottom. As fresh broke comes forward, the consistency tends to rise, it calls for water, the level tends to rise and the level control then disposes of the liquid broke into the broke chest. The broke consistency record does not give the straight line of a normal control function, but it is dealing with a random input and, as long as it controls levels at the right value, that is as much as you can do about it. Slight variations, of course, average out in the broke chest.

MR. W. A. BANKS: Firstly, is the output of the broke pulper 1.1 times the output of the hydrapulper feeding the system? Secondly, is the wet broke transferred back into the main pulper feeding system in the same way as the dry broke or is the dry broke slushed in the pulper treated separately from the wet broke?

MR. GARDNER: The output of this broke pulper is, in fact, 1.1 times the stock preparation output, but over about $\frac{1}{2}$ hr. Obviously, we cannot produce that quantity continuously and the effort required to repulp broke straight off the machine is considerably less than breaking up fresh pulp. The output from the broke pulper is taken conveniently to the couch pit; it is a halfway house on the machine, the broke pulper discharging its output into the couch pit, where it picks up any of the wet end broke, so that the wet end broke is blended with the dry broke. From the couch pit, it is pumped under level control into the broke chest and blended back into the system as a function of the fresh pulp being fed into the system.

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Instruments for automation

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ON 23rd MARCH 1960, Mr. W. A. GILMOUR IN THE CHAIR

Synopsis

The present position regarding instruments suitable for automatic control of the papermaking process is discussed. Particular emphasis is placed upon the importance of robust measuring elements, which will produce repeatable results. Pneumatic and electric transmission systems play an important part in the trend towards centralised control and the standardisation of instrument types. The importance of the pneumatic force-balance receiver controller is explained and the increasing use of electronic controllers is predicted. Regulating units, safety and alarm systems complete the requirements for fully automatic control as a prelude to full automation. Typical illustrative examples are stock proportioning and moisture control systems now in continuous operation.

Introduction

A CHAIN is no stronger than its weakest link. For automation to be possible, a wide range of reliable instruments must be available. The papermaking process and the methods by which its stages are interlinked must be thoroughly studied, taking into account interaction between stages and the performance of the equipment used. Finally, an automatic system must be designed to operate for the required period of time, producing paper economically, by eliminating the effect of variables that can affect quality, whether these variables are inherent in the raw materials and their treatment or externally impressed due to ambient changes such as power supply variations, mill temperature and humidity.

Modern instruments have the standard of reliability required for the full automation of the papermaking process and the thinking of those concerned with automation has progressed deeply into an understanding of the process with a view to applying automation. The final stage has yet to be realised.

Types of instrument

A CATALOGUE of available equipment would be uninteresting and out of place in this paper. It is sufficient to draw attention to the main groupings and then to concentrate upon significant details in so far as they affect the subject. These groupings are—

1. Measurement and transmission units.
2. Recording, indicating and controlling units.
3. Regulating units.
4. Safety and alarm units.

The signal transmission and control media may be mechanical, pneumatic, electrical or hydraulic.

1. Measurement and transmission units

The major part of any control problem in a papermill is usually the method by which variations in the controlled condition can be measured. The measuring system must be robust. Even the automatic mill will require maintenance work and accidental damage to the measuring system during a shutdown could seriously delay the start-up or lead to a subsequent fault. The measuring system must be repeatable within a close tolerance, with no measurable hysteresis and with a long-term stability of zero point, range and linearity of calibration. The *absolute* accuracy may or may not be important compared with the repeatability, because the numbers associated with the measurement in many cases have no intrinsic value to the operator. For example, the value 270°F for dryer temperature control has no real meaning, but the results obtained when the instrument pointer indicates 270 must be identical from day to day. On the other hand, the pH value of paper stock must be known accurately. The essential difference is that, in the first instance, the required result—the moisture content in the paper—is inferred from the measurement made, whereas the measurement in the second case is, in fact, the required result. Most measurements are inferential—for example, flow through an orifice plate (pressure difference), level (pressure), temperature (vapour pressure), liquid expansion, e.m.f. or resistance, load (pneumatic pressure or electrical strain), consistency (apparent viscosity).

Many instruments function using a direct mechanical linkage between the movement of the measuring

element, say, a thermal system and the controller mechanism. Additionally, the element positions a pointer on a scale or a recording pen on a chart. These instruments are widely employed in many control schemes. For full automation, all measurements should be converted into a common signal. It so happens that the need for centralised control panels in the petroleum and chemical industries and the distances involved between plant and panel have resulted in the production of a wide range of pneumatic transmitters having a common signal of 3–15 lb./sq. in. for 0–100 per cent. change of the measured value. Earlier designs, shown schematically in Fig. 1A, use the principle of *motion-balance*.

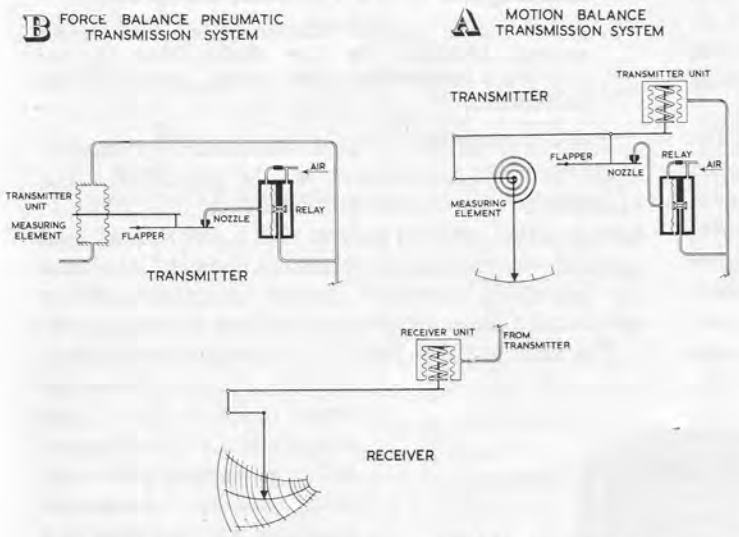


Fig. 1—Diagram of pneumatic transmission systems

Movement of the measuring element unbalances a flapper-nozzle detector system, which trips an amplifying air relay to provide the transmission signal and simultaneously restores the flapper to a balance position relative to the nozzle. A change in measurement over the range of 0–100 per cent. causes a total flapper movement towards the nozzle of the order of 0.005 in. The relay will travel through its full stroke representing 3–15 lb./sq. in. output pressure change for a nozzle pressure change of less than 0.5 lb./sq. in. The system is inherently stable in spite of supply pressure fluctuations. A recent development is the *force-balance* design, whereby the proportional feedback pressure is applied in opposition to the measurement force (Fig. 1B) just as one adds weights to a balance to restore equilibrium. The elimination of mechanical linkages between measuring element and feedback reduces hysteresis and lost motion and the construction is more robust. A typical example of a modern force-balance transmitter is the differential pressure cell, which may be used for measuring differential across an orifice plate or venturi, liquid level in open or closed vessels and low pressure measurement within the range 0–15 in. water gauge to 0–30 lb./sq. in. The output signal is an air pressure range of 3–15 lb./sq. in.

Fig. 2 illustrates a development of the differential pressure transmitter for stock chest or head box level measurement. The sensing diaphragm, constructed from 0.006 in. stainless steel, is fully exposed using a 3 in. diameter mounting flange, providing direct

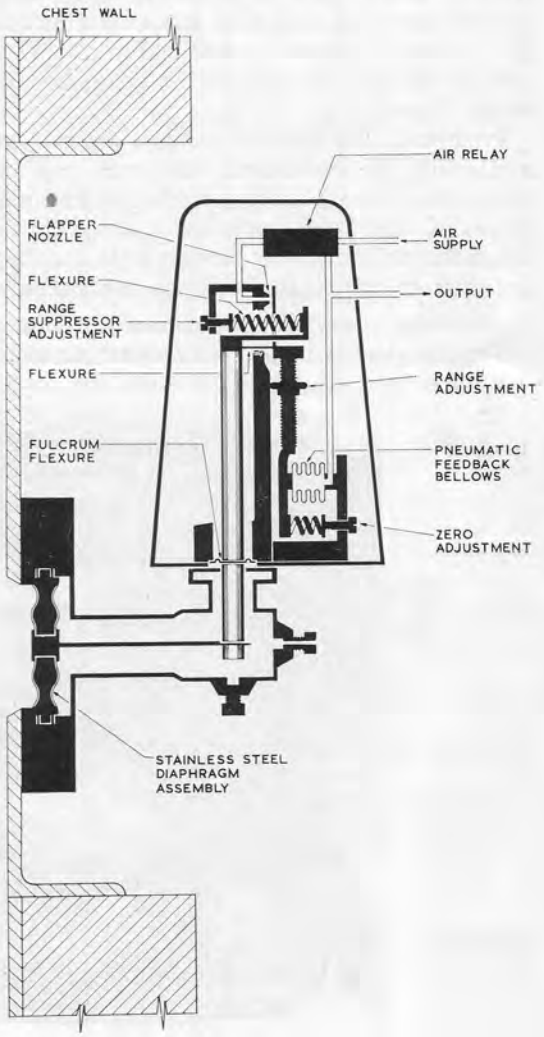


Fig. 2—Stock chest force-balance level transmitter

contact with the stock with no danger of blockages or mechanical damage. The design of the pneumatic force-balance mechanism, which is fully protected by means of a heavy cover, ensures complete stability of zero and range. The instrument has been thoroughly proven by long periods of continuous and fault-free operation in papermills.

Corresponding motion-balance and force-balance transmission systems are available using electronic circuits and electrical transmission signals, but no degree of signal standardisation equivalent to pneumatic transmission is available at present. Work in this field has now been initiated.

Distinction must be drawn between physical measurements (such as pressure, level, flow and temperature) and analytical measurements (such as pH, substance, formation and moisture). The latter tend to be made by instruments giving an electrical output signal.

Progress in full automation must depend upon the availability of instruments that will measure the properties in which the papermaker is interested as a means of setting the controllers that govern the performance of the machine—for example, furnish, gloss, thickness, colour and surface finish, to name only a few.

2. Recording, indicating and controlling units

The most widely used type of control instrument in a papermill at the present time is the motion-balance, pneumatic recorder controller. Instruments of this type have been used throughout industry generally for the past 40 years, with constant and consistent improvements in design. Fig. 3 shows a typical instrument with the chart support plate removed to expose the mechanism. The following operator facilities are provided—

1. Set point or index value adjustment.
2. Record of the controlled variable, usually on a 24 hr. circular chart.
3. Indication of controller supply air pressure.
4. Indication of controller output signal air pressure. Frequently, this value is recorded using a second recording pen, as in a consistency controller.
5. Automatic to manual transfer switch and remote manual regulator for use during start-up, for emergency operation and when servicing the instrument.

These instruments have a standard of reliability equal to any requirement in the papermill. For example, in petrochemical processing, it is usual to have production runs lasting 12–15 months, without a shutdown and highly explosive chemical reactions are frequently concerned, when calibration drift or accidental failure would have serious consequences.

The basic control function is proportional action, whereby changes in output signal (3–15 lb./sq. in.) are proportional to the deviation between measurement and index values. Additional functions are derivative and integral actions, whereby variation in output is proportional to rate of change of deviation or to the time integral of the deviation, respectively. These controller actions have been adequately described in the literature.[1–3] Integral action is added to proportional action to ensure that a constant control point is maintained, in spite of varying process load and supply changes, whereas derivative action increases the speed of recovery after an upset from equilibrium conditions. It is also necessary to recall

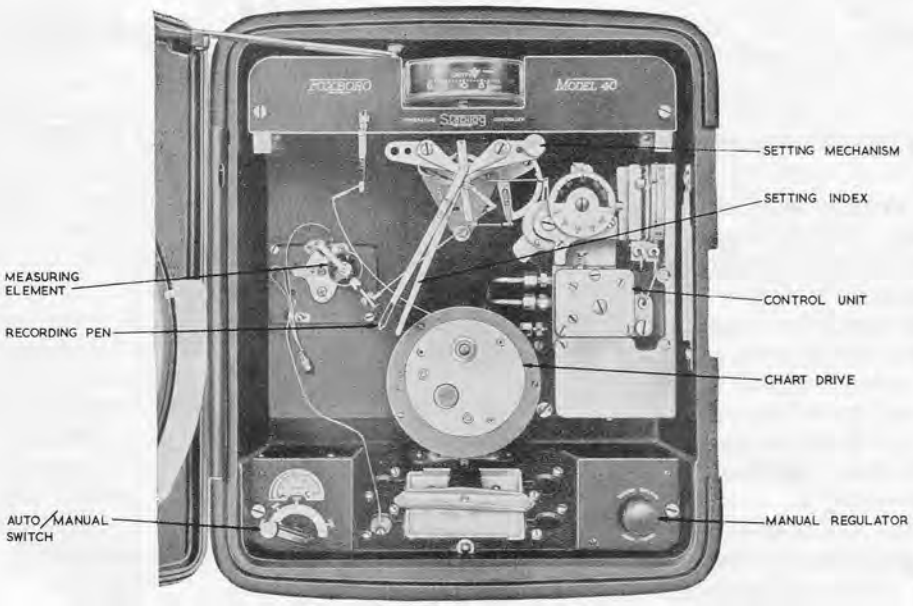


Fig. 3—Motion-balance recorder controller with chart support plate removed

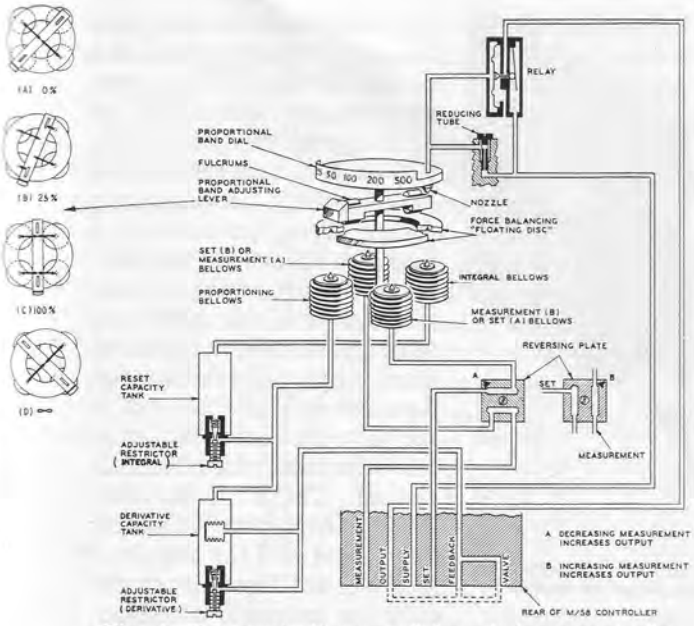


Fig. 4—Schematic diagram of force-balance controller

that the equilibrium attained is *dynamic* and, in the ideal state, resembles a sharpened pencil balanced upon its point. A human operator must wait to analyse a trend in a measured value, but the controller mechanism detects the smallest deviation and produces the required change in output signal. On the other hand, a human operator, using stored intelligence, frequently can anticipate a required course of action, but a simple controller cannot anticipate: herein lies the strength and the weakness of a modern controller. A large scale upset may find a simple controller continuing to function under circumstances that would cause an alert operator to shut down. Furthermore, the use of fixed, but manually adjustable controller settings (proportional band, integral and derivative action times), requires the empirical determination of optimum values by use of reasonable skill and under conditions of average operation. When the process is running well, full advantage cannot be taken of the more favourable conditions, unless manual changes are made to the controller settings. These are not great drawbacks, as many can testify, but it is important to understand the limitations of the equipment used in order to design for better performance. An important improvement has been the introduction of force-balance controller designs, using 3–15 lb./sq. in. air signals and having no direct connection with the measurement system, with the consequent possibility for entirely separate recording and controlling functions. A well-designed controller is superior in performance to that of the earlier motion-balance designs for the reasons given above in connection with pneumatic transmitters.

Fig. 4 is a schematic diagram of a modern force-balance pneumatic controller, illustrated in Fig. 5. The four bellows support a moving ring, which forms the flapper detector unit for the nozzle and amplifying relay system. Stepless adjustment of proportional band is possible over the range of zero to infinity, which considerably enhances the flexibility of application of the instrument.

A coincidental change in design has been the reduction in size and appearance of the information presented to the operator, with the exception of the recording chart width, which remains at 4 in. effective (the operating width of a 12 in. circular chart). A typical design is shown in Fig. 6, which illustrates the recorder with the controller mounted at the rear to form an assembly that can be removed completely from the front of the panel. All operating adjustments are fully accessible to the operator and, in case of failure, a replacement unit, with all adjustments preset, may be installed in a very short time. The standardisation of components permits the holding of stock replacements for such an emergency. Electronic controllers with their associated transmission equipment offer an alternative approach to pneumatics, often at higher cost. Their standard of reliability needs to be established in papermills, also the handling of maintenance and the training of instrument

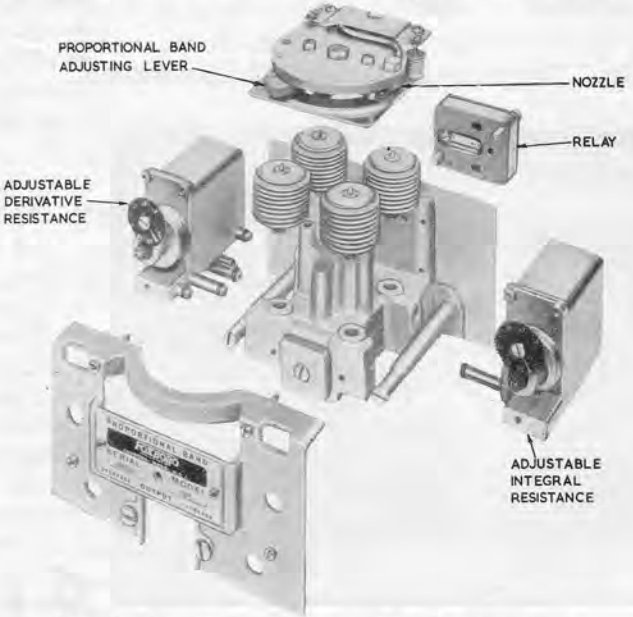


Fig. 5—Construction of force-balance controller

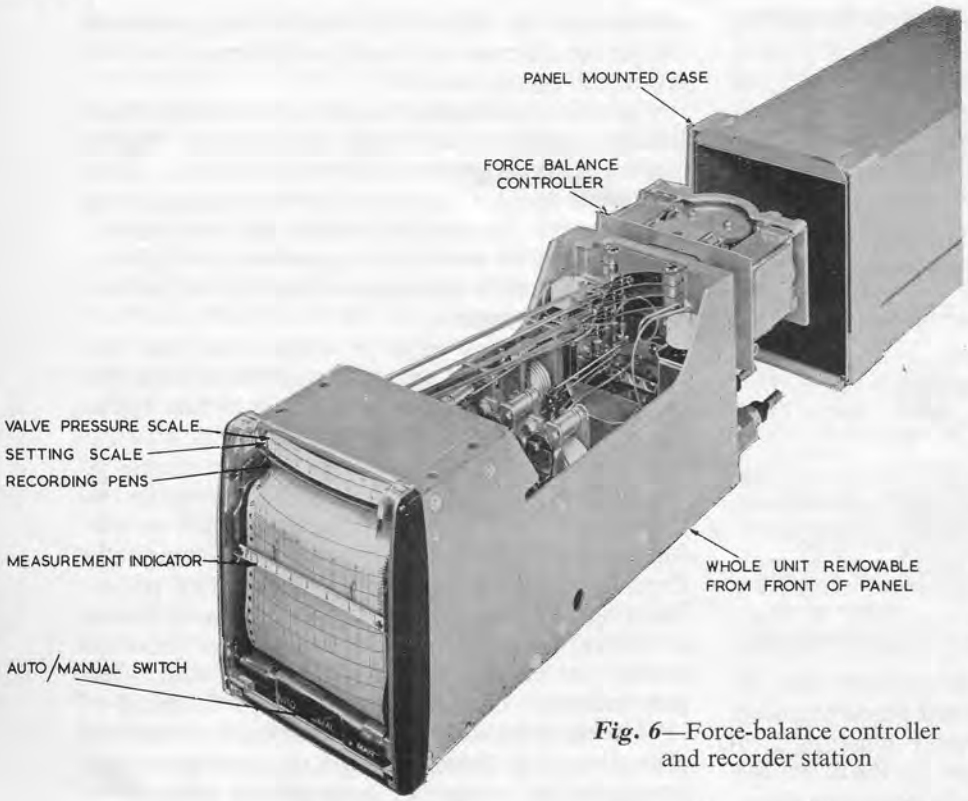


Fig. 6—Force-balance controller and recorder station

mechanics. The use of transistors and magnetic amplifiers to replace vacuum tubes has created a turning point in the application of electronics for control.

A recent design of this type is shown in Fig. 7. The functions accessible to the operator are completely separate from the recorder, thus permitting a flexible arrangement for panel mounting and the use of indicating and controlling only with alternate arrangements for data logging. An interesting feature is the provision of a deviation indicator at the top of the controller, using an amplified scale of the index value setting dial. All auto/manual transfer operations relate to this deviation indicator and not to the valve position indicator as has been usual with pneumatic designs. The controller electronic circuit uses transistors throughout and the associated measurement transmission circuits use magnetic amplifiers. As manufacturers and uses become more skilled in application techniques, new system designs will emerge and the move towards electronics should increase in momentum, eventually to stabilise as the relative merits of pneumatic and electronic systems are judged objectively.[4] There are several interesting possibilities, particularly in the field of optimum controller settings. It should be possible to design a system that is self-optimising and will take advantage of available conditions to stiffen the control loop, relaxing only as conditions deteriorate. This would lead to an improved quality of control with increased yield and quality of product.

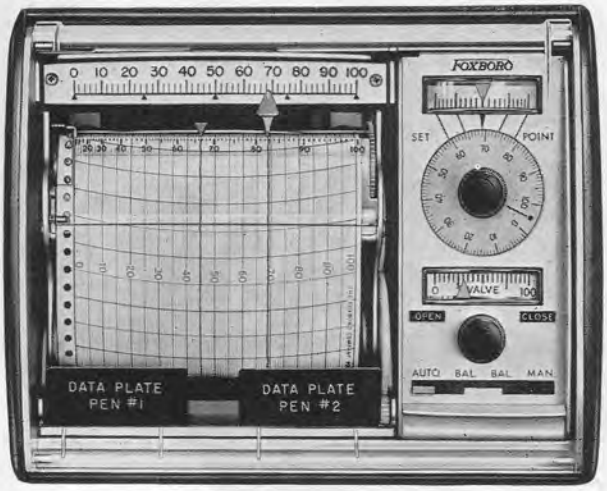


Fig. 7—Electronic recorder and controller

3. *Regulating units*

This term includes such units as control valves, variable speed motors, sluice gates and vibrating feeders. A wide range of suitable units to meet the needs of the paper industry has been produced by co-operation between suppliers and users. Stock flows, clay and titanium oxide suspensions in water at 40 per cent., rosin size and pigment suspension are typical materials that can be controlled. For stock flows, diaphragm valves, V-notch slide valves, rotating plug valves, pinch valves and butterfly valves are in regular use. A wide range of reliable and robust pneumatic operators is available. Up to 3 in. or 4 in. diameter, it is normal to use a spring-opposed, air diaphragm motor. An accurate positioner is essential to ensure precise coincidence between the controller signal and the stem position of the valve. This provides an additional servomechanism with

large force available at the point of application, so that the effects of hysteresis, stem friction, out-of-balance forces and high starting load may be overcome. Larger sizes require air cylinder operators, with an appropriate positioner. There is much work to be done in the field of electrical operators, which are cumbersome and expensive, with performance characteristics that do not match those of pneumatic equipment.

A fluid coupling may be fitted with a pneumatically positioned control arm and used for applications in which high power losses due to large throttle valves would be a consideration and for which it would be expensive to provide a suitable valve. A typical example is the use of a fluid drive unit to vary the throughput of a high capacity bleached pulp pump. Similarly, there are several widely variable gear drives and hydraulic pumping units that are now converted for use with 3–15 lb./sq. in. pneumatic signals.

4. Safety and alarm units

A well-designed system should anticipate possible failures and their consequences, in addition to the effect upon the control system of such routine events as paper breaks. On the other hand, it is important not to attach undue emphasis to the need for the ultimate in interlock, since additions are costly and themselves constitute a possible additional hazard. It is the old tale of a man to watch a man to watch a man . . .! When such features are introduced, a high degree of reliability is necessary. A scheme designed for continuous operation may be suspended or diverted during emergency conditions and restored to normal working conditions when the emergency has passed. It is practicable to design for automatic start-up and shutdown.

Applications

By way of illustration, two fully automatic control systems will be described. They have been in continuous operation for more than a year with no major hiatus in production attributable to the instrumentation. Considerable savings have occurred both in capital investment and production costs. The operators enjoy the flexibility offered and are fully co-operative in making the few adjustments necessary and intelligent use of the information presented.

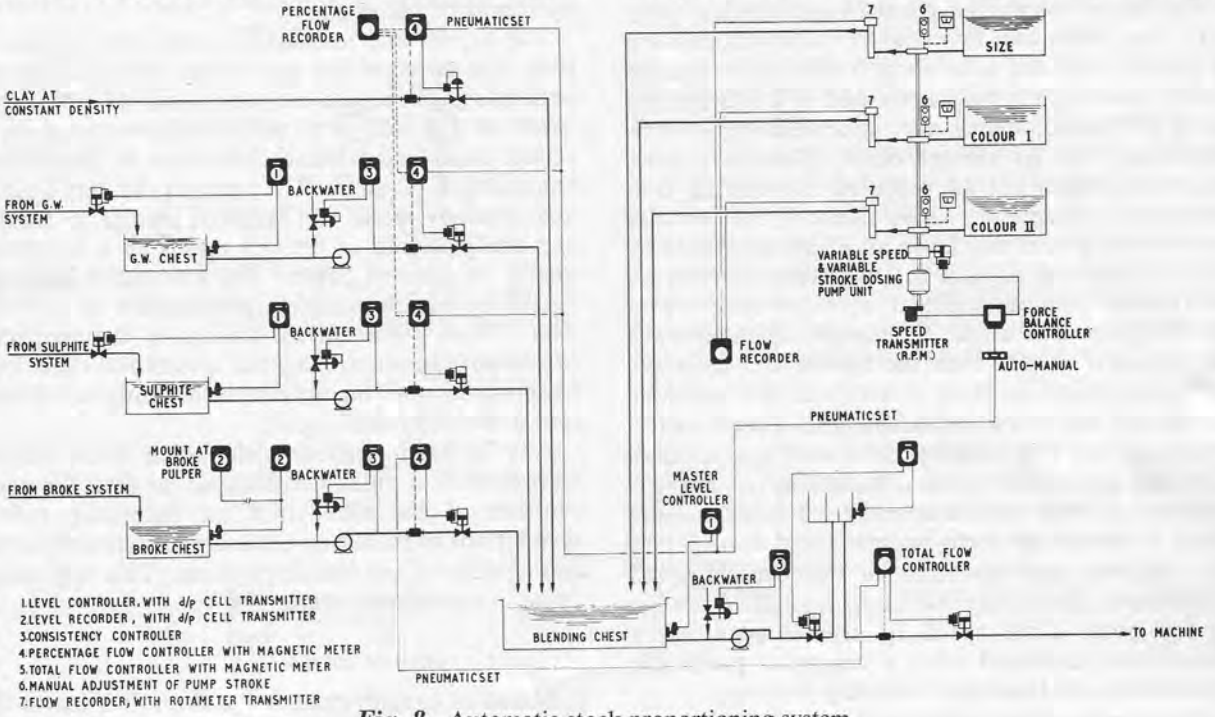


Fig. 8—Automatic stock proportioning system

Automatic stock proportioning

Fig. 8 illustrates a comprehensive automatic control system, at the heart of which are magnetic meters. This instrument has been fully described elsewhere[5] and is an outstanding development in the field of papermill instrumentation. Stock at the range of consistencies normally used may be metered with an

error of less than 1 per cent., full scale value, without offering any impedance to flow and with no nooks and crannies where stock can stagnate. Magnetic meters were first applied for stock blending in this country on the No. 6 papermachine at Dartford. The illustration shows the system installed on the München Dachauer No. 8 machine for magazine papers at a maximum rate of 240 tons/day. This system was designed with full co-operation of mill management, machine designers and instrument manufacturers and is believed to be in Europe the most comprehensive automatic system to be installed and to operate continuously.

The furnish comprises groundwood, sulphite pulp, clay, size, alum and two colours. The groundwood is a slush pulp and is level-controlled into a storage chest. The sulphite pulp is slushed in a hydrapulper using automatic control and, after refining, is level-controlled into its storage chest. The clay, alum, size and colours are all prepared at constant concentration. Magnetic meters measure the groundwood, sulphite and clay flows, which are controlled by proportional and integral action pneumatic recorder controllers, with air cylinder operated slide valves for the pulps and an air diaphragm operated valve for the clay. At the time the system was designed, sufficiently small magnetic meters were not available for the size and colour flows, therefore a triple metering pump unit with common drive shaft was selected. This has a hysteresis and non-linearity of approximately 3 per cent. deviation, so the system is linearised using a pneumatic force-balance speed transmitter, force-balance controller and air cylinder for speed adjustment. Each component flow is adjusted relative to the pump drive speed by remote push-button control and measured using a rotameter pneumatic transmitter and three-pen recording receiver.

The blending chest is fitted with a diaphragm force-balance pneumatic transmitter and proportional and integral pneumatic controller, the output signal of which operates the setting indexes of the groundwood, sulphite and clay flow controllers and the pump speed controller. Each flow controller has a special design of pneumatic setting index adjustment, whereby movement of the index is linearly proportional to the applied 3–15 lb./sq. in. signal from the blending chest level controller. The required percentage of component is set by manual adjustment of a 2 in. diameter dial in the instrument case door. Any required furnish can be set by simple adjustment of the three, flow percentage dials to the required numbers shown on the recipe card and push-button operation of the metering pump setting to give the required readings on the stroke indicators. As a check, the three magnetic meter flows are totalised electrically and a multipoint recorder registers each flow as a percentage of the total.

The total flow of stock is measured and controlled by a magnetic meter system and a pneumatic transmitter in the flow controller sets the pneumatic index percentage adjustment of the broke magnetic meter flow controller. This ensures that adjustments made to the broke percentage do not affect the proportioning system adjustments and that the broke addition is related directly to the total stock flow. Alum solution is added to the diluted stock circulating pump suction by means of pH control.

The capital and installation costs were no greater than the costs of an equivalent mechanical proportioning system. On the positive side of the balance sheet, all the data are continuously recorded on a central panel from which each flow can be individually controlled, if required. The operator can very quickly and precisely make any required change in furnish and the precision of control results in a consistent quality of finished paper. The keynote is increased flexibility, with a complete presentation of essential data. There are incidental savings by the simplicity of equipment such as magnetic meters and chest level transmitters and the total system being condensed into a relatively small space.

Any further increase in automation would require equipment that could continuously analyse the composition of the sheet plus an automatic colour comparator to make any necessary adjustments to the setting dials of the blending system. This step seems to be in the remote future.

Automatic moisture control

Moisture measurement in the sheet as it leaves the dryers is now possible, using an electrical capacity system.[6,7] This uses the dry sheet as a dielectric and, because of suitable design, the measuring head is placed on the top side of the sheet only. Several hundreds of these systems are in operation to control the drying steam so as to maintain the required moisture content to within $\pm \frac{1}{2}$ per cent.

The electrical signal is amplified electronically and operates a pneumatic proportional and integral controller. Owing to the complexity of the thermal lag between drying steam and moisture in the sheet, it is necessary to control the drying steam pressure, using a proportional or proportional and integral controller and to adjust the setting index of this controller automatically by means of the output signal from the

moisture controller (Fig. 9A). Not only does this cascade system eliminate all variations from steam supply pressure changes, but the quality of control also is improved.[8] At a paper break, the cascade action can be isolated to give steam pressure control and the system can distinguish between a dry-end (new reel or capacity head lifted for cleaning) and a wet-end break.[9] For this purpose, dryer photocell switches are used to lower automatically the setting index of the pressure controller to a value that gives sufficient steam to maintain the temperature of the dryers and felts, without overheating (Fig. 9B).

This high degree of automation gives a direct reading moisture scale in the region of ± 2 per cent. of the controlled value, which is adjustable on a calibrated scale, to compensate for specific, major weight changes. Weight changes within ± 5 per cent., barely affect the accuracy of calibration.

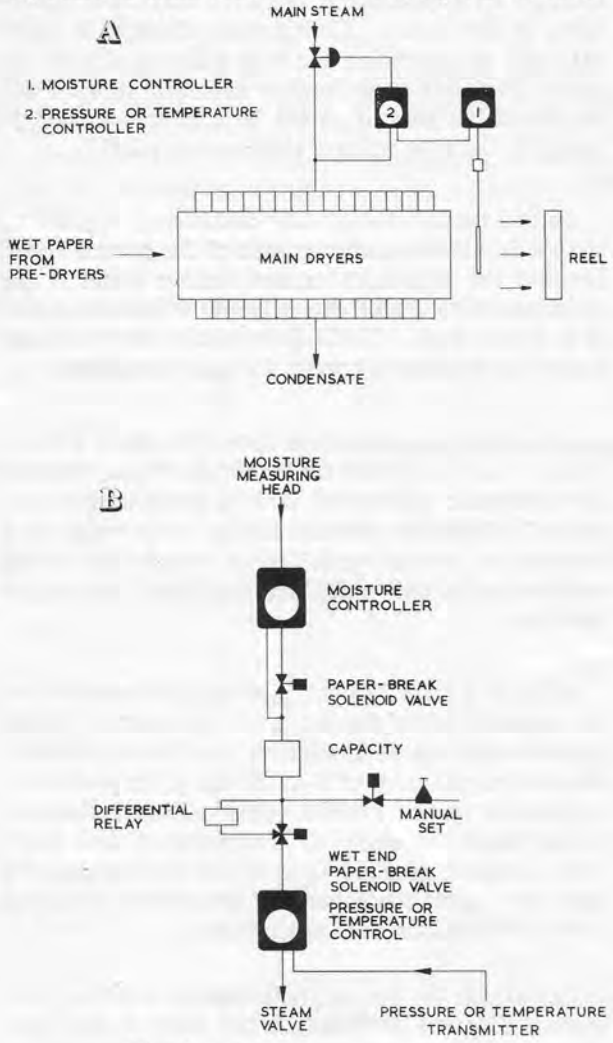


Fig. 9—Moisture control system:
A—Schematic diagram
B—Detail of paper break system

Conclusion

THERE is available a wide range of instruments suitable for the control of various operations in a papermill. Some of these instruments have been designed with the needs of the mill well in mind. The standard of reliability is high and is equal to or better than that of the majority of equipment used in the mill. Designs are flexible, permitting a high degree of interchangeability, local or central panel mounting and indicating or recording of measurements. Whenever required, these instruments have been integrated into schemes leading to the continuous and automatic operation of large sections of the mill, particularly stock preparation drying and broke disposal. Future developments will depend to a certain extent upon the introduction of analytical instruments that can measure the required paper properties on the machine and provide signals for the further adjustment of localised control loops. With this purpose in view, it is likely that there will be an increase in the use of electronic instrumentation in the papermill.

Acknowledgements

Thanks are due to Mr. L. S. Yoxall for permission to publish this paper, also to München Dachauer Papierfabriken, Heinrich Nicolaus G.m.b.H. for permission to publish details of their No. 8 machine stock proportioning system.

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discussion

MR. G. THOMPSON: I am very interested in the application of automation to the blending of a machine furnish and the ability to cut down on the capacity of stock chests as a result, as it has been usually understood in the past that capacity is a means of levelling out variations.

MR. B. W. BALLS: Thirty or forty years ago in the oil industry, it was normal to have large capacities to smooth out fluctuations. As confidence in automatic control increased, processes were designed to use it to advantage. In the modern refinery, crude oil enters at one end and the products leave at various stages with practically no intermediate storage capacities, apart from surge capacities to control pump suction heads.

There is no reason that a similar trend should not occur as the paper industry gains more confidence in automatic control equipment. There would be large savings in capital costs. A moisture control system, for example, costs approximately £2 500, installed. This money is saved easily within the first year of operation: the rest is profit to pay for more improved efficiency. Full use of instrumentation in new designs results in considerable space (therefore capital) savings, since floor space is costly. Dartford No. 6 machine is a splendid example.

MR. THOMPSON: Does the very high viscosity of the stocks we are dealing with (around 3 per cent. consistency) introduce difficulties in mixing after blending? Presumably, the points made about the oil industry refer to oils of a much lower viscosity.

MR. BALLS: Considerable care was taken in estimating a reasonable blending chest capacity, also in designing the agitator system. The mill quoted in my paper makes high-grade paper and is very satisfied with the results obtained.

MR. B. W. MATHEWS: Do you have any information about magnetic flow meters being used for automatic weight control in conjunction with (*a*) consistency controllers, (*b*) beta-gauges?

MR. BALLS: The problem of combining the magnetic meter with a consistency controller arises from the non-linear consistency scale, also that consistency measurement by any present method is a function of variables other than fibre content. Do not underrate the consistency controller on that account: if one is installed on any machine, there is a marked improvement in the results. Considerable thought is being extended to determine the true bulk density of the stock. Probably some form of radiation method will be successful; then it would be a simple matter to compute the flow using a simple multiplier.

MR. MATHEWS: Even with consistency regulators, the stock will sometimes go out of the control band, because the regulators cannot remove water if the consistency is low and can only add a limited amount if it is too high. Could flow meters automatically adjust the volume to correct for such variations?

MR. BALLS: That could be done. Provision is made on the total stock flow controller (stuff gate control) for automatic adjustment from a basis weight controller. It must be emphasised that basis weight is a function of several variables, of which inlet stock consistency is only one, but admittedly the major variable.

MR. G. R. HYDE: Can you give some information on the repeatability of the magnetic flow meter? We at present enjoy the advantages of an almost uniformly standard signal range of 3–15 lb./sq. in. for pneumatic equipment. Is there under consideration a standard signal range for electrical equipment of this kind? With frequent changes in machine throughput, the need to readjust controllers for best control under all process conditions becomes pressing.

MR. BALLS: In the magnetic meter, accuracy and repeatability are identical, better than 1 per cent. Measurement sensitivity is a small fraction of 1 per cent. A stock flow measurement device (an open loop system, no feedback) must be accurate.

There are millivolt and milliampere signals of which 0–5, 1–5, 0–15, 0–30, 4–20 and 10–50 are typical values. American designed instruments normally use live zero and European designs normally use zero/zero. This is a matter for fundamental instrument design, now being considered by a British Standards Committee. In view of international requirements, there will be delays in achieving widely accepted standards.

MR. F. W. HAYWARD: Mr. Balls said that it is not true that speed of response is one of the main advantages of electric or electronic over pneumatic control. Surely, the most important advantages are the replacement of compressed air by electric power and of copper tubing by cables. This makes for ease of installation and maintenance and increased reliability. It seems to me that, when a valve can be operated electrically with the smoothness characteristic of pneumatic operation, electric control will replace pneumatic control in many processes, including papermaking.

MR. BALLS: Pneumatics and electronics are complementary systems. At present, the best way to operate a valve is pneumatically. Any electrical method is either cumbersome, costly or both. It is normal to convert from electrics to pneumatics at the regulating unit.

What I wished to emphasise was that, when high speed of response is necessary, it can be obtained pneumatically. Speed of response is not necessarily an inherent feature of electronic and slowness of response one of pneumatic controllers, nor always an essential factor of control loop. Within the compass of a papermill, there is scope for alternatives. In deciding the system, the factors of cost and experience will be considered. Industry has forty years' experience in the handling of pneumatic systems, so that design and installation work is based upon a vast store of accumulated experience.

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Speed control of drives in the papermill

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GIVEN AT THE SEVENTY NINTH CONFERENCE: CONNAUGHT ROOMS, LONDON, W.C.2 ON 24th MARCH 1960, Mr. W. A. GILMOUR IN THE CHAIR

Summary

The paper discusses the potential causes of speed variations in papermachine drives of the type now in most common use—the Ward Leonard system. The principal causes are variations in load torque, temperature and electrical supply conditions.

The basic idea of closed loop control is discussed and a typical control system using electronic means of speed regulation is described in detail.

The paper concludes with a description of the application of closed loop speed control systems to supercalender and winder drives using high amplification exciters.

Introduction

THE drives that power papermaking machines may be divided into two categories, depending upon the method of transmission of power to individual sections of the machine. Lineshaft drives such as the Marshall drive, employing mechanical transmission, have only one variable speed prime mover. Sectional electric drives, which power most of our larger papermachines, have a driving motor coupled to each section of the papermachine, these motors running at a predetermined speed relationship to obtain the necessary draws down the machine.

In both cases, the accurate control of driving motor speed is essential. General machine speed and (when a sectional drive is employed) individual section speeds must remain constant at the value set by the machine operator in the face of any disturbing factors that may arise until the operator makes a further deliberate change in speed. Accepted tolerance figures within which drive speeds have to be maintained are—

1. General machine speed to within 0.2 per cent. of top speed (that is, within 2 ft./min. of the set speed on a machine with a top speed of 1 000 ft./min.).
2. Individual section speeds to within 0.1 per cent. of top speed (that is, within 1 ft./min. of the set speed on a machine with a top speed of 1 000 ft./min.).

General machine speed control is considered necessary to ensure a consistent basis weight of the finished sheet.

In this paper, the nature and magnitude of factors that can disturb the speed of a papermachine drive will be discussed, mention will be made of the principles underlying all forms of automatic speed control devised to overcome the effects of these disturbances and, finally, one automatic speed control system at present applied to both lineshaft and sectional drives will be described. Speed control of supercalenders and winders will also be discussed.

Causes of drive speed variation

MOST modern papermaking machines with electric drives whether sectional or single motor employ one of the d.c., Ward-Leonard systems shown in Fig. 1. In each system, the armature power of the shunt or compound wound driving motor is derived from a d.c. generator driven by an a.c. motor, this motor being connected to the mill a.c. supply. Unless properly regulated, the speed of the d.c. motor can be affected by changes in load torque, temperature, supply frequency and supply voltage.

Load torque variation

The causes of these variations and their magnitude vary from section to section. On a wire section, the torque imposed on the drive varies with the setting of the suction box vacuum. This is true also for suction presses. Dryer load torque varies with the amount of unextracted condensate in the cylinders and with the pressure applied to the doctors—particularly on MG cylinders. Together with these major causes of load torque variation, there are numerous causes for smaller cyclic and random torque changes.

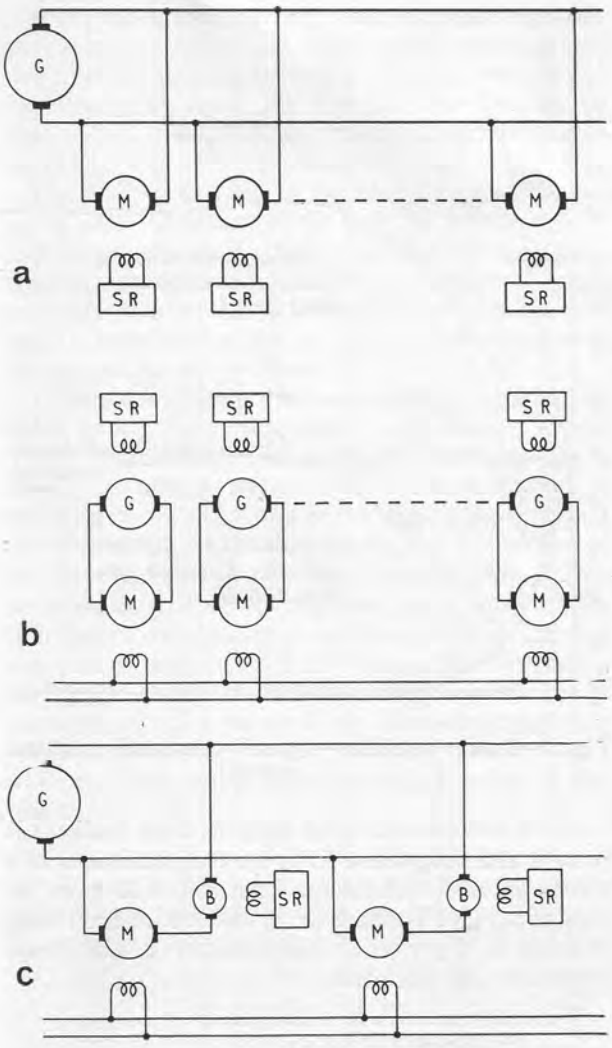


Fig. 1—Basic Ward Leonard systems

On a normal run, it is quite possible for load torque to vary by as much as 10 per cent. over a period of several hours, with peak changes on some sections of up to 20 per cent.

For the type of drive shown in Fig. 1(*b*), but without automatic regulation of speed (each generator running at constant speed and with a fixed value of excitation current), a 10 per cent. change in load torque at the shaft of any of the d.c. motors could produce a change in speed of that motor of as much as 1.2 per cent. of top speed or 12 ft./min. on a 1 000 ft./min. machine. How the automatic speed regulator deals with load torque changes will be described later.

Temperature variation

Under certain conditions, particularly at start-up on a winter morning, the ambient air in a drive annexe can change widely. A typical figure might be from 40°F to 75°F. This temperature change can be reflected in the operating temperature of the drive motors affecting in particular the field temperature. When a motor is excited from a constant d.c. supply, increase of temperature decreases field current, tending (unless dealt with by a speed regulator) to speed up the motor. Such ambient temperature changes as that described could produce speed changes of the driving motor of up to 1 per cent., if working unregulated.

Variation in electrical supply conditions

Changes in the frequency and voltage of the a.c. supply to a motor-generator (m.g.) set can affect its speed, the generator output voltage and hence the speed of the driving motor supplied from the generator. Mills taking their supply from the grid are usually less subject to frequency variations than mills generating their own power. The speed of an m.g. set driven either by a synchronous motor or an induction motor is proportional to supply frequency.

The speed of an induction motor driving an m.g. set can be affected by changes in supply voltage. Any decrease of voltage from its nominal value increases the motor 'slip', reducing its speed. Mill distribution voltage variations are normally kept to within ± 3 per cent. of the nominal value of the supply, but depressions of considerably greater magnitude have been encountered under certain fault conditions.

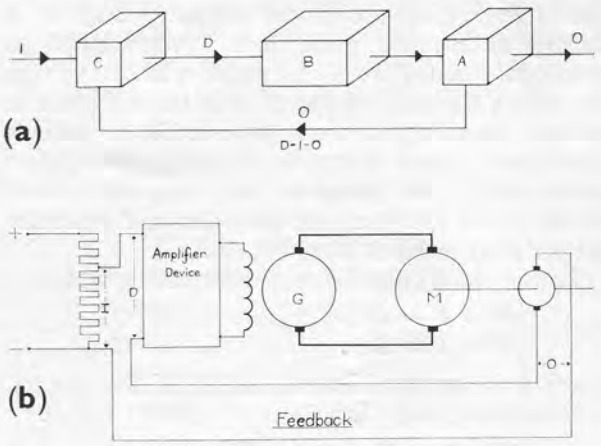


Fig. 2—(*a*) Block diagram of a closed loop control system
(*b*) Closed loop speed control of a Ward Leonard drive

Principles of automatic speed control

IT is clear that an unregulated Ward Leonard system would be incapable of driving a papermachine within the required limits of speed variation due to the disturbing factors already discussed. Before examining particular types of automatic speed regulator as applied to papermachine drives, it is perhaps opportune to examine the basic principles behind the functioning of such regulators.

All regulators include some form of closed loop of the type shown in Fig. 2(*a*). Block *A* represents an output element, in this case, a drive motor whose speed is to be regulated. Block *B* represents a power amplifying element or group of elements capable of accepting low power input signals and amplifying them to such a level as to control the speed of the motor. Block *C* is a difference element, which subtracts the output signal *O* generated at the motor from some reference signal *I*, which represents the desired speed or angular position of the motor shaft.

For instance, in a position control system, the angular position of the rotating motor shaft would be the output signal *O* and *I* would be the corresponding angular position of some master shaft at the same instant; *C* would be some form of mechanical or electrical differential; *B* could be a rheostat in the field of the motor represented by *A* and capable of effecting speed changes of *A*. A load change at the motor output shaft, tending to make the output shaft lead or lag behind its correct angular position would cause an output from the differential *C*, in turn changing the excitation of the driving motor to restore it to the correct angular position.

Similarly, in a speed control system of the type shown in Fig. 2(*b*), *O* is the output voltage of a tachogenerator, its value being proportional to rotational speed; *I* is a highly stable reference voltage for setting the required speed; *D* is the difference in voltage between reference and feedback and is amplified in some electronic or rotating amplifier, which excites the generator supplying the section motor. Both the electronic amplifier and generator are included in block *B* of Fig. 2(*a*).

Two equations can be written for such a system—

$$D = I - O \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$O = k \times D \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where k is the amplification factor of the system.

Substituting in (*1*) for *D*— $O/k = I - O.$

Therefore, $O = I/(1 + I/k) \quad . \quad . \quad (3)$

The greater the value of k, the more nearly does *O* equal *I*.

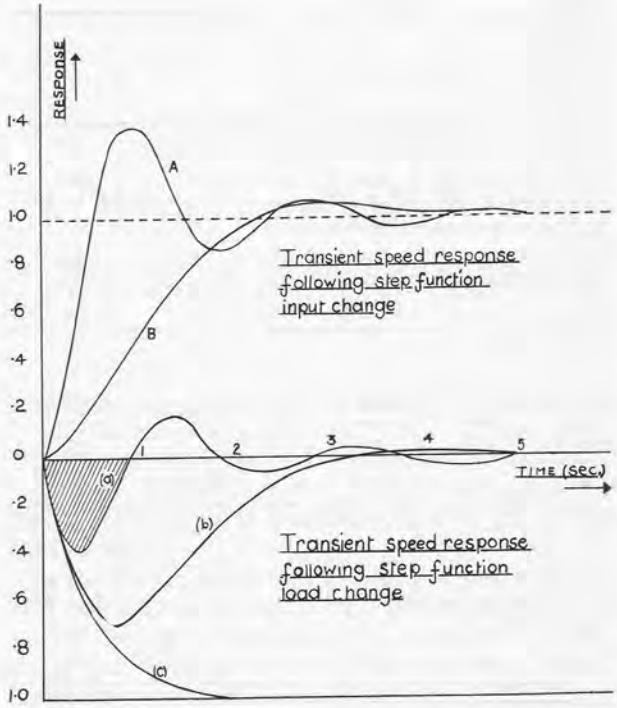


Fig. 3—Speed regulator—typical calculated response curves

Let us now consider what happens when feedback is present and not present from the output element in a system whose k can change from 100 to 90 as in the case of a Ward Leonard drive with an inherent drop in speed of 10 per cent. when load torque is increased from 0 to 100 per cent.

When no feedback is employed, $D = I$.

Therefore, $O = kI$.

From (*2*), $O_{nl} = 100 \times I$,

$O_{fl} = 90 \times I$.

Thus, *O* has changed 10 per cent.

When feedback is employed, the values of *O* at no load and full load can be obtained from equation (*3*).

$$O_{nl} = I/(1 + 1/100) = 0.990 \times I.$$

After application of load, k drops to 90.

$$O_{fl} = I/(1 + 1/90) = 0.989 \times I.$$

The value *I* differs for the open loop and closed loop cases, but it remains constant in each case for the two values of k. Thus, we see that the output speed is changed by only 0.1 per cent. with feedback, compared with 10 per cent. without feedback. The accuracy of control has been improved by a factor of 100, which is equal to the amplification of the system.

It is important not only that a speed regulator should have sufficient gain to ensure that speed changes due to load, temperature and supply disturbances are kept negligibly small, but also that the response or time of reaction of the system to such disturbances should be kept to a minimum.

Fig. 3 shows two sets of theoretical response curves for a drive regulated in the fashion just described. Curves *A* and *B* are fast and damped responses, respectively, to a step function change in speed reference equal to unity. It will be noted that curve *A* has an overshoot of 40 per cent., whereas curve *B* has practically no overshoot.

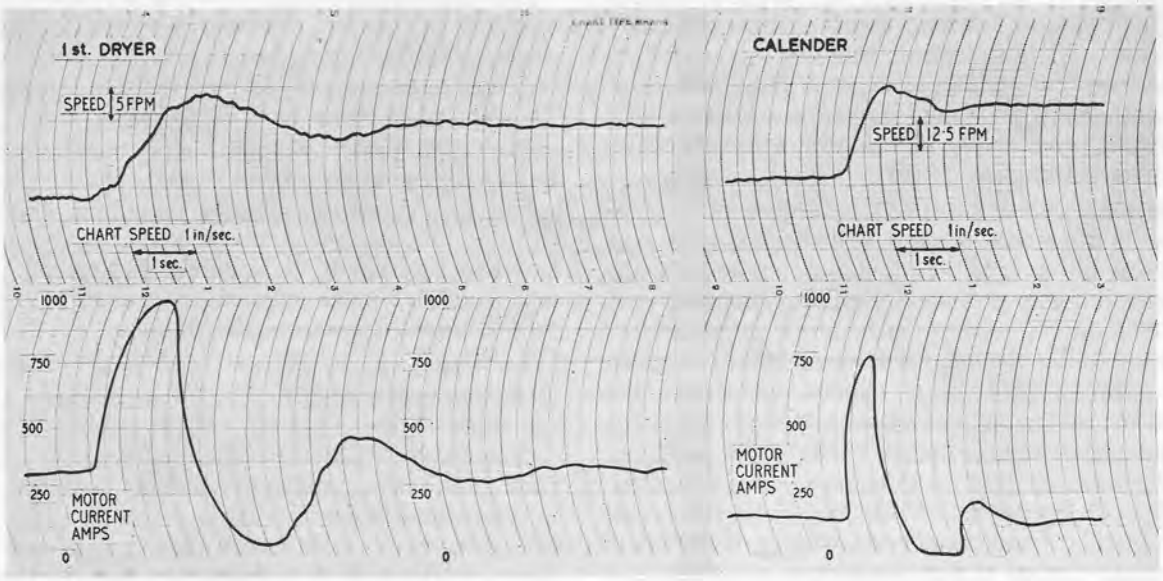
Curves *a* and *b* are the corresponding responses in speed to a step function load torque change, which, if the regulator were not present, would produce a permanent change in speed as shown by curve *c*. The stretch or contraction of the sheet is proportional to the time integral of these curves or, in the case of the curve *a*, to the shaded area of the diagram. It can be seen that the slower response setting of *b* results in a stretch or contraction of about 5 times that for curve *a*. In terms of a 1 200 ft./min. machine and a load torque change that would produce a speed change (unregulated) of 1 per cent., the fast acting regulator would limit the accumulated displacement to $\frac{1}{2}$ in., while the slow acting regulator would permit a displacement of $2\frac{1}{2}$ in.

Recorded speed responses to step function changes in speed reference are shown in Fig. 4(*a*) for a newsprint dryer section and in Fig. 4(*b*) for a newsprint calender section. The dryer section is driven by a 550 h.p. motor. A 10 ft./min. sudden change was made to the speed reference. Correction to the first point of coincidence was effected in 1.1 sec. with an armature current peak of 3 times the steady value.

The calender, also driven by a 550 h.p. motor, was subjected to a sudden speed reference change of 26 ft./min. Correction to first coincidence took place in 0.6 sec. with a current peak of 6 times the steady value.

A practical speed regulating system applied to papermachine drives

HAVING discussed the basic principles behind automatic speed control of papermachines, let us examine a typical system. Fig. 5 is the schematic diagram for one section of a sectional drive: *M* is the driving motor whose speed is to be regulated and, to it, is coupled the feedback tachogenerator *TG*. The generator main field *F1* is excited from a flux resetting magnetic amplifier capable of an output of 2 kW. and made up of the saturable reactors *SR1* and *SR2* and the rectifier *MR3A*, *MR3B*, *MR4*, *MR5*, *MR6* and *MR7*. The output of the magnetic amplifier is in turn regulated by the three-stage preamplifier *V1*, *V3* and



(*a*) Dryer drive actual speed reponse (*b*) Calender drive actual speed reponse

Fig. 4—Transient response recordings taken on a 280 in. wide newsprint machine running at 2 300 ft./min.

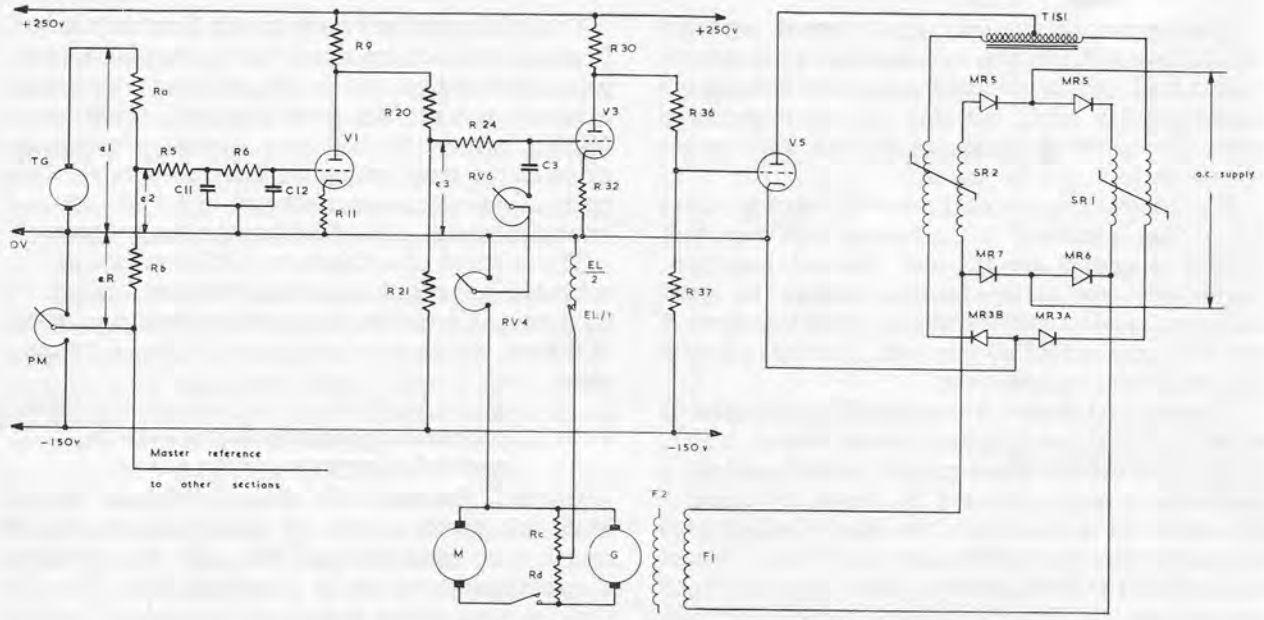


Fig. 5—Schematic diagram of one section of a sectional drive control scheme

V5, of which *V1* and *V3* are pentodes and *V5* is a tetrode. At the input to *V1*, the speed reference voltage *eR* is compared with the output voltage of the tachogenerator *e1*.

Thus, the motor *M* replaces the output element *A* of Fig. 2; element *B* is made up of three components—the generator, the magnetic amplifier and the hard value amplifier—while element *C* (the difference element) comprises the resistances *Ra* and *Rb*, subtracting *e1* from the *eR* and feeding the difference *e2* into the amplifier.

Should a load or some other change tend to make the section increase in speed, *e1* increases, raising the potential of the grid *V1*. This in turn reduces the potential of the grid of *V3* and increases the conductivity of *V5*, raising the magnetic amplifier flux reset level. The magnetic amplifier output voltage to the generator field *F1* is reduced and hence the armature voltage applied to the motor *M*.

The tachogenerators that provide the feedback voltages are coupled to the non-drive ends of the section driving motors. These tachogenerators have to be designed and constructed with particular care. The speed control system can only be as accurate as the performance of the tachogenerator allows. In particular, at any fixed speed, these machines must have a constant output voltage over prolonged periods and under varying temperature conditions. The relationship of output voltage to speed must be linear and the ripple component of the output must be kept to a low value.

In a sectional drive, the reference voltage has to be applied to all section regulators, its value being set at a common master potentiometer. One type of master reference potentiometer is shown in Fig. 6. It is in the form of a multi-turn potentiometer, rotated by a pilot motor. The master reference line is connected to a brush that travels parallel to the axis of the rheostat, riding in the resistance element groove. Such a rheostat for high speed machines may have a brush travel time of up to 20 min. from end to end. The d.c. supply voltage applied to the ends of the potentiometer is electronically stabilised.

As it is necessary to vary the speeds of sections relative to one another to set the desired draws down the machine, the reference voltage applied to each section speed regulator must have a trimming adjustment. With the type of system already described, this is comparatively easy. A small proportion of *Rb* in Fig. 5 is made variable in the form of a small potentiometer. It can either be mounted in an operator's control station or in the section speed regulator, driven by a pilot motor and push-button controlled from the front of the papermachine.

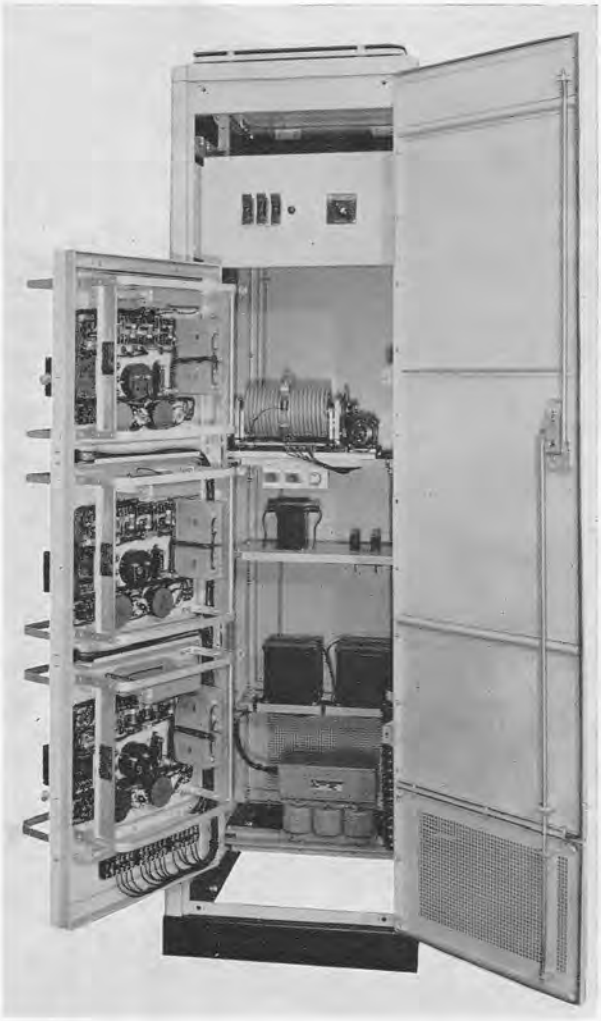


Fig. 6—A speed reference adjustment rheostat

Four section speed regulators are shown in Fig. 7, two in each cubicle. The valve preamplifier (*V1*, *V3* and *V5* of Fig. 5) is mounted on a swinging panel. In addition to the three-stage preamplifier, there is a fourth valve that controls crawl speed, acceleration and standstill generator voltage.

The magnetic amplifier is mounted at the back of the regulator cubicle. The two saturable reactors with their control and gating windings take the form of toroids. In this case, selenium rectifiers are used to rectify the amplifier output and to act as blocking rectifiers in the control circuit. This type of rectifier is now being replaced by germanium and silicon semi-conductor rectifiers, which occupy much less space.

The gain or k for such a system is of the order of 750. Thus, changes of load that might produce a change in speed of 10 per cent. of top speed, were the drive unregulated, only produce changes of $10/750 = 0.013$ per cent. of top speed.

This type of system can equally well be applied to single motor drives coupled to lineshafts, a single electronic speed regulator controlling the speed of a lineshaft motor.

Speed control of supercalenders and winders

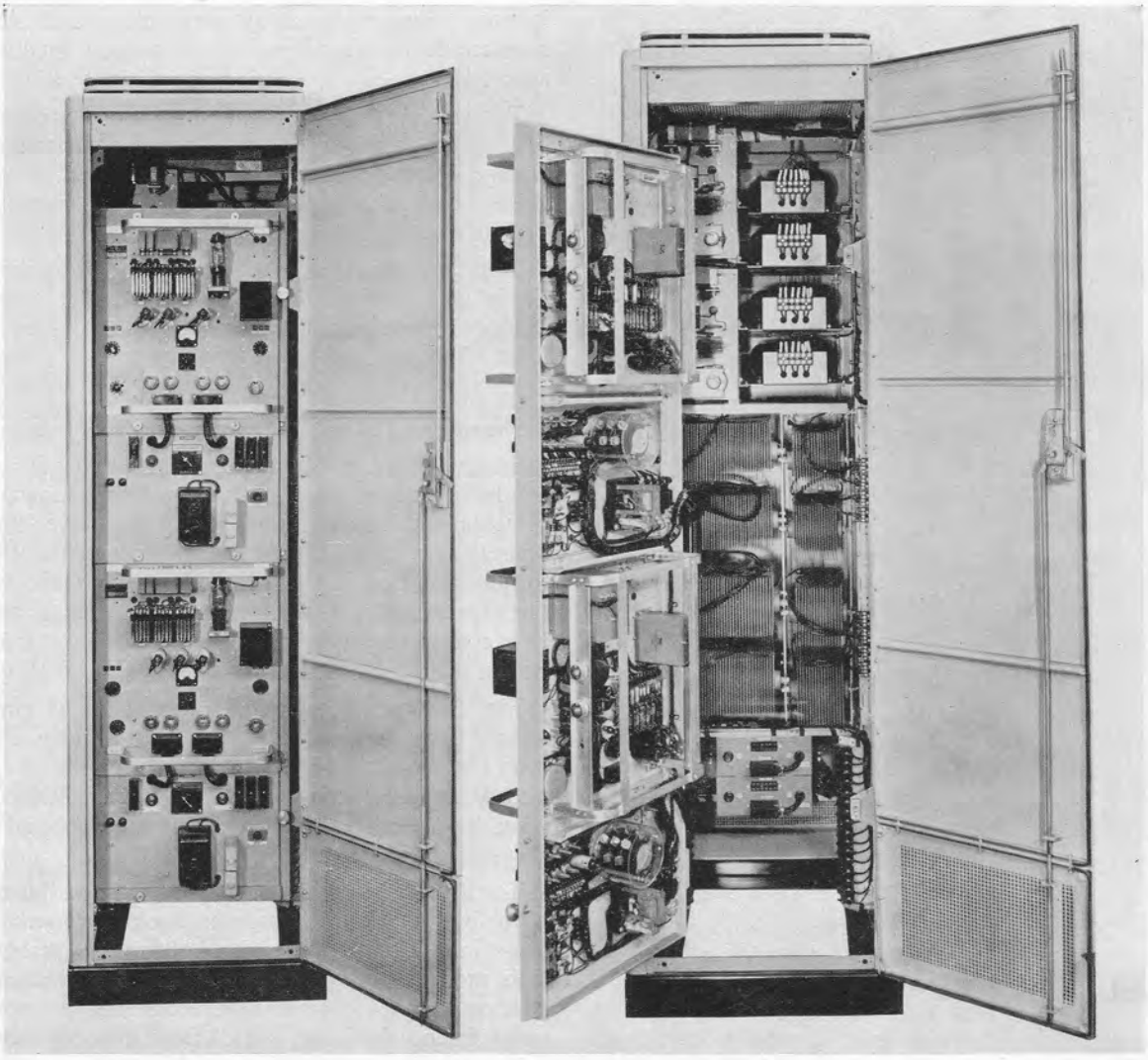
SPEED control requirements for supercalenders and winders are not so rigorous as for papermachines. The principal requirements are that the drive should operate at a steady thread speed, irrespective of load torque and that it should accelerate and decelerate the supercalender or winder smoothly and as rapidly as is commensurate with the holding of sheet tension within acceptable limits.

Fig. 8 shows schematically one type of control system for a supercalender drive. It includes closed loop speed control of the main stack drive motor and closed loop sheet tension control of the unwind reel sheet by a braking generator and the rewound reel sheet by a wind up motor.

The speed of the main motor is varied by adjustment of the output voltage of the generator. This generator in turn is excited by the high amplification exciter *GE*. This exciter is capable of producing a power amplification of up to 15 000. Separate opposing feedback and reference fields are excited from a tachogenerator and motor-operated reference rheostat, respectively.

At crawl speed, the reference rheostat applies a low reference voltage to the reference field. Should a load torque change tend to cause the main motor speed to vary, the excitation of the feedback field changes. A very small change in feedback voltage can produce a large change in the output of *GE*, which adjusts the generator excitation to restore the motor speed to the desired value. Such a system only requires a gain factor of $k = 30$ to 50—that is, less than one tenth of the corresponding value for a papermachine drive speed regulator.

A similar system can be applied to winder drives. Here, even on very high speed winders, it has been found that satisfactory thread speed operation can be obtained by comparing the speed reference signal with



(a) (b)

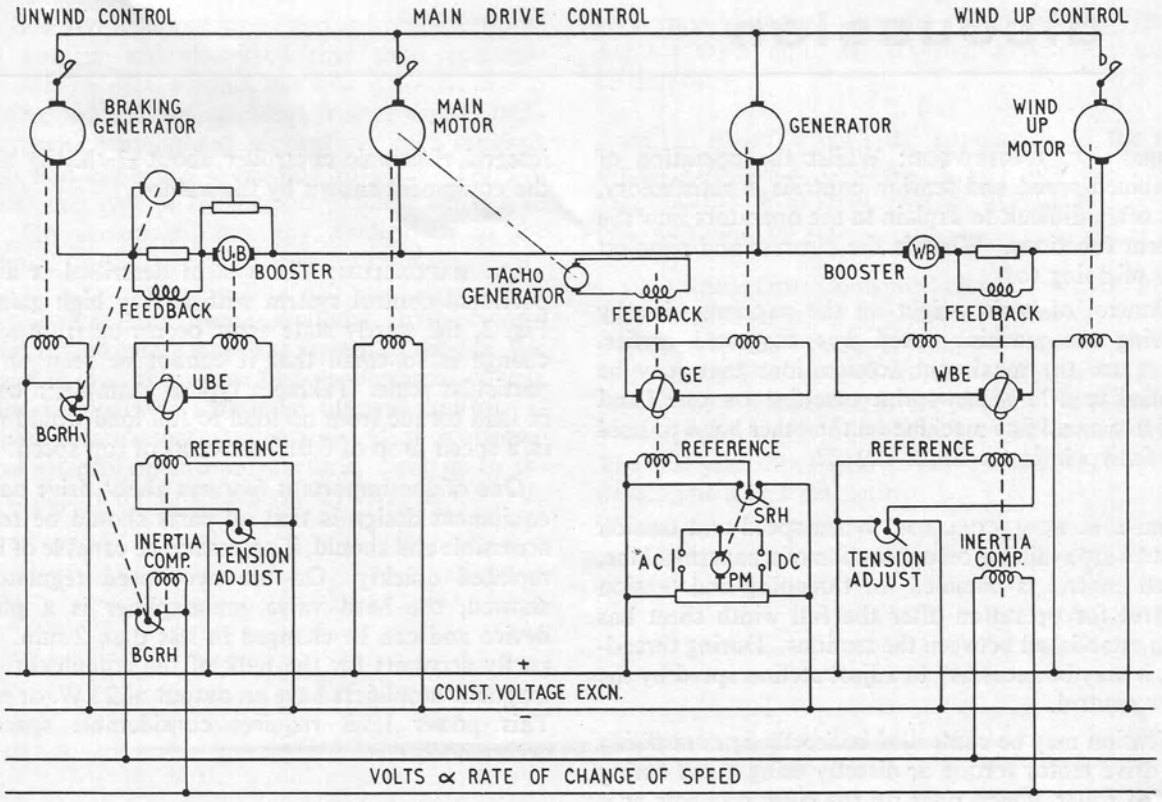
Fig. 7—Speed regulator cubicle (*a*) exterior, (*b*) interior

a feedback from the generator armature voltage leaving the motor outside the closed loop.

Conclusion

THE closed loop control system is a highly effective means of regulating drive speeds. The higher the gain of the system, the greater the degree of accuracy. There are of course actual limitations to the maximum value of gain, an important one being the effect of gain on the system stability. The higher the gain, the more difficult it is to prevent hunting.

Each type of drive in the papermill has its own requirements of speed accuracy. The most stringent accuracy is required by the sectional papermachine drive, followed closely by the lineshaft single motor papermachine drive. Supercalenders and winders require accurate control of thread speed, but of a much lower order than that of the papermachine drive.



SUPERCALENDER CONTROL SCHEME

Fig. 8

Acknowledgement

In conclusion, the writer would like to thank the Chief Engineer, Motor & Control Division, A.E.I. Ltd. for permission to read this paper and the members of the Industrial Applications Engineering Department for their help in preparing it.

discussion

MR. N. C. UNDERWOOD: Whilst the operation of combined speed and tension controls is satisfactory, it is often difficult to explain to the operators how the system functions. What is the clearest and simplest way of doing so?

Control of basis weight on the papermachine by altering the machine speed was suggested earlier. What are the maximum accelerations that may be applied to a large newsprint machine on one hand and to a small fine machine on the other hand to hold the draw within the limits stated?

MR. I. M. M. MACCALLUM: When speed and tension control are available on one section of a papermachine, speed control is intended for threading and tension control for operation after the full width sheet has been established between the sections. During threading, it may be necessary to adjust section speed by the draw control.

Tension may be controlled indirectly by controlling the drive motor torque or directly using a leaf spring loaded roller, which rides on the sheet and acts as a sheet tension feedback transducer, feeding a signal to the section regulator.

A satisfactory rate of change of speed found for high-speed newsprint machines with sheet on the machine is 100 ft./min.^{2}.

MR. B. W. BALLS: The form of the curve in Fig. 3 resembles those shown yesterday to draw a comparison between proportional, integral and derivative controller actions and their effect upon recovery time and indicates the presence of integral control action with no offset (or droop) due to load change. The author did not distinguish any particular type of feedback control action, but referred to the 'gain' of the control amplifier. Does the control system include proportional, integral and derivative (as used in process control terminology), even though the time constants are so very short? The figure of 750 gain inverted into process terminology is termed a very narrow proportional band and, therefore, without the inclusion of integral action, even a slight droop or offset should be evident upon load change.

Furthermore, I was interested by the size of the equipment. I showed a picture of a proportional-integral electronic controller about $\frac{1}{100}$th. the size of the equipment shown by the author.

MR. MACCALLUM: The system described is a proportional control system with a very high gain. In Fig. 3, the steady state error occurring from a load change is so small that it cannot be seen on that particular scale. Taking a typical example, a change in load torque from no load to full load would result in a speed drop of 0.015 per cent. of top speed.

One of the important features about drive control equipment design is that all parts should be readily accessible and should, if necessary, be capable of being replaced quickly. On the two speed regulators I showed, the hard valve pre-amplifier is a plug-in device and can be changed in less than 2 min. This partly accounts for the bulk of the equipment. The magnetic amplifiers have an output of 2 kW. or more. This power level requires considerable space to accommodate it.

MR. BALLS: That is the essential point of difference. The equipment shown yesterday has a low power output, which is amplified at the regulating unit.

MR. D. ATTWOOD: There is an important difference between speed controllers and the ordinary process controllers, which have developed from recording indicators. We have always been used in process control to having a record of the process variable. Mr. Gardner spoke of future developments possibly towards 'blind' controllers. Speed controllers are inherently 'blind' and we have found it necessary to install recorders to find out what is happening to the speed control.

MR. MACCALLUM: I think this is largely a question of economics. The regulator is designed to operate as a 'blind controller'. Sometimes it is felt worthwhile to install equipment to give accurate, continuous monitoring of section speeds. Such equipment will give records of draws and can be of help to the production staff. It also gives a record of whether a section drive control equipment is healthy.

MR. G. R. HYDE: About a year ago, a form of sectional speed control was described that used analogue controllers on each section, but with a master digital controller using a measurement from a digital tachometer, which monitored sequentially each separate section and applied a correction to these. Do you consider this type of refinement, which is capable of very high accuracies, has any application in the papermill?

MR. MACCALLUM: Some sectional drive control equipments do imply a similar system to the one you mention in that they have fast proportional control systems with slower additional integral control. It has been found that straightforward proportional control systems operate satisfactorily right up to the highest papermaking speeds yet reached. If we go to very much higher speeds, say, in the range 3 000–4 000 ft./min., such a system as described might be necessary.

MR. K. SEWELL: With the application of the new silicon controlled rectifiers, I can foresee a vast simplification with great increase in reliability—what has been done on this?

MR. MACCALLUM: Controlled rectifiers are still in the development stage for applications. Eventually, controlled rectifiers—these are semi-conductor devices with an action similar to the thyratron—will be capable of producing armature power for d.c. motors. They require a very low power level to control them. The next year should see considerable advance in their development and marketing.

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Machinery for automation

J. HOWARTH and W. A. BANKS
Black-Clawson International Ltd.

GIVEN AT THE SEVENTY NINTH GENERAL CONFERENCE: CONNAUGHT ROOMS, LONDON, W.C.2
ON 24th MARCH 1960, Mr. W. A. GILMOUR IN THE CHAIR

Synopsis

Suggestions are made how the furnish prepared in pulping machines can be given more uniform qualities before it is refined, thereby reducing the band width of instruments for refining control.

Modified gland packings are discussed, which reduce the amount of dilution water introduced into the stock by gland packings; continuous freeness recording and controlling instruments are reported upon.

The working efficiency of control valves is commented on and remarks are made regarding chest design, agitation, etc. A modern automatic broke handling system is fully described.

Modern methods of automatically tensioning machine clothing is suggested as a means of prolonging the life of wires and felts and suggestions are made to overcome the difficulties of changes in atmospheric conditions in the machine house.

Introduction

THE title of this paper, given a cursory glance, will suggest that we are approaching a phase when a whole series of new machines is about to be released by the makers and that these will completely revolutionise the whole papermaking process. Nothing could be further from reality. Our approach to this interesting subject and the inherent problems that it carries has been to co-operate with the paper technologist, instrument and controls engineer in such a manner that existing proven equipment can be modified as necessary, so that it will carry out the functions demanded from it by the automatic process.

A typical enclosed loop (Fig. 1) requires mechanical handling and/or power actuation equipment. Such a loop consists of—

1. An established standard with suitably accepted tolerances.
2. A measuring device or instrument capable of comparing directional and quantitative variations of the controlled medium to the accepted standard.
3. A device or machine for correcting the medium quality in such a manner that it becomes acceptable within the range of the standard.

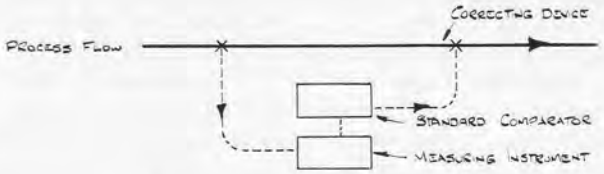


Fig. 1—Typical enclosed loop

Many such loops are required in the complex process of papermaking and, as more and more of the loops are closed (thereby reducing the number of manual tasks remaining), we tend to proceed further towards complete automation. The installation and servicing of a number of systems has allowed us to study the future machinery requirements that will be necessary for a fully automatic process. Motorisation, remote and centralised control and part automation of several essential processes such as refining, broke handling and papermachine head box control have all contributed towards the ultimate goal.

Reliable machinery, requiring a minimum of maintenance and designed for efficient servicing, is necessary, if the system is to run continuously and trouble-free. Developments in these fields together with several new departures from the presently established design fundamentals are being explored. Several important modifications have been found necessary to generally accepted papermaking principles, also some of the machinery that to date has been successfully employed must be propounded.

Stock preparation considerations

THE power required to prepare a pulp furnish ready for application on to the papermachine is allocated in a manner similar to the examples shown in Fig. 2.

J. Howarth is Chief Engineer and W. A. Banks is Service and Development Manager

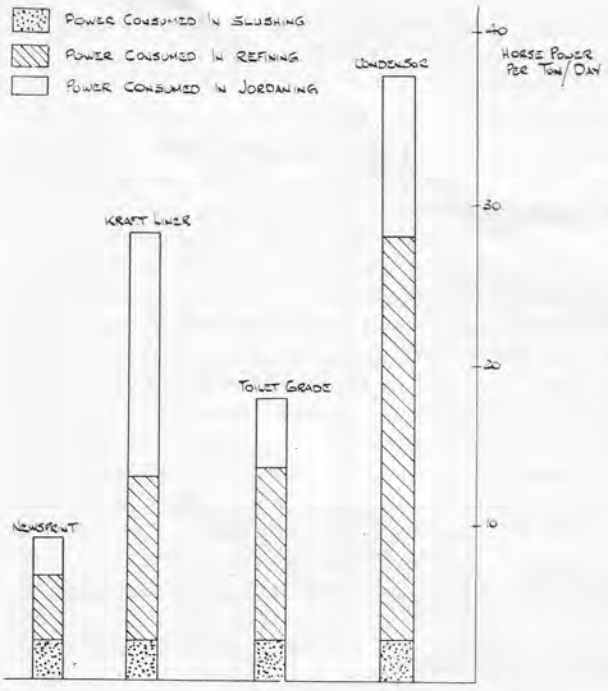


Fig. 2—Power comparisons for various furnishes

Here, we see that 25 per cent. in the case of newsprint to only 6 per cent. in the case of high grade papers is used in the pulping process. The remainder is expended in the refining and Jordaning processes. In this country, we do not have available the facilities existing in integrated pulp and paper mills. The range over which the qualities of incoming pulp varies is considerable. Shipment and storage causes bales to be frozen, contain excess moisture and even be sunburnt. Wastepaper furnishes also vary in quality, some cannot be broken down in the conventional hydrapulper, owing to wet strength additives, wax and a variety of coatings, even broke returned for reprocessing can be wet, dry, plain or coated. Large undefibred pieces that will pass through the 25 mm. diameter holes of the hydrapulper extractor plates need to be broken down separately. Machinery should be installed in such a manner that the stock feeding the refiners is of a homogeneous nature and constant quality. Two forms of pre-refining equipment are currently being developed. Fig. 3 shows typical stock preparation flow diagrams, the upper one suggests the installation of a pre-refiner fitted with a simple rotor and stator running with a fixed clearance. Such a machine requires 1.4 h.p. per ton per day and this can be absorbed in the gross horsepower figures shown in Fig. 1. All separate machines, however, require non-useful power that is consumed by packing gland friction, bearings, etc. The lower diagram suggests important modifications to the hydrapulper equipment, consisting of a stationary bedplate installed below and working in conjunction with a rotor having pre-refiner bars. This system also works with a fixed, predetermined clearance; moreover, exhaustive laboratory, pilot plant and full-scale tests have shown that the extra power required can be absorbed in the gross total horsepower. Typical pulps reduced to a common defibring standard have shown total power savings of 10 per cent. These developments are still in a comparatively elementary stage, but enough evidence is available to show that pulps can be prepared ready for refining in such a manner that the freeness and defibring standards are reasonably constant.

We all recognise the importance of consistency control and how consistency variations affect refining characteristics. Control is ineffective, however, when variable quantities of water are introduced into the system at various stages. Gland packings of agitators, pumps and refiners have been a considerable source of trouble in this respect. Although these supplies can be metered, lantern rings and worn gland sleeve cavities become blocked with dried out pulp and restrict the gland water flow. A stock system of the type shown in Fig. 3 contains machines having a total of 18 glands that can consume up to 700 gal. water/hr. A batch refining system as shown in Fig. 4, requiring several passes through a set of hydrafiners piped in series, has the further disadvantage that the gland water continuously dilutes the stock as the refining of the batch proceeds. Spring-loaded, face type seals have been used on some installations, but these are not readily adaptable to refiners and Jordans, since axial adjustment of the shaft in relation to the stator housing is necessary. Several proprietary seals of this type require water-flushing connections and the design and fitting of such items is not readily understood by shift maintenance personnel. Lip type seals, chevron-shaped and installed in conjunction with specially plated sleeves give a reasonable life when run in the 'dry' condition and have been successfully used to seal against 80 lb./sq. in. stock pressures on large hydrafiners running at 1 500 rev./min.

Automatic control of refiner and Jordan load is possible with the Duotrol automatic adjuster. This unit can be preset for the desired power value and it will automatically maintain this setting irrespective of variations in stock consistency, freeness or inlet flow conditions. It will also automatically maintain this

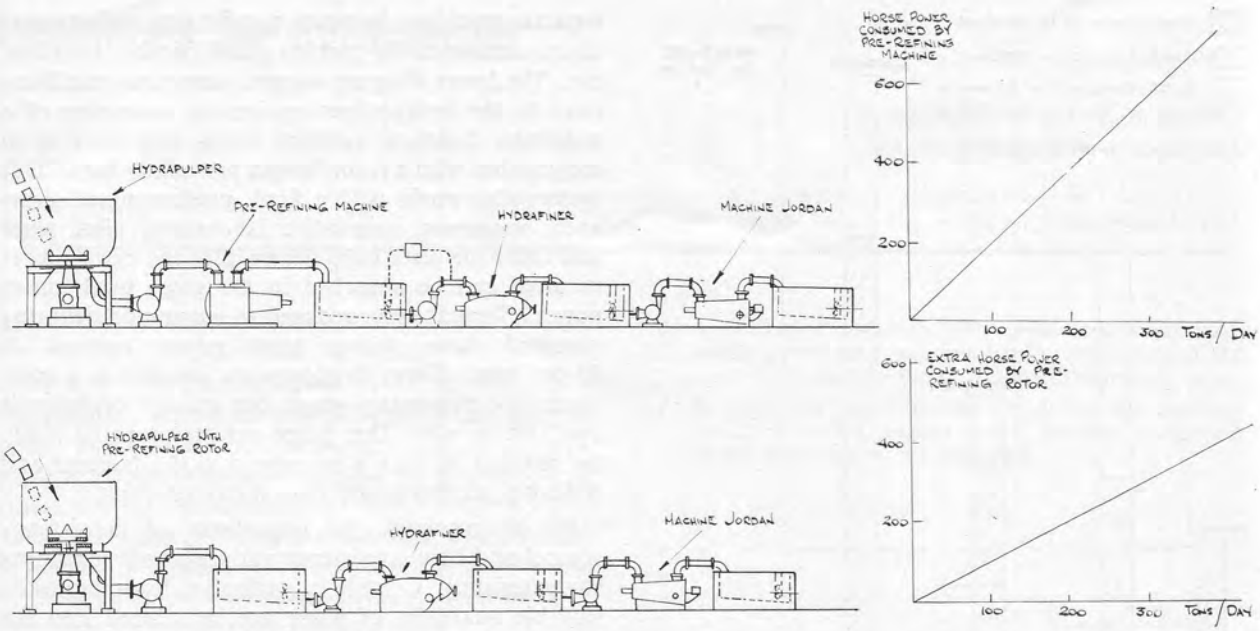


Fig. 3—Typical stock preparation flow diagrams

setting for any number of refining cycles. Evaluation of results obtained show that when this device is applied to refiner systems that do not utilise Jordans for final trimming, the freeness of the stock feeding the papermachine will vary and this variation is usually proportional to variations in the freeness of the stock being fed to the refiners. It will be realised, therefore, that some form of continuous freeness measuring device is necessary. Our early experiments of modulating the constant load setting characteristic by instruments that monitor the vacuum being drawn at the couch roll is not satisfactory, because of system inertia. With such an arrangement, there is a distinct time delay between deviation and the necessary correction. Continuous freeness recording and controlling instruments installed immediately after the refiners are envisaged for future use in conjunction with the load-setting device and our American research department

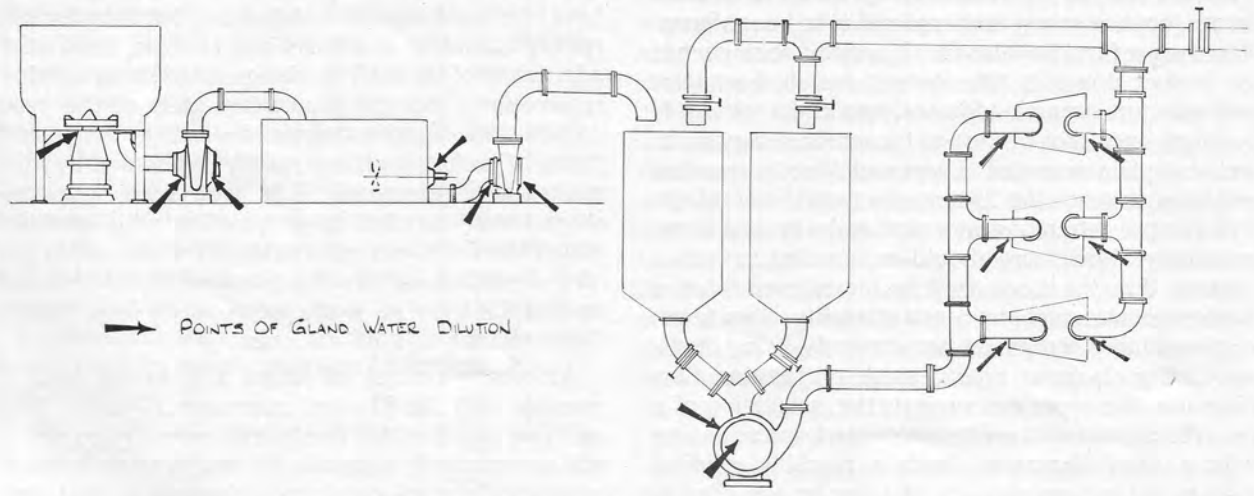


Fig. 4—Typical batch refining system

is at present in the final stages of producing a promising machine that will continuously record freeness and will also perform functions to adjust freeness.

The performance of conical refiners and Jordans, when in new condition, measured in terms of freeness change and strength development, rapidly rises to a maximum and gradually falls away as the useful life is expended (Fig. 5). The gradual wearing away of the cone surfaces distorts the shape into a partial Schiele curve, the complete curve can be seen when examining worn footstep bearings. Deep ridges appear along the surface of refiner bars and these are coincident with the introduction of short bars in the cone due, we consider, to the abrupt change in surface area. These considerations lead us to believe that an entire departure from orthodox filling design is necessary and we are currently working on developments that we hope will produce a machine giving constant performance throughout the useful life of the fillings.

When discussing the subject of control, one must also consider the question of valves. These are vital, since they ultimately control the functions being measured and computed by various complex instruments replacing the human brain. The shape of the valve orifice can be designed to give a reasonably straightline function of position to pressure drop, but certain mechanical difficulties exist and these must be overcome. Clearances, open enough to provide smooth operation when handling papermaking pulps, are too wide to produce a watertight feature. Conversely, valves designed for handling water and low consistency stocks have a high friction factor when used on high consistency pulps. We are of the opinion that greater attention in the future must be given to valve designs, even if several types have to be produced to suit the specific applications. Quality, trouble-free service and designs giving rapid accurate response should override the ever-appearing question of cost.

A few words about chest designs; stratification, crust and foam formation and dead pockets all contribute to unnecessary variations in the pulp qualities. Continuous systems are advocated, since intermediate storage chest capacities can be kept to a minimum. Large horizontal chests fitted with propellers or axial flow pumps are being superseded by cylindrical vertical chests fitted with side drive agitators. High speed agitation—apart from unnecessarily absorbing power due to slippage—does not produce the desired effect of just maintaining the pulp in absolute suspension. A great deal of research work is yet to be concluded, the ultimate aim being to produce chest shapes and dimensions that, in conjunction with efficiently designed agitator units, will provide the desired result.

The advent of the selectifier screen, in conjunction with cyclone type cleaners, allows the whole of the stock approach, wire pit return and mixing pump system to be totally enclosed. Aeration troubles are thereby reduced and the enclosed system allows for fully automatic control of stock dilution, flow to the papermachine head box, stock temperature and pH. This type of enclosed, pressurised screen, when installed within close proximity to the papermachine head box, delivers a dilute stock to the slice that is clean and flocculent-free, thereby improving the sheet basis weight and caliper profiles. Screen rejects can be handled continuously and automatically in a clean manner and, since little floor space is required, it is possible to install cascade screening systems when necessary.

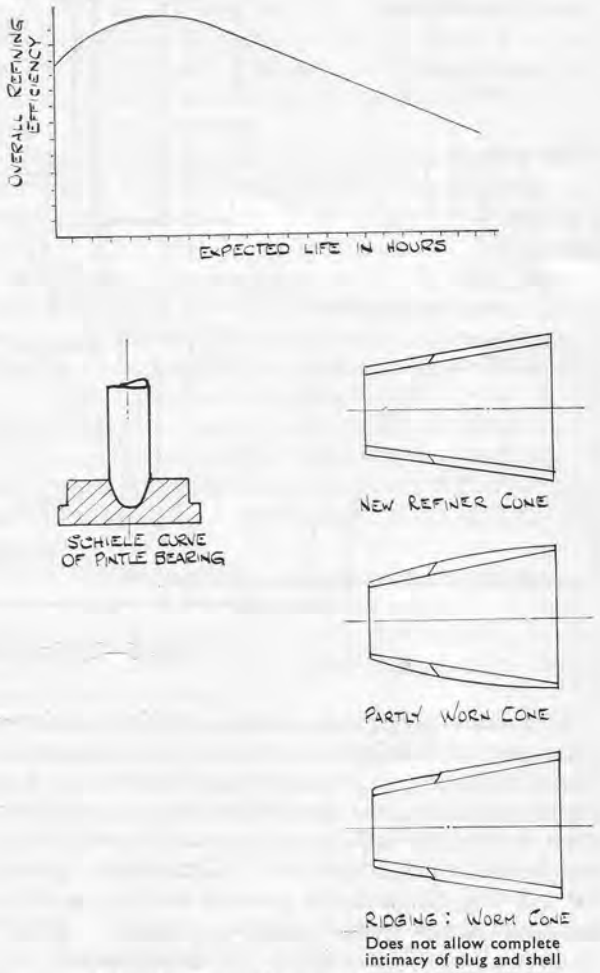


Fig. 5—Rate of wear of refiner fillings

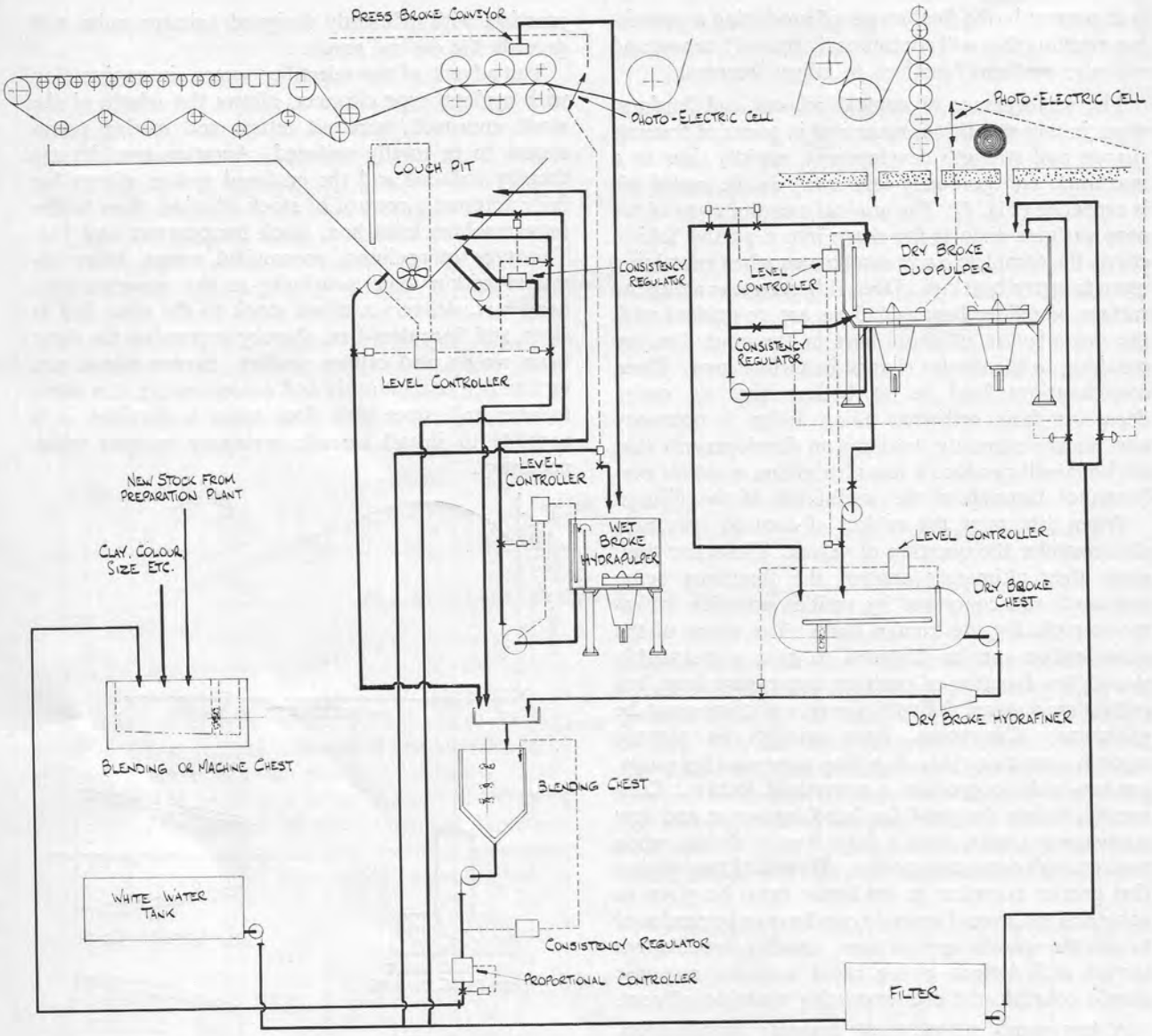


Fig. 6—Typical enclosed broke system

Broke-handling processes require special machinery when they are fully instrumented and made automatic. There are three points where broke collects—the hog pit, the press broke pit and the dry end of the machine (that is, from the last dryer, from the calender stack and from the reel, respectively). Equipment required for the hog pit and the press broke pit is comparatively simple—small diameter propeller agitator equipment, usually consisting of a shaft built into the pit and fitted with a series of agitator blades is all that is required. In the case of the dry end of the machine, it is usual to install a Duopulper underneath the machine. This consists of a large cast iron or sheet steel tank (somewhat similar to a hydrapulper, but fitted with two rotors) and the two vortices created by the rotors produce a mixing action that will quickly slush the dry broke to a condition that is pumpable.

Earlier systems utilised the press broke pit as the central receiving chest. The broke from the hog pit and from the Duopulper was pumped into this

receptacle and, from there, it was metered back to the stock preparation system. With many grades of paper, however, it has been found necessary to treat the dry broke separately, firstly, because of wide consistency variations and, secondly, because the dry broke has to be refined before it is metered back into the system.

A modern arrangement is shown in Fig. 6; here, the slushed broke from the Duopulper is pumped batchwise into a dry broke chest, a level control instrument automatically starts and stops the pulper dump pump, thereby ensuring that the level in the pulper is maintained within preset limits. Stock from this dry broke chest is passed through a refiner and is metered into a master broke chest, where blending of the refined dry broke with broke from the presses and from the hog pit takes place. The complete mixture is then metered back into the blending chests of the stock preparation system. In this final metering system, a consistency regulator is provided and also a proportional controller. The addition of whitewater to the press broke pit when a paper break occurs on the press is controlled by a photoelectric cell. Immediately the sheet breaks and the web drops into the press broke pit, this cell automatically starts the backwater pump feeding water into the press broke pit. The water flows at a predetermined rate, this being controlled by a hand-operated throttling valve, adjustable to suit various production rates of the machine.

Papermachine considerations

WHERE the stock enters the papermachine head box, a change in the character of the process takes place. Up to the head box, the process deals with the treatment of the fibres, the proper blending of the furnishes, the correct metering of additives, the dilution of the required consistency and so on. During these stages, the main characteristics of the finished paper are determined and, to a high degree, these characteristics are controllable.

We must now discuss the processes from the machine head box onwards. These are largely determined when the machine is built or, in most cases, are only variable by making changes in the construction of the machine—for example, the width and length of the wire, the number, size and disposition of the presses, the number of drying cylinders and the number and size of the calender rolls are all constant features of the machine. Even the line pressure at the press rolls, which may be a desirable variable, cannot be adjusted too much, without removing the rolls to regrind and correct the camber. This built-in process stability in the papermachine design is in many ways a very desirable feature, since it helps in producing a uniform product and, indeed, it explains why papermachines were running successfully before automatic controls were invented. Nevertheless, it limits the scope for instrumentation to influence the sheet quality, since not even the most advanced controller can be effective in the absence of an inherent controllable variable.

The use of automatic controls on the papermachine itself is, with one or two notable exceptions, likely to be confined to taking care of the correct mechanical functioning of the machine itself and with performing useful operations in the event of a paper break. Automatic broke disposal as previously described is already successfully operating in high production mills and, in addition to feeding slushed broke back into the system at controlled consistency and seeing that no chests overflow, it also releases the machine operators for feeding the sheet again. The one outstanding controllable process on the machine is that of drying the sheet to the required moisture content. In this matter, advances in plant design have made closer control possible.

Nowadays, one would not consider the dryer section without at the same time taking into account the mill ventilation system and, in particular, the machine hood.

For any large machine, especially machines in countries where the winter is severe, there are strong economic reasons for considering the use of a dryer section hood completely enclosing the dryer section both above and below the machine house floor level. Both in drying capacity and specific consumption of steam, very appreciable advantages are possible compared with a hood enclosing only the upper part of the dryer section and drawing some air from the machine house.

The condition of the air in the machine house is a most capricious variable and not only the weather, but also the opening of doors and hatches in the machine house, can play havoc with machine house atmospheric conditions.

In attempting to control the drying process, it is most desirable to have constant conditions in the hood and a totally enclosed hood can provide circulating air at a controlled velocity, temperature and humidity and also avoids the fault (well known on wide machines with open hoods) of having different drying rates at the front and rear of the machine.

The possible disadvantages of a totally enclosed hood are obviously associated with the operation of the machine in the event of a paper break. To take

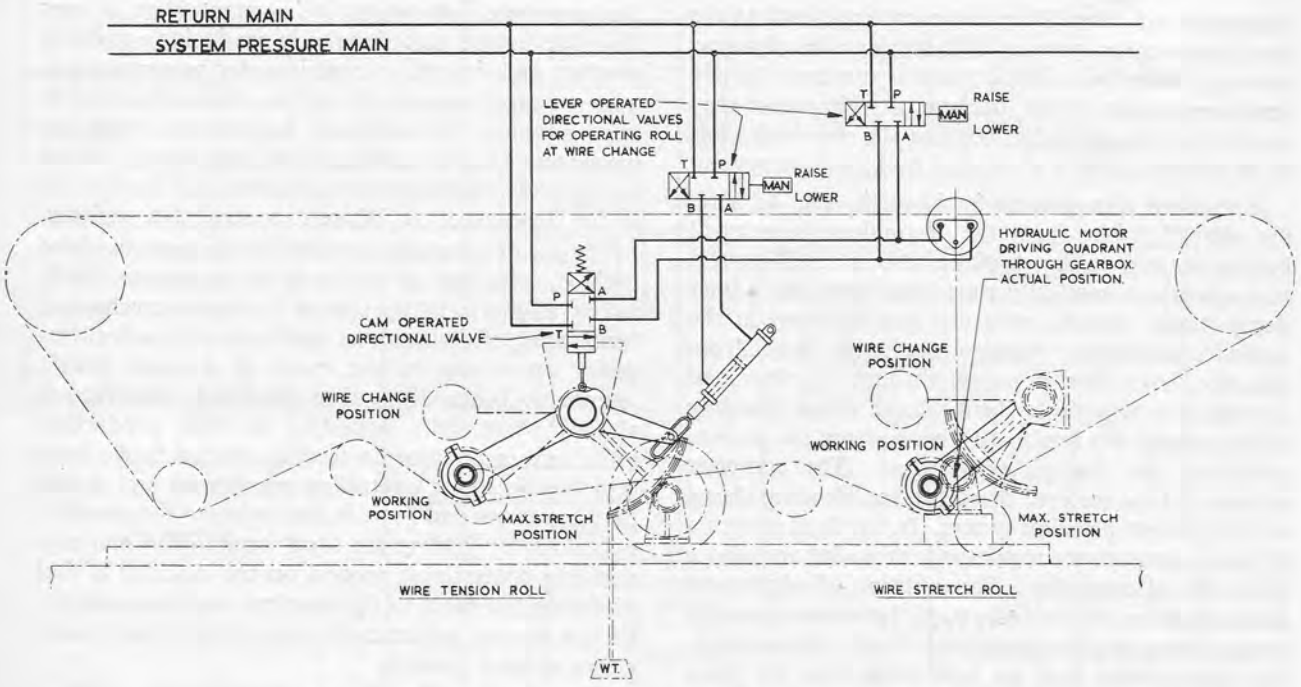


Fig. 7—Hydraulic diagram of wire tension and stretch system

care of this situation, the lower section of the hood above the floor level at the front of the machine is arranged on a signal from photocells in the dryer section to lift automatically in the event of a paper break. Windows are fitted in the hood at eye level to allow observation of the machine and it can be arranged for cool air to play over the footwalks during the time the operators are inside the hood.

Given constant ventilating conditions in the hood, there is a much enhanced possibility of achieving accurate sheet moisture control. The percentage moisture present in the sheet can be found by measuring the dielectric constant of the sheet, which is related to the moisture content. This measurement can then be fed to a controller on the valve regulating the steam pressure in the drying cylinders. Unfortunately, an adjustment of the steam pressure in the dryers takes a little time to effect a change of temperature at the dryer surface and the difficulties in applying automatic moisture control have recently centred around overcoming the time lag in the system in a suitable manner. This problem now appears to have been satisfactorily solved.

Basis weight

BASIS weight is the only other principal paper quality that has been measured on the machine, apart from moisture content. Continuous traversing of the sheet by a head using a beta-gauge to measure the basis weight is in common use and the recordings of cross-direction variation obtained are useful to indicate the need for correction at the slice. The averaging of the readings, however, to use for control of the stuff gate has met with too many snags to be recommended and it would seem that, when a variation takes place gradually over a long time (such as occurs with basis weight), the judgment of the operator is adequate.

Inevitably, most of the controls of the papermachine are concerned with the mechanical operation of the machine itself. On heavy machines, it is now not unusual to install a hydraulic system to take over the functions that might otherwise be carried out by hand, electric motor or compressed air. This system is built up of a central hydraulic pump unit with pressure regulating equipment feeding hydraulic fluid at a pressure of about 1 000 lb./sq. in. into main header

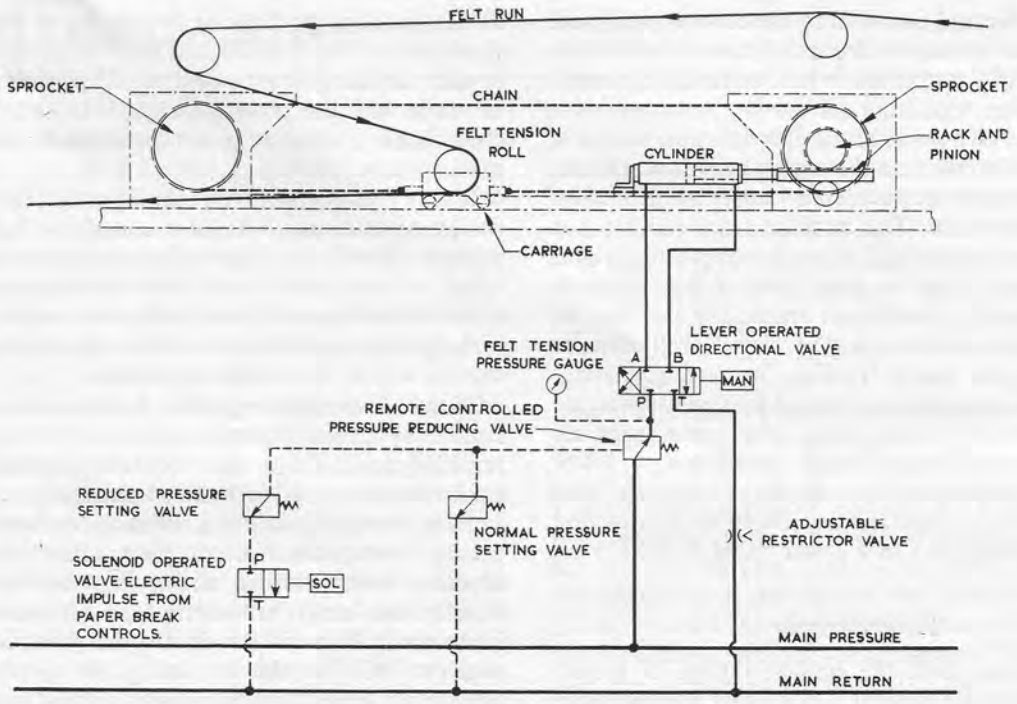


Fig. 8—Hydraulic felt tension controls

pipes running the length of the machine. Where movement or loading is required, the hydraulic fluid is taken through control valves to cylinders or hydraulic motors. Most of the functions carried out hydraulically can hardly be said to have anything to do with automation, but this is not necessarily the case.

Two examples of automatic control of machine clothing may illustrate what is possible by hydraulic and mechanical means, without the use of conventional control instruments. It is well known that machine wire life is closely related to the wire tension and there are strong reasons that the tension should be little more than sufficient to allow the wire to be driven effectively.

In the example (Fig. 7), the wire is tensioned by a roll carried in fulcrummed arms, supplemented by a system of weights. The angle formed by the wire under the tension roll in conjunction with the system of weights produces a resultant tension in the wire that can be predetermined by the choice of weights, provided the angle of wire around the roll remains constant. Any change in tension in the wire results in a change in position of the tension roll and this change of position is used, by actuating a cam-operated hydraulic valve, to initiate the movement of the following wire stretch roll to bring the wire tension back to the preset value and the wire tension roll to the original position. The cam-operated valve feeds hydraulic fluid into one side or other of a hydraulic motor, which is geared to drive a quadrant on the fulcrum of the stretch roll arms. The use of weights in this application was chosen, because it provides a very simple system combined with high sensitivity. Overriding controls on the stretch roll motor and a normally unconnected hydraulic cylinder at the tension roll provide the necessary movement of the rolls for wire changing.

A second use of hydraulics for automatic machine clothing control is in the tensioning of the felts. This is used on both press and dryer felts, although it is most important on the dryer felts, which is here considered (Fig. 8).

On large machines, the weighting gear on weight-operating dry felt stretchers is most unwieldy and economies can be effected and a most desirable control feature included by the use of hydraulics. In principle, the weights of the normal mechanical stretcher are replaced by a hydraulic cylinder and the pressure of the fluid in the cylinder and the rate of operation are controlled from a small panel adjacent to the stretcher. Facility is also provided for hydraulic retraction of the stretch roll when felt changing. The resulting felt

tension is indicated on a dial in the control panel and any change in felt tension from the preset value during the running of the machine is automatically corrected by the pressure regulating valve.

In the event of a paper break, it is desirable to relieve the tension of the felt on the drying cylinders and this can quite easily be achieved with hydraulically-operated stretchers. The stretchers are fed from a main pressure line through a pressure regulating valve, which can supply oil to either side of the cylinders. By operating the directional valve, the felt can be brought under tension or the stretch roll can be retracted to the slack position for felting. Under normal running conditions, the felt tension is regulated by an extension valve from the main pressure regulating valve; under break conditions, a lower tension is desirable and then an electric impulse from the break detector operates a valve to allow a second pressure regulator set at a lower value to take over.

Future trends

It is assumed that the present design of paper-machine automatic control is not likely to contribute much more whilst the machine is making paper. For all its size, the processes carried out on the paper-machine are very limited and most of these are built in and not susceptible to control. If any advance is to be made with the present design, it is likely to be in sheet feeding, which at present, even at its best, leaves a lot to be desired.

It may well be, however, that before many years the design of machines will have changed considerably. Both the problems of formation and pressing at high speed indicate that the established machine design has serious fundamental limitations and, to run at very high speeds, the required size of a conventional dryer section would be an embarrassment.

Ways of overcoming these limitations are being studied by several groups and it could well be that the resulting designs will allow control of variables that cannot be controlled with the present design. For this to be a practical possibility, we shall need to know, in usable terms, the factors that affect formation, drainage rate, pressing, air drying and the way in which these factors are interrelated. When this stage is reached, there is no doubt that the instrument engineer will be able to bring the papermachine operation to the advanced stage of automation already reached in stock preparation.

discussion

MR. N. C. UNDERWOOD: There are problems in continuous hydrapulping, especially with a mixed furnish, for one bale of different pulp in six or seven can make itself felt as a slight change in furnish leaving the hydrapulper.

When chests are used for smoothing, they are often too large, although they also provide storage capacity. Provided the agitation is sufficiently vigorous, all input furnish oscillations faster in period than the average holding time in the chest will be smoothed out, for practical purposes.

If inherent stability is intended to have the meaning usually implied in control engineering, the rate of change of flow from the flow box with head changes, the rate of change of cylinder temperature with supply steam pressure (as well as most of the other inherent control sections) will not be small enough to maintain the product within commercial tolerance. We have to rely on the skill of the operators or on automatic controls to supplement that inherent stability.

Mr. Banks said wire tension should be low; if so, the wrap around the table rolls and the amount of stock jump at high speed can be serious. There is certainly a case for measuring the wire tension and having it more closely maintained during the life of the wire.

Has the author considered schemes such as that proposed by Garret *et al.** for automatic start-up and shutdown, bearing in mind that he is advocating such small chest capacities?

It was said that many of the factors built into the machine are not amenable to control. There is much room for improvement; the level of basis weight across the machine, the drying across the machine and the different form of short term variations that occur on two similar machines standing side by side could all be considerably improved, with resulting increase in uniformity of product.

MR. W. A. BANKS: Uniform quality of pulp coming from a hydrapulper is exactly my point about the possibility of using a hydrapulper rotor working in conjunction with a bedplate. More power for pulping is used than is at present consumed by conventional hydrapulpers, so reducing the total amount of refining and giving a more uniform product.

In the past, chest capacities have been determined by individual ideas of downtime. Some mill engineers think that chests, other than the machine chest, must have a high holding capacity and time, since further back they contain stock at higher consistency. As reliability of stock preparation machinery is improved, large chests are no longer necessary.

MR. J. HOWARTH: The machine is a relatively stable piece of equipment in as much as so many of its parts are constant features. That is not to say that some of the things not at the present time variable ought not to be so—and this may come about—but, to make them variable, will call for a machine different from the one normally considered to be a Fourdrinier machine.

There is clearly a minimum wire tension high enough to allow the wire to be driven and, in addition, as Mr. Underwood said, to prevent stock jumping. Once that minimum has been determined, it is as well not to exceed it. There was a report on wire life *Study of newsprint machine wire life* by the Pulp and Paper Research Institute of Canada that showed there was a close relationship between wire life and wire tension; the device we showed is one way of ensuring that this minimum, once established, is not much exceeded.

MR. R. GARDNER: In our experience, substance can be maintained quite constant by adequate control in the preparation plant. Frequent adjustments at the stuff gate mean something wrong farther back. One cannot justify an automatic control to make an adjustment once in 4 or 5 hr. The same thing applies to moisture control: the short-term variables are regulated, long-term ones are adequately adjusted manually by the operators.

The papermakers repeatedly confound us on the size of chests for kraft preparation by 'soaking time'. We give them a large chest, the level of which is controllable to regulate the soaking time to the minimum, thereafter minimum capacities for general stock preparation.

* Garret, G., Eastwood, M. and Goode, M. F., *Instrumentation for the automatic start-up of the wet end of a papermachine*; *Tappi*, 1957, **11** (6), 403

MR. W. A. BANKS: We have a great deal of experience with semi-automatic systems using either cycling or duocycling refining methods: I think simplicity is a prerequisite of preventive maintenance and that process controls like the stuff gate can be manually set and left.

There are indications that the modified type of pulping equipment with elevated temperatures in the hydrapulper will reduce soaking (or after-soaking) time and chest sizes can consequently be reduced. Full figures from many full-size mill installations are needed before a complete analysis of this question can be made.

MR. H. R. HUTLEY: Referring to Mr. Underwood's comment you need a reasonably large surge chest to take up variation in percentage of sulphite to mechanical pulp in, say, newsprint furnish.

So far, we have dealt with newsprint mills or those that make one grade of paper all the time. Can these future trends be applied to mills making small and varied orders?

MR. BANKS: When groundwood pulp is fed directly into the blending chest and only sulphite pulp has to be slushed in a hydrapulper, it is possible to adopt a system of slushing and refining sulphite continuously, blending it directly with the groundwood. If so, there may be an argument for continuously slushing sulphite separately and continuously slushing the groundwood, treating the sulphite in the refiner separately. It may well be true that you need a chest of capacity to give reasonable mixing of groundwood to sulphite with present systems.

A small mill making many different grades of paper will require several small separate stock preparation machines to bring the various grades of paper within the scheme of automation. Here, we would lay down a very simple system to make one grade fully automatically. To make an entirely different grade, the basic flow diagram system must be modified and possibly the size and number of the stock preparation machines so that this second grade can be made at least semi-automatically.

MR. BALLS: We are frequently concerned with small mills that make many grades of paper. Of course, the system I showed for continuous stock preparation would require modification. Certain essential features of it, however, are useful and accuracy of metering and wide turn-down range have been proved. This gives wide flexibility of adjustment. We have installed systems where the colours and the clay are continuously blended into the stock pump suction instead of being blended into the chest to keep the machine chest free of colour and clay. The reduction in volumetric capacity permits rapid changes to new orders, with due care that the mixture is properly blended.

The stage from recording moisture content to controlling it is so simple and relatively inexpensive that it is a pity not to take advantage of it. Langmaid* reported the results of considerable statistical analysis of results and demonstrated that, when controlling drying steam from pressure or temperature, there was a scatter in moisture content of approximately 3 per cent. This was reduced to 1.5 per cent. by the addition of moisture control, which justifies it in preference to moisture recording only. Nowadays better results are obtained.

* Langmaid, J. G., *Year Book*, 1956, **11**, 279 (Amer. Pulp & Paper Mill Supts.' Assocn.)

Trends in automation in the paper industry

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Elliott Brothers (London) Ltd.

GIVEN AT THE SEVENTY NINTH GENERAL CONFERENCE : CONNAUGHT ROOMS, LONDON, W.C.2
ON 24th MARCH 1960, MR. W. A. GILMOUR IN THE CHAIR

Synopsis

Computing is suggested as the key to automation; analogue and digital methods are briefly described in order to discuss their relative advantages. Examples of use of these techniques in the advanced control systems that are the first stages in automation are described and analogue simulation is discussed as an aid to plant design and analysis. The development of further stages of control as local functional sections of computing rather than as a single large control computer is introduced.

Introduction

COMPLETE automation is the replacement of routine labour by instrumentation, control techniques and power-driven equipment. Not only does it enable tasks to be performed by automatic devices that were previously performed by human agency, it also allows tasks to be performed that were previously impossible on the grounds of complexity, expense or operator fatigue and unreliability. The benefits of automation are not necessarily a smaller wages bill, they can also be a more efficient mill or a more constant product.

The true key to automation is the function of thinking and deciding—in other words, computing. Mechanical handling and power actuation are the means of translating these decisions into actions on the plant. Instrumentation is a means of informing this computing device of the state of the plant. In this sense, the instrumentation is the senses, the computing device is the brain, the actuators are the muscles.

This black box called the computing device is nothing to be afraid of: an *on/off* controller is a computing device, a two- or three-term controller is a computing device. The concept is not new, the device is not strange and remote. In full automation, the computing will be a little more complex than in these simple devices; to balance this complexity, more reliable techniques have been developed and are being applied.

Mr. Sutherby and Mr. Mooney are in the Sales Department, Pulp and Paper Industry

Computing and logical processes

IT is necessary to understand a little of the strengths —and the weaknesses—of computing techniques to understand the present-day trends in automation.

We have two basic computing techniques, the analogue and the digital; in most applications, each could perhaps be used, but each has its particular strength that leads to its selection for certain purposes, though there is naturally a band where they overlap and the choice will depend perhaps on other considerations. They can, of course, be combined in order to obtain the advantages of each in a single system.

Analogue techniques are the more familiar to the engineer : every time he takes a pneumatic line from a transducer to a meter, he uses air pressure at an analogue of his process variable and every time he feeds this pressure to his two- or three-term controller, he feeds it to an analogue computer.

Analogue computers work on displacement, air pressure, electric voltage or electric current proportional to the variable that is being represented. Voltage is the most flexible medium and will normally be referred to, but most analogue computations could equally well be carried out pneumatically or by using electrical current. Means are available for adding voltages, for multiplying voltages and, if necessary, for integrating and differentiating voltage.

Now consider what might happen if a plant engineer wanted to know the heat used by his drying cylinders. Steam flow alone is no use, since the temperature or the pressure of the steam might also fluctuate. Furthermore, the steam, after it leaves the cylinders, gives up heat to the condensers. If the engineer tries to do the necessary calculation by hand, he will use his steam tables to obtain heat per lb. of

steam going into the cylinders and the flow rate will then give him heat per minute. He will now do the same calculations for the exhaust steam and subtract their result from the input figure; he will then have the heat used by his drying cylinders.

If the engineer wants a number of cases to draw a graph with, he must do a number of calculations. He would obtain a quicker and easier result by employing analogue techniques to do the calculation continuously and to draw a continuous curve for him. Where he would multiply, we have a unit doing the multiplication continuously; where he would subtract, we have a subtraction unit. For each of his separate sums —each addition, each subtraction, each multiplication —we have a unit and these units are working continuously on the instrument readings and we can thus draw a trace of heat used.

We may go on from here, should the requirement be stated, by further increasing the number of computing units. The accuracy of their results in a calculation such as this is perhaps 1 or 2 per cent. of full scale less than the figures obtained by accurate numerical calculations directly from meter readings. These errors increase slowly with the amount of calculation carried out.

In addition to this limitation on accuracy, it is not easy on an analogue system to allow for time delays—that is, distance velocity lags—nor is it easy to store values for a long period.

Digital techniques are in many ways complementary. Basically, they are electronic versions of the abacus or the desk calculator using electronic versions of the relay. The speeds at which these machines are required to operate eliminates the possibility of using moving parts. The abacus or the desk calculator uses counting techniques and follows mechanically the same process as is used in doing sums on paper. The digital computer does the same thing using electronics rather than beads or pin wheels.

The use of relays is less obvious and, rather than go into details, it is easier to trust that the more complex systems can work on elaborations and refinements of a few simple ideas. The first idea is that, to work out a sum on paper, figures are written down or stored. In a digital computer, an 'electronic relay or logical unit' will become energised and 'hold' this state; this can then correspond to the digit written down in the particular line of figures of the sum.

Secondly, a desk calculator can add, subtract or multiply by the use of pin wheels and similar devices; an electronic computer contains the equivalent of pin wheels and can in a similar manner add, subtract or multiply.

Thirdly, to carry out a computation on an adding machine, there is a certain sequence of operations—set up first number, set up second number, operate lever for addition, write result on paper and so on; the equivalent programme of operation can be written down and given to someone else to carry out. For a computer, the programme is written down and then stored in the digital computer itself, where it can be used at the computer's own very high speed. Finally, when these logical units are switched, their output current can be used as a signal outside the machine as well as in it, just as if a switch or a relay contact had been closed.

The digital computer with these electronic relays (or logical units) works very fast; whereas a relay may take 20 millisec. to switch, a logical unit may take a microsecond or one twenty thousandth as long. The latest transistorised logical units are extremely reliable and fully suited to industrial uses.

The digital computer can easily store numbers and, as a result (in order to economise on equipment), it carries out each separate computing operation in serial form and thus it is in some ways slower than an analogue computer, but it is still many times, even many thousands of times faster than a man. On the other hand, the digital computer can on large systems be cheaper, more flexible and very much more accurate than an analogue machine. It is the digital computer that can most easily be used for the making of calculations or of routine decisions, which need only be made once a day, once an hour or even once a second. The same machine can carry out a large number of such calculations on a time-sharing basis. Therefore, it is the digital computer that is used for payrolls, economic and scientific calculations and the other forms of office work. The analogue computer is better if an output is required continuously from a single computation.

One or two applications of computation will serve to show how these techniques are used in practice.

An analogue computing application

By use of a moisture meter, it is possible to measure the mean sheet moisture content at the dry end of the papermachine. It is also possible to install a basis weight measuring device; but, in a normal beta-gauge, the reading obtained is one of total mass, not fibre mass or oven-dry basis weight. Automatic control of the oven-dry basis weight is rendered difficult by the effect of the normal moisture

content. However, it is possible to use an analogue computing unit to subtract the reading of mean moisture content continuously from the mean beta-gauge reading and the result is the oven-dry basis weight, that is, a reading of fibre content alone. This reading can be used to set about controlling the stock flow to obtain constant basis weight.

This is an example of a deductive measurement. Two readings that can be obtained with available instruments are combined directly and continuously, in a simple computation, to obtain a reading of some more difficult measurement. It is also possible to obtain not only a mean oven-dry basis weight, but also an oven-dry profile free of any complications because of moisture streaks. This information is thus easily available for slice adjustments or investigations into the head box flow. This shows how a simple analogue computation can be used to remove unnecessary labour and improve product quality.

Analogue simulation

ANOTHER aspect of analogue computing that is quite distinct from on-line control is plant investigation by means of analogue simulation. This means the building up of a mathematical model of the plant by using the adding, subtracting and multiplying boxes of an analogue computer; in this case, a general purpose machine, in which the model can be built up by choosing the interconnections of a number of standard computing units.

It is possible to write down the equations of, for instance, the ideal mixing of a flow of diluting water to thick stock in terms of a mass balance equation and a fibre balance equation; black boxes or computing units may be set up to solve these equations and so simulate the process; in the same manner, tanks, head boxes, controllers, valves, pumps and so on can be simulated. Then, ideally, we can build up a model plant, we can try out suggested control loops, we can experiment in a way no plant manager would permit on a production mill and we can investigate new designs and all this on a general purpose model that can be used for something quite different tomorrow.

There are, unfortunately, many hidden traps in this picture. You may have noticed that we slipped in the word *ideal*. The mathematical expressions for ideal flow of a perfect non-viscous liquid are fairly easy, for a viscous liquid they are manageable; when the effects of changes in viscosity owing to the thixotropic nature of the liquid, the instability of eddies and the separation of layers of different density are taken into account, the expressions become terrifying, the finding of the correct constants a considerable task and the simulation correspondingly difficult. It may be possible to circumvent some of these difficulties by ignoring certain effects and simplifying others, but the simulation must lose something in trueness.

An approach that can be employed is the use of computation in simple cases to obtain the optimum settings for ordinary controllers. It is possible to use the analogue computer itself to obtain the optimum settings within the limits of process knowledge previously mentioned.

The method is very powerful and it is essential if plant design is ever to advance to being a science from being the art of intelligent extrapolation from previous plants to the new designs. It is necessary for more and more simulation work to be done on simple sections of the plant until engineers and simulation experts have built up the necessary quantitative knowledge of the operation of the plants. When this has been done, full advantage will be obtained from the power of the method to provide a cheap mathematical model on which it is possible to experiment and to avoid the trial error techniques at present being applied to full scale plants.

This paper is not concerned with the instrumentation problem, but an example of the advantages of the third aspect of automation—mechanical handling and power actuation—is instructive. It is obvious that the greater the capital invested in a single papermachine, the more expensive the hold-ups on this machine become. One example of what can be achieved in minimising these delays is an automatic device available in America that, following a break at the wet end, will have the paper back on the machine within about 15 sec.

This device makes use of position control of water jets controlling the paper width. When a break starts on one side of the web, a jet is immediately started to provide a cut down the sheet to isolate the break and this jet is then moved slowly back across the wire until the sheet is restored to its former width. The paper wastage is reduced to 15 sec. worth of production and complications from disturbance to the thermal equilibrium of the dryers are avoided.

Local digital control

IF one could simulate a plant fully, one could know all about its performance and at any time one might be able to calculate the settings of every control in the plant to obtain the desired result, which of course

assumes complete knowledge and complete instrumentation. In an imperfect world where neither of these things is available there is an important step towards full automation—the optimising controller, which is a form of automatic experimenter.

The papermaker has moisture control loops, possibly a basis weight controller or other loops keeping the product within some of its specification limits, he will have his specialist knowledge and he may also have instruments indicating surface finish or some similar quality. He has instructions to make paper to a certain specification and as much of this paper as possible. He will have a number of settings under his control (dryers, vacuum box, machine speed) and he will set these to what he considers the optimum conditions to keep to his instructions. In general, for one paper quality, he will keep to these settings, but he may occasionally make changes according to his knowledge of machine performance; there is rarely any method of showing that the machine is running at its optimum conditions, not to a satisfactory setting.

This is just the sort of problem that a small computing device was designed to answer. There are available today optimisers, which are digital computing units that will carry out untiringly routine tests to obtain maximum efficiency.

If a target is chosen for a plant, maximum production, maximum production per lb. of steam, minimum cost or anything else, it first requires instrumentation capable of producing the required information. It is then possible to compute an index of this target, which the controller should maximise. In order to carry out this maximisation, the controller first reads the index, then it makes one or more small variations to the settings of the variables under its control—steam valves, controller set points, etc.—the form of these variations depending on an elementary amount of knowledge of the plant. After giving the plant time to settle down (and this time must be known), the controller looks at the index again—if it has improved, the step was beneficial and should be repeated; if it has become worse, the step was a bad one, it should not be repeated and some other step should be tried.

This device can at the same time provide for keeping some quantity at a specified reading. The optimiser is arranged so that the variations it puts into each setting are sufficiently small not to endanger the plant and their range is so limited that under no circumstances can the safe operating limits of the plant be exceeded. This technique has many applications in continuous plants such as in paper or pulp mills; providing there are several ways in which a specification can be achieved, a device such as this can be continually searching for the best way.

What has been described so far are systems that are already applied to papermills or else proved on other plants and on the shelf waiting for someone to decide to install one in a papermill. It is now possible to consider developments from these techniques; taking as the objective an automatic papermill, which is a computer-controlled papermill. This gives rise to the idea of a central computer locked away in an office connected by miles of wiring to all parts of the plant and reading every instrument, controlling every actuator. This is a frightening prospect, for in this complex computer only one resistor has to fail and the whole plant may come to a grinding halt. Consider, therefore, an approach to computer control from the other direction.

We already have a partially computer-controlled plant. We have specialised analogue computers (two-term controllers) controlling local loops. This paper has described larger, but still small, computers (optimisers) controlling the set points of conventional controllers, while these local controllers looked after the normal random variations on the plant. If you consider the conventional controllers as doing the routine work of the lowest grade of plant labour then the optimiser or the analogue computing loop do the routine work of the next grade. Other local computers, small special purpose devices could do the local work of, say, supervising the beaters or the pulpers. Over these, another computer will do the routine work of the mill manager and so on. Each unit will have a limited task, it will receive instructions from a computer with higher responsibility and it will issue instructions direct to the plant or more often to a computer with a lower level of responsibility. We have echelons of computers as we have levels of management. In this system, should a resistor fail, the effect is not unlike a man being ill, his office ceases to issue instructions and the plant runs on at slightly lower efficiency until he returns.

It has already been shown that savings can be obtained by computers installed to do office calculations. At least one of these is now working in a large British papermill. These computers fit into this scheme quite easily. In time, the provision of information to them or the actions taken on the information they provide will be done by other computers, not by office workers carrying out routine work.

Besides the obvious advantage of this approach, that a single failure will not stop the plant, this idea has many other benefits, each separate computing unit is simpler and therefore easier to test. Besides, units can be installed separately, thus increasing efficiency in stages without a very large and expensive equipment programme.

The rate at which automation can come could be much faster than many people realise. It is not necessarily going to come in a moment as a complete new mill, it will creep up as more and more loops are completed in existing mills, as the instruments and the knowledge become available and as these loops are linked by management type computers.

discussion

MR. A. F. TOUT: In discussing optimisation, Mr. Sutherby used the analogy of a man using an altimeter to find the top of a hill. The implied alteration of one factor at a time is equivalent to the restriction that the man must move always in an E–W or N–S direction, in which case the highest point he reaches will not be the top of the hill, unless he is very lucky. Furthermore, in studying the variables one at a time, there is a danger of confounding time trends with the main effects. Is the control mechanism capable of dealing with more than one variable at a time?

MR. P. F. SUTHERBY: The tactics employed by an optimising controller can vary with the application; two or more inputs can be varied at a time (if this is necessary) and the performance of the process is well enough known to allow this. The principle of always walking uphill is bound to lead to the top, but noise can have a slowing effect on the rate at which the optimum point is found. Besides, if the optimum point is changing because of uncontrolled variations, the optimiser must change the controlled variables fast enough to keep up with this rate of change; this is a limitation in certain circumstances.

MR. W. A. BANKS: As machinery designers, we have a great deal of interest in fundamental hydraulics. I question the mathematical connection between two models: I am thinking particularly of centrifugal pumps. We can make a model of a centrifugal pump and produce a mathematical formula that enables us to scale up that pump; the mathematical connection is known as specific speed. This holds good provided the pump is working on water. Immediately we introduce papermaking fibres into the fluid, the whole problem becomes complex, because we cannot scale fibres down. What happens in other industries carrying out similar research work using suspended solids?

Secondly, the question of optimising. Unfortunately, the modern refining machine does not perform as a straightline function; in fact, not even a square function. The rate of change of freeness to a rate of change of set load is more like an asymptote: adjusting the plug increases the load, but there is little (if any) change in freeness; a further adjustment changes the freeness by a large amount. You mentioned use of computing, some of which, if not satisfactory, would become more complex. A simpler and more economic way of controlling freeness is to use proportional control, which makes for much cheaper instruments.

MR. SUTHERBY: Mineral processing is another typical industry in which particle size problems cause difficulties in scaling down; in this, the distribution of particle size and the preferential behaviour of certain sizes also make mathematical analysis very difficult. This emphasises the need for co-operation to overcome these difficulties.

I certainly do not suggest a complicated system where a simple one would do, but there are cases when a simple control is insufficient.

MR. L. A. LAWRENCE: I have seen one or two computer installations and I believe the machine will work only on the binary system. Is the conversion to the machine and the conversion from the machine done automatically? Although preparation of wage packets and the like may be their immediate useful function, their true function will lie in their application to industry, with enormous possibilities.

MR. SUTHERBY: In the decimal input device, knobs are set to the required decimal number by an operator and decimal displays or printouts are standard. I think computers were more rapidly introduced into the business world, since the working of business processes is more easily defined. To express the exact numerical relationships and time delays of, for instance, the effects on the output of a papermachine of a change in input conditions is very difficult. Even in the more straightforward case of accounting systems, many difficulties have been encountered.

general discussion

MR. L. LANDON GOODMAN: Recently, I have been in touch with papermaking and converting companies to try to obtain figures of savings resulting from the introduction of automation, but to little avail. There are a number of applications of automatic control in the paper industry, therefore it is surely not too much to expect that these figures would be available and I found it disappointing that no such figures were given in the papers or in the discussions. I have heard that the application of moisture meters pays off in about four weeks. Figures from one or two of the large papermakers in America suggest that it is quite usual to expect about two years' purchase for reasonably large capital outlays in this field. Two years' purchase is a very good investment. Are similar returns being obtained in this country?

Mr. Gardner mentioned a figure of 3 per cent. for the instrumentation of No. 13 machine. It has been calculated that the cost of complete instrumentation of a new plant (not instrumentation of an existing plant) to automate it as fully as possible is, taking an average for all industries, 6 per cent. of the total investment in plant and equipment. Therefore, the paper industry has an advantage over many other industries. When the cost of equipment was mentioned, it would have been both interesting and helpful to have had the figures for costs per unit output. In the motor industry, cost per unit output is sometimes lower for automated plants than for conventional plants.

Benefits of automation are not easily costed. In other cases, there are many hidden savings that have been mentioned and are worth repeating. There is the reduction in human drudgery. Many jobs in industry inspire neither man nor management. New methods are a challenge. Uniformity and consistency of the product are extremely important. These may well give a larger share of an expanding market. Reduction in reject material is, of course, most important. One large, non-British company—not in the paper industry—had an extremely low figure of 1 per cent. for rejects. When they applied full automation, that figure fell tc 0.3 per cent. There is, too, saving in floor space, increased output from plant at its existing size, improved safety and, on the debit side, an increase in technical staff and more maintenance. Maintenance can be a problem and it is necessary to study the automation of maintenance, as well as the automation of plant.

There is the thorny question of the amount of research and development. Throughout industry, one of the stumbling blocks to the application of automation is the development of sensing devices. Is sufficient research being carried out, both in your industry and in the industry of your suppliers? Certainly, the amount of research being done today in this country is open to question. Some of the large chemical companies have found it necessary to develop a proportion of their own advanced instrumentation, which they then put out for manufacture.

My own feeling is that instrumentation, particularly sensing devices, requires much more concentrated research, which should be carried out by users as well as by suppliers. The cotton textile industry developed rapidly when the mills developed their own machinery. A rapid decline occurred in this industry when the development of machinery was left to textile machinists and cotton textile machinery has literally not developed significantly since the end of the last century. There have been improvements, of course, but fundamental developments have not come about. The need for research must be repeatedly emphasised and with it the necessary standard of technological knowledge. Practical knowledge is vital, but it is on practice combined with theory that this country must build its future. Plant should be designed together with instrumentation and control equipment: electronic equipment on existing plant is not the best way. It was stressed that high speeds and the present design of paper plant do not go together. The present type of mill was in its day—and still is—a remarkable piece of development, but is there anyone here who would say that it will take the same form in fifty years' time? If not, it means there are going to be developments—then let us have them earlier rather than later.

In order to use computer, instrumentation and control techniques plus other ideas about which we have heard, it is often necessary to break down operations into basic steps and rebuild them employing these artifices. The possibility of a breakdown in a centralised plant with computer control has been discussed. Consider the analogy of man who has one central organ in his head that directs his movement—his brain. The brain can be damaged and portions removed without really affecting the I.Q. or personality, except that melancholic tendencies may be reduced. In the human body and in the brain in particular, there is a high degree of redundancy. We

can introduce a degree of redundancy in our plant and equipment by planned duplication and so overcome breakdowns. If you specify in the course of your researches that you require a degree of redundancy, you need not fear outages.

In my studies in the paper industry, I have found that one or two places other than the preparation plant and the mill lend themselves particularly to improvement. There are all the ancillary operations, the handling of the raw and finished material, the warehousing and, one step further than that, there is a wealth of work to be done in improving handling on the converting side, but that is outside the scope of this conference.

It should not be long, in my opinion, before the paper industry will be applying more and more automation leading up, not to a completely automatic mill, but to a mill with a high degree of automation in the smaller, may I call them batch mills that have to change their orders regularly, than you will find in the very large newsprint mills.

MR. P. H. PRIOR: We hear much of computers, relatively expensive to purchase and use, but with truly amazing powers for very difficult problems. Is it possible to have an intermediate type of computer to deal with rather smaller problems at less cost? Is progress actually being delayed by so much attention being given to such super-capabilities on problems beyond the needs of most businesses?

MR. SUTHERBY: I think there are a number of possible replies, but the answer is largely one of economics; small special purpose computers, analogue or digital, can certainly be built, but a general purpose machine enables design costs to be spread over a large number of units and the writing of a programme is much cheaper than designing a special purpose machine. Even here, however, there is a balance in very small machines.

MR. G. F. J. MANSELL: Could Mr. Gardner enlarge on the subject of continuous measurement of gloss?

MR. R. GARDNER: It is a current investigation and we have installed two permanent installations for gloss measurement on a supercalender with every indication that the operator can achieve some benefits from them.

MR. MANSELL: You would be traversing the sheet, I presume, not taking a single position measurement.

MR. GARDNER: These are static positions, one on each side of the sheet. We agree that scanning equipment would be more advantageous and see little difficulty in such an installation.

MR. G. THOMPSON: As a generalisation, all the authors have put forward a very strong case for low chest capacity after preparation, metering and blending, pointing out the economies and low capital costs that result, presupposing that the raw materials going forward to preparation are uniform. If not, then with low capacity storage we shall suffer all the way through, in spite of excellent control in metering and blending, unless we have excellent consistency control and continuous freeness recording, which is not yet a reality. With baled pulps, there is uniformity within limits. What happens in an integrated or partly integrated mill, because the chemical pulp component of the furnish will probably be batchwise and, therefore, have variations. If there is also a groundwood system, it is well known that it is subject to considerable variation; only by mixing and blending in quantity is the product reasonably uniform.

Mr. Balls' paper referred to a partly integrated mill where all this continuous measuring and metering was in operation. In view of the excellent claims made about its operation, what are the relative storage capacities before and after metering and blending?

MR. B. W. BALLS: This is an individual problem and should be discussed in relation to the particular system concerned. The case I described used slush groundwood and baled sulphite pulp and the mill was responsible for specifying the conditions of operation. The conventional method of using a large machine chest is not essential in a continuous blending system and the blending chest can be quite small. Some of the chests in the forward part of the system can also be smaller than is usual. The mill has its own problems, for example, on the groundwood side, in bringing the slushed pulp forward uniformly. In automatic control work, we are concerned principally with the blending part of the system.

MR. W. A. BANKS: In an integrated mill where the groundwood is prepared in a groundwood mill, then pumped over into the papermill, I have watched this several times. On a Monday morning at start-up, the system is not really stable until it has been running for 4 or 5 hr., when the groundwood mill itself has settled down to a level condition. This suggests having a large blending chest.

Mixing stock and its additives with water is done relatively simply in a centrifugal pump, with water coming back from the wire pit. In other chemical industries, axial flow constant delivery pumps, one for each additive introduced into the mix, are used. These are then brought to a central centrifugal pump that actually does the mixing. Systems are working with no less than five components, three of which are solids in suspension. The unit is rather cumbersome, consisting of one housing, around which are set a series of axial flow pumps. I feel sure we could use this for newsprint, by mixing the groundwood and the sulphite in a hydrapulper of the type I described and discharging from this a uniform stock to this special pump, where additives such as colour, size, clay, etc. could be introduced.

Our development department is building a mixer like this to decide its suitability for mixing. From our experiences of storage chests using poplar groundwood from Northern Italy and Southern France, chests with conventional agitator equipment give poor suspension of the groundwood in the water and the power required to agitate satisfactorily is comparatively high.

MR. C. R. G. MAYNARD: We have heard it suggested that our industry is probably not carrying out enough research in this field. If members of the panel agree with this, on which particular parts of the field should more research be done? Do you think the individual paper companies ought to carry it out or should it be done co-operatively for the whole industry by the Research Association?

MR. BALLS: I consider that the paper industry does a considerable amount of research into its own problems and many ideas have been handed over to instrument manufacturers for commercial development.

MR. N. C. UNDERWOOD: There is definitely insufficient research work being done, but this is due primarily to a shortage of top grade scientific personnel. Speaking from experience, the development of instruments requires a tremendous amount of effort and we doubt whether we gain either technically or financially as much as when developments are carried out on the process itself.

MR. C. G. WALLACE: What has been done for automatic control of the soda recovery process in some of the smaller esparto mills?

MR. BALLS: In Scandinavia, for example, a vast number of recovery plants are fully controlled. Evaporators, where the basic instrument measures differential temperature at the final effect to control the required density of liquor, the recovery furnace, green liquor, causticising and liquor blending are all automatically controlled. Approximately three times as many instruments are required to make pulp compared with the instruments required to make paper from the pulp.

THE CHAIRMAN: Mr. Underwood said, 'When the machine parameters that determine the desirable properties in the sheet are known, it is supposed that measurements taken either on the machine or in the control laboratory will be fed back in a known manner so as to alter the machine conditions.' That is very true and not very satisfactory for automation. Does the panel think that what is really wanted is a very thorough investigation of non-destructive testing of paper in connection with its applicability for various purposes, because it is only when you have such tests that you can monitor them on the machine?

MR. UNDERWOOD: Yes. Our problem now is that our customers are asking for controlled properties that we do not know how to control. For example, while one knows how to make the strength of a paper come up to specification, it is doubtful if the stretch at break can be controlled as easily. This points out the need for much more detailed investigations on the paper-machine to find which lever or valve is turned when the routine test laboratory says the compressibility in the thickness dimension is not what it ought to be. This is the sort of research that pays off rather than adding refinements to a new compressibility tester.

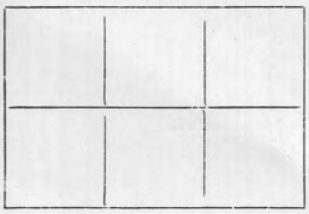
MR. P. F. SUTHERBY: Until one knows the exact effects of changes on the machine, one cannot carry out complete control. This control can then be very much tighter, if measurement can be made on the machine rather than in a laboratory.

MR. BALLS: One important criterion—the octane number of gasoline—is impossible to measure continuously and is determined by an engine test with little possibility of feeding the result into a process control system. Faced with this problem, a petroleum company has developed a measurement based upon the use of standard instrument modified to measure 'octane improvement' continuously as a guide to plant operation and it is now available commercially. This indicates that when there is a need and when a number of people are working together, the answer will come out in due course.

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(Summaries from foreign journals continued from page 230)

Determination of hardness-forming substances in water

A. G. Rurchemie, H. List, A. Gubin and M. Jung
G.P. 961/035; *Chem. Zbl.*, 1957, **128**, 9187

(from *Water Pollution Abs.*, 1959, **32** (7), 231)

To determine hardness-forming substances in water, measured amounts of water are mixed in succession with measured amounts of an indicator solution and of a buffer solution. The mixtures are passed through a bulb, through which light is passed to a photocell that converts it to energy impulses used for operation of measuring, indicating and controlling apparatus. Indicators and buffer solutions used are within a range of 0–0.2° (German) of hardness.

Measuring the whiteness of optically bleached papers

L. F. C. Friele
Papierwereld, 1959, **14** (3), 393–396

A PHOTOMETER with suitable tristimulus filters or possibly a spectrophotometer can be used for measuring the TAPPI brightness of paper that contains no fluorescent additive. Such measurement depends upon the remission of blue light and the intensity of the light remitted over the range of visual wavelengths. Results with optically bleached papers, however, do not tally with visual assessment, as the fluorescent material converts ultra-violet light into blue visible light and this, added to the directly remitted light, compensates the yellowness and so raises its visual whiteness. Light sources in ordinary photometers provide hardly any ultra-violet light and the optical bleaches cannot therefore have any effect.

The Elrepho photometer uses a xenon arc lamp to provide a substitute for daylight and, in conjunction with tristimulus or colour filters, can be applied satisfactorily to the rapid measurement of whiteness in optically bleached papers (allowing for a correction filter, as the other filters are designed to be used with a filament lamp light source). Results are reported of an investigation that used 28 observers to determine the brightness of various papers (some of which contained optical bleach), using the method (No. 116) published by the Delft Fibre Research Institute.

It was found that the brightness value did not discriminate for overblueing nor for reddish or greenish departures from white. The observers were all untrained in paper assessment and judgment was shown to be influenced by the size of the sample and the brightness, as well as the colour of the viewing surround. Standardisation of these conditions is at present under review internationally.

Research is in hand on the physical efficiency of optical bleaches. So far, it has shown that the conversion of absorbed ultra-violet light into visible light is practically complete and no improvements in effectiveness can therefore be expected. Visual efficiency, however, can vary widely, as the eye is more sensitive to optical bleaches in the green range than in the red range.

The various stages in bleaching a kraft pulp and its strength properties

P. Colombo, D. Corbetta, A. Pirotta, G. Ruffini and A. Sartori
ATIP Bull., 1959, (1), 4

THE aim of this work was to find a bleaching process that would give a pulp with as high a degree of whiteness as possible (80—84 G.E.) and having strength properties similar to those of the unbleached pulp, whilst keeping production costs within economic limits. The bleaching agents used, at least in the first stages of bleaching where the degradation of cellulose is only slight, were chlorine gas and sodium hypochlorite. The final bleaching treatment was studied, using several agents that have a milder effect on cellulose, in order to compare the degrees of whiteness and stability attainable with a range of bleaching agents.

Bleaching tests

The chemical characteristics of the two pulps used are given in Table 1.

TABLE 1

Property	*Kraft pulp 1*	*Kraft pulp 2*
Holocellulose (%)	96.00	94.80
Alpha-cellulose (%)	86.00	83.60
Solubility in 17.5% NaOH (relative to pulp weight) (%) ..	9.60	9.02
Solubility in 10% NaOH (relative to pulp weight) (%) ..	8.93	11.90
Pentosans (relative to holocellulose) (%) ..	11.40	11.70
Cuoxam viscosity 1% (cp.) ..	101	103
Roe number	4.20	5.70
Permanganate number TAPPI (25 c.c.)	17.10	20.10
Theoretical chlorine demand for bleaching (%)	7.00	11.30

It is interesting to observe the consumption of chlorine during the reaction. In the first 5 min., 70 per cent. of the chlorine is used up; in the next 25 min., another 25 per cent. is used and, finally,

it takes 70 min. for the remaining 5 per cent. to be used.

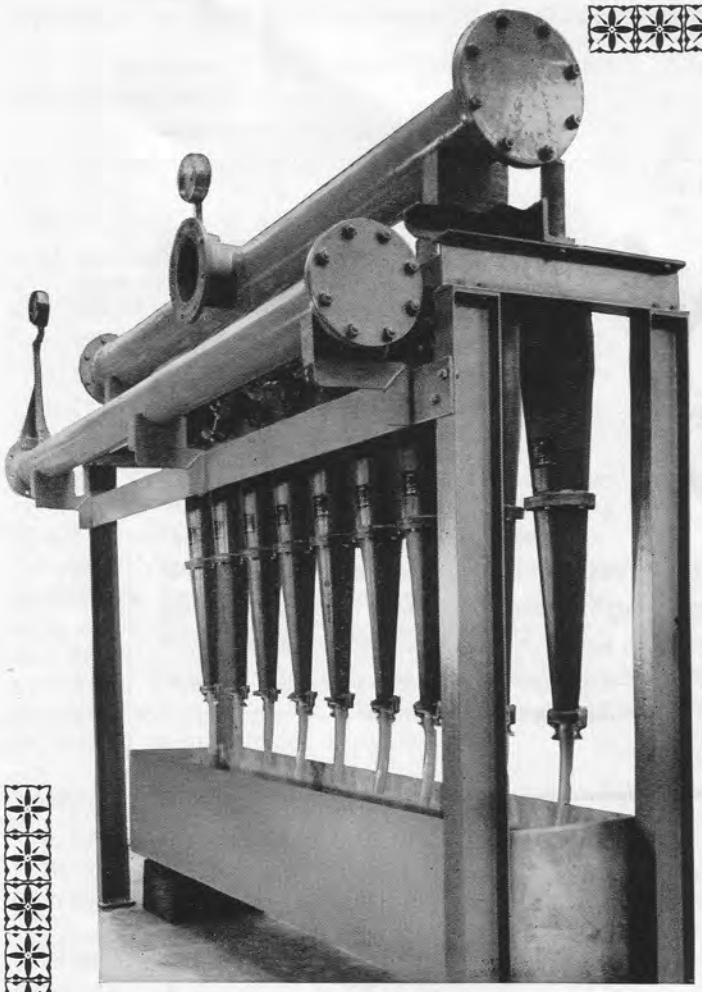
Experiments were carried out to study the effect of chlorination on the permanganate numbers and viscosities of the two pulps. When chlorination was done in two stages, the permanganate number decreased more rapidly and, for a given chlorine addition, the quantity of residual encrusting material was lower for the pulp treated in two stages; on the other hand, the viscosity also was lower. It is evident that the effect of removing the chlorinated lignin by washing with alkali after the first stage is to make the reaction of the chlorine with the encrusting materials in the second stage more energetic, but less selective, so that cellulose degradation is increased. It should be noted that the reaction time for two-stage chlorination is double that for single-stage and, consequently, oxidation of the cellulose is more likely. It is true that single-stage chlorination is best for making a bleached pulp that will have high strength properties in the later stages and this makes it possible to increase the degree of whiteness without simultaneously reducing the viscosity excessively.

During chlorination, the encrusting materials are changed into soluble products and the purpose of washing with alkali is to remove these materials. This problem has been investigated fairly extensively, so the tests in this work were confined to an investigation of the effect of pulp consistency and the best results were achieved at a consistency of 15 per cent.

TABLE 2—FINAL STAGES OF BLEACHING OF PULP ROE NUMBER 5.7

Properties measured	*Alkaline wash + hypochlorite*	*Alkaline wash in the oxidising phase + hydrogen peroxide*	*Alkaline wash in the oxidising phase + chlorite*	*Alkaline wash in the oxidising phase + hypochlorite*	*Hypochlorite + hydrogen peroxide*	*Hypochlorite + chlorite*	*Chlorite + hydrogen peroxide*	*Hypochlorite + perborate*
Degree of whiteness								
Preliminary stage	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5
Stage 4	63.7	73.5	74.0	73.5	76.5	79.0	78.0	76.5
Stage 5	76.5	78.5	79.0	80.0	84.0	82.0	82.0	80.0
Decrease in whiteness (points)								
Stage 4								
24 hr. at 100°C	5.2	8.5	7.5	6.0	11.0	10.0	9.0	10.0
Stage 5								
24 hr. at 100°C	2.5	3.0	3.0	5.0	2.5	4.0	2.5	4.0
Exposed to light for 1 week	4.0	2.0	3.0	4.0	2.5	4.0	2.0	3.5
Stored	5.0	0.5	2.0	2.0	2.5	2.0	2.0	2.0
Viscosity								
Preliminary stage	41.3	41.3	41.3	41.3	41.3	41.3	41.3	41.3
Stage 4	38.0	33.0	24.5	36.0	22.0	22.0	34.5	22.0
Stage 5	20.0	21.0	26.0	23.0	19.5	23.0	30.5	23.0
Wetness (500° C.S.F.)								
Stage 5—								
Breaking length (m.).. ..	7 200	7 800	7 600	8 000	7 400	7 700	8 100	7 800
Tearing strength	108	110	117	114	106	110	116	102
Bursting strength	71	71	67	69	67	71	73	72
Beating time (min.)	13.5	13.5	16	15.5	14	14	17	15
Wetness (400° C.S.F.)								
Stage 5—								
Breaking length (m.).. ..	8 200	8 400	8 200	8 400	7 900	8 200	8 700	8 400
Tearing strength	98	98	106	102	95	99	106	92
Bursting strength	78	75	71	72	69	74	78	76
Beating time (min.)	20.0	20.0	21.5	21.5	19.0	20.0	21.5	20.5

(*continued on page 313*)



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(Summaries from foreign journals continued from page 310)

In the examination of the hypochlorite stage, two systems were used—

1. Chlorine – chlorine – hypochlorite
2. Chlorine – hypochlorite – hypochlorite

Experiments were carried out to find—

(*a*) The extent of degradation with a second chlorination stage in an acidic medium in comparison with hypochlorite treatment.

(*b*) The extent of degradation with a final hypochlorite stage relative to its bleaching power.

(*c*) The stability of the degree of whiteness when bleaching ends with a hypochlorite stage.

The pulp of Roe number 4.2 was used in all these experiments. The results can be summarised by stating that it is best to use all the chlorine in a single stage; this quantity being 70 per cent. of the total chlorine requirement for complete bleaching. After washing with alkali, no more hypochlorite should be added than can be completely used up in 90–120 min. This method of bleaching preserves the pulp's strength properties and the degree of whiteness is high enough for making various grades of paper.

Washing with alkali in the oxidising phase

It has already been seen that the reaction time of kraft pulp with chlorine must be as long as 60–90 min., even though the reaction is 90 per cent. complete after 30–40 min. In this way, the oxidising action of chlorine on the chlorolignins gives products that are more readily removed by washing with alkali. This effect can be increased by using alkaline peroxides that have an oxidising and depolymerising action on the chlorinated lignin and at the same time oxidise coloured substances that might be adsorbed on to the fibre.

Final stages in bleaching

By using chlorine, alkaline washing and hypochlorite in the preliminary stages, it is possible to produce a semi-bleached pulp with a degree of whiteness 65–70 G.E. and with strength properties little different from those of the raw pulp. The strength properties of a bleached pulp are not reduced by more than 10–15 per cent. when its viscosity is above 30 cp.; consequently, the final treatment is designed not only to give degrees of whiteness of 80–85 G.E., but also to keep viscosity at a favourable level. The results are given in Table 2.

Final stages of bleaching of pulp Roe number 5.7

Similar results were obtained with the Roe no. 4.2 pulp. In conclusion, it is observed that it is possible to bleach sulphate pulps to whitenesses of 77.5–84 G.E. by using various combinations of reagents. The strength properties of these pulps are all very similar and not more than 10 per cent. lower than those of the original pulp.

The effect of drainage conditions on the sheet-forming properties of pulps, with special reference to the amount and quality of fines

E. Giese and L. Dietzsch
Zellstoff u. Papier, 1959, **8** (2), 43–48

EXPERIMENTS were made on a laboratory scale to find the effect of varying the wire mesh size on sheet properties and especially on the amount and type of fines. The pulps used in the work were two groundwood and a beaten, bleached sulphite pulp. The Rapid-Köthen sheetmachine was used to make the test sheets and the wires had square meshes and a simple weave as specified in DIN 4189 (Wire weaves). The total aperture area of the wires was 37.9 per cent., as is usual for papermachine wires in general use. The weaves of the wires were—

1. 0.5 mm. × 0.32 mm. (No. 12 wire)
2. 0.4 mm. × 0.25 mm. (No. 16 wire)
3. 0.32 mm. × 0.2 mm. (No. 19 wire)
4. 0.25 mm. × 0.16 mm. (No. 24 wire)
5. 0.2 mm. × 0.12 mm. (No. 31 wire)
6. 0.16 mm. × 0.1 mm. (No. 38 wire)

The first figure given is the mesh aperture; the second, the wire thickness. The sheet basis weight was kept as low as possible and the amount of pulp used was just sufficient to form a uniform sheet on the coarsest wire.

The fractionation method devised by Unger was used to separate the fibres from the fines. With this method, the fractionator is fitted in the container on the Rapid-Köthen sheetmachine and the construction ensures that the fibres lie parallel to the wire, resulting in a sharp separation of the fibres according to length. Wire fractionation can separate fibres from fines, but it cannot distinguish between fibre mucilage and fibre flour. However, if aqueous suspensions of fines of the

same consistency are allowed to sediment, then it is found that a mucilage-rich suspension shows a higher sediment volume after a given period than one predominantly containing flour.

The amount of sedimentation can be used as a characteristic of the type of fines. In practice, the pulp is centrifuged in a new type of laboratory centrifuge at 39*g* and the amount of sediment is recorded photographically.

According to the type of pulp, the results showed that there was a fairly pronounced relationship between stuff losses and mesh aperture when a sheet was formed on the wire. This is particularly true for the fines fraction. The strength properties of the sheet—especially the static strength properties, since they are markedly influenced by fines content—reflect these changes in stuff composition. It was also found that high-quality, mucilage fines particles pass through fine mesh wires preferentially. Since the amount of this loss with high-grade fines is small, it has scarcely any effect on the value of the fines remaining on the wire.

For the practical papermaker, the results can be summarised by saying that in no case should pulps with a high fines fraction, such as pulps for making newsprint and medium fine papers, be used on coarse wires. This would result in a large loss of fines and a reduction in the initial wet strength, causing trouble at the pick-up. Previous work with very coarse machine wires, to find if machine speeds could be raised by increasing the drainage capacity, showed that the lower limit was a 21/10 wire (triple twill weave) at a speed of 1 181 ft./min. and with an open pick-up. The use of 20/10 wires (a coarser wire) caused great difficulties at the pick-up, doubled the number of wet-end breaks and reduced the machine speed by $98\frac{1}{2}$–$131\frac{1}{4}$ ft./min. When wire length allows, it is better to use a 24/10 wire. All relevant factors must be considered, however, before deciding on the drainage conditions in each case.

A new dynamic strength tester for heated paper

T. Eich

Das Papier, 1959, **13** (13/14), 301–305

THE question of testing the strength properties of paper while hot is becomingly increasingly important, especially in the packaging of such materials as cement, artificial manure and gypsum. In this case, the dynamic strength properties are considered to be more significant than the static ones and this is borne out by experience. At present, the most widely employed method of testing paper in a dried and/or hot condition is the drop method used for testing bags and sacks; as this method is extravagant in personnel, material and cost, a new and simpler method was developed.

In the apparatus, the test sheet is fixed centrally between a clamp and a circular plate, which has a number of radial holes through which pass streams of hot air. The jets of hot air are simply to keep the test piece at a high temperature during testing and to ensure that no moisture is absorbed. An arc-shaped metal rod is fixed to the end of the tester pendulum and to the end of this rod is attached the ball that actually penetrates the test piece. The pendulum makes an angle of 45° with the vertical in both the initial position and in the final position when it has been allowed to swing through its arc and the test is complete. When the pendulum is released, the ball contacts the test piece with a maximum speed of 125 cm./sec. and a kinetic energy of 51 cm. kg.

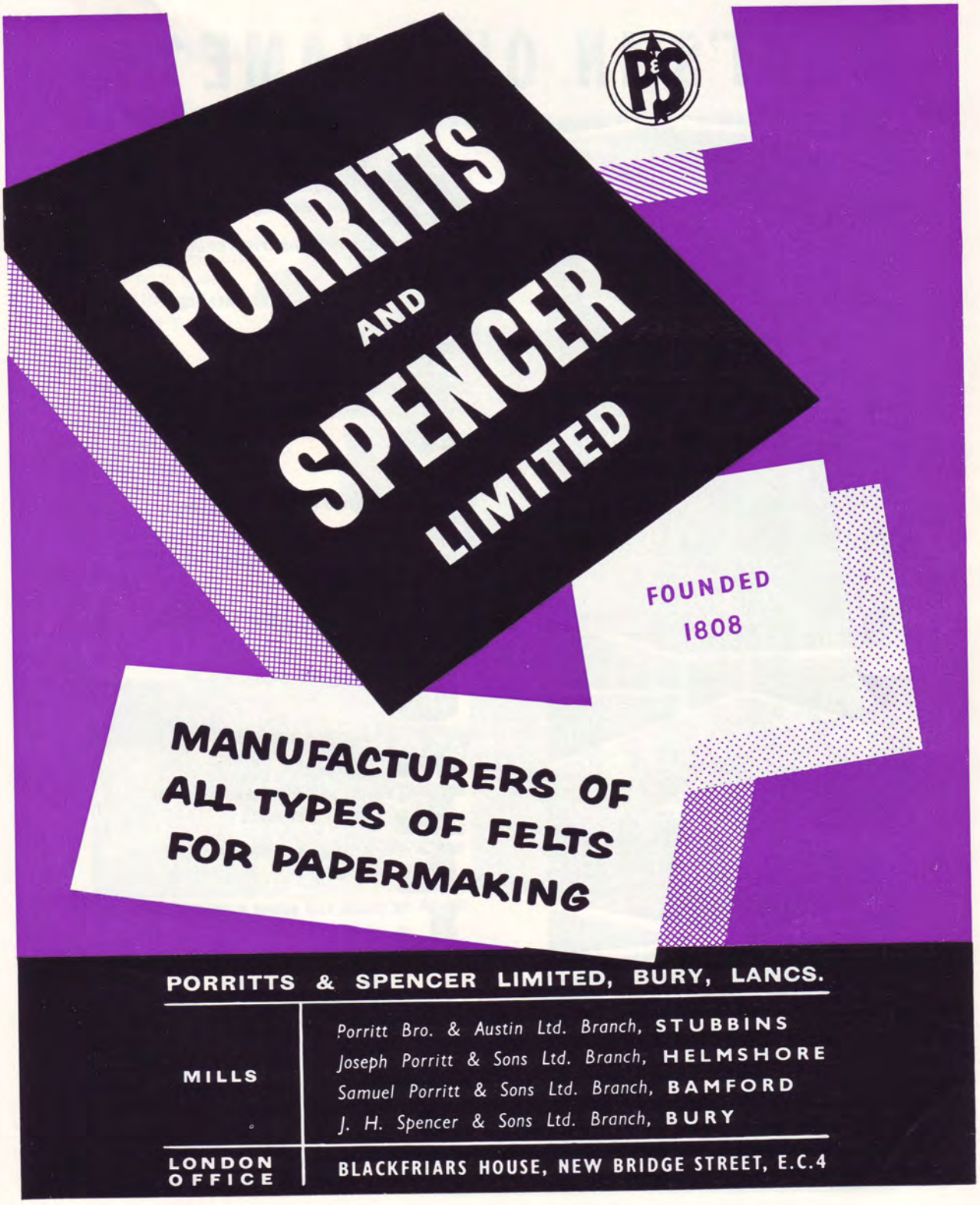
Using this apparatus, it was found that up to 100°C the moisture content of the paper had a pronounced effect on its penetration strength, the relationship between the values being almost directly proportional. In experiments on the relationship between substance and penetration strength, three papers were used—

1. Sheets made on a Rapid-Köthen sheetmachine of substance 50, 69, 89, 108 and 124 g./sq. m., the degree of beating being the same in each case.
2. Unbleached kraft bag paper of substance 72, 78, 89 and 95 g./sq. m.
3. Creped kraft bag paper of substance 75, 76, 83, 90 and 94 g./sq. m.

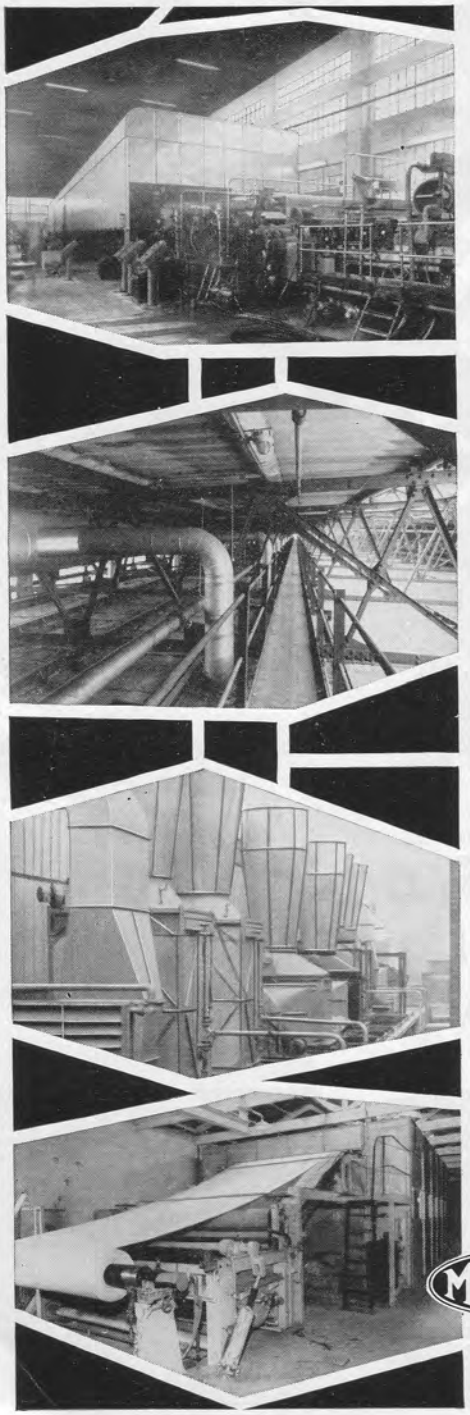
In the heat tests, predrying was for 6 hr. at 80°C and testing was also done at 80°C. The results showed that the penetration strength was proportional to the substance. The tensile strength, tensile stretch, static tearing strength, bursting strength (Schopper) and tearing strength (Brecht-Imset) were also determined, but only with test sheets *1* did these values show a definite relationship to penetration strength.

A final evaluation of the ball penetration apparatus cannot be made yet, as the amount of work done with it is still small, but work is continuing and will be published in due course.

(*continued on page 319*)


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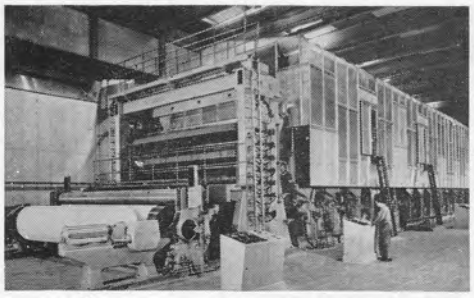
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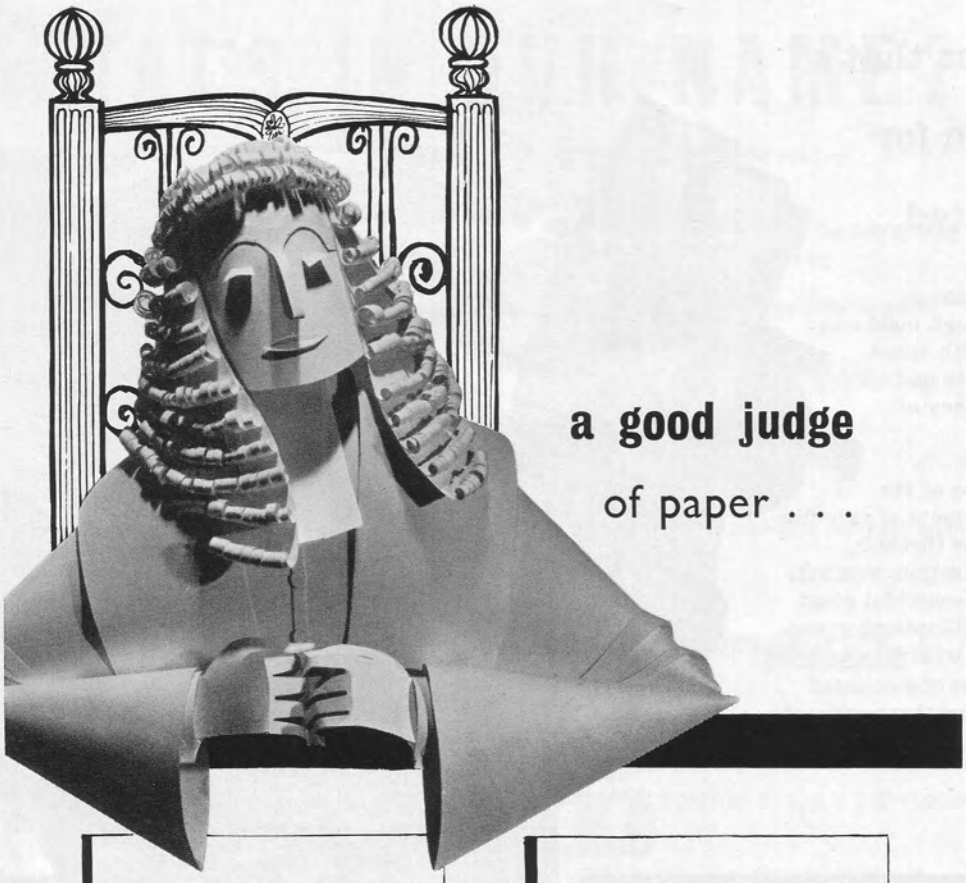
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(Summaries from foreign journals continued from page 314)

Luminescence analysis of mould contamination of paper

A. P. Petrova-Zavgorodnyaya
and D. P. Erastov
Izvest. Akad. Nauk S.S.S.R., Ser. Biol., 1959, (3), 403
(from *Chem. Abs.*, 1959, **53** (17), 16 536)

LUMINESCENCE analysis of mould contamination of paper offers a means for the detection of amounts of contamination that are hardly detectable by conventional methods. A study of luminescence elicited by monochromatic radiation with maxima at 436, 405, 365 and 313 mμ showed that the use of luminescence analysis for detection of mould foci on paper is only possible with a radiation source with a maximum at 365 and 313 mμ. Good luminescence is exhibited by moulds with a colourless mycelium.

At the initial stage of paper infection *Chaetomium affine* shows grey luminescence followed by a brilliant cornflower blue one, while the perithecia are at first brown and then become black; pigmentation is olive yellow. *Fusarium moniliforme* shows light yellow luminescence at the initial stage of paper infection, which is followed by a brilliant canary one. *Sporotrichium bombycinum* has at first a cream luminescence and then a violet one.

Colour photographs of mould luminescence, catalogued empirically, provide a rapid identification by luminescence analysis of the infection foci of documents.

A new method for investigating the structure of paper

P. V. Prober
Bumazh. Prom., 1959, **34** (9), 19–20

THIS is an easy and rapid method of obtaining information on the structure of a sheet and on the type, distribution, number and dimensions of the constituent fibres. The surface of the sheet to be examined is moistened with a 5 per cent. solution of hydrochloric acid and, when the acid has been absorbed, the sheet is put into a drying oven at 105°C for 5–10 min. With hard-sized papers, absorption can be made more rapid by using a mixture of 1 part alcohol and 5 parts acid. If the sample is examined under the microscope after this treatment, the intermeshing and dimensions of the fibres are clearly distinguishable. The differences in colouration between the fibres make it possible to measure and classify the different types. The effect of a short treatment with weak hydrochloric acid is to cause a certain amount of hydrolysis on the surface of the fibre; groundwood fibres, which contain a large amount of lignin, show very little change in colour.

The micro-contour test for measuring paper smoothness

L. A. van Gastel
Papierwereld, 1959, **14** (4), 431–2,436

THE two commonest methods for measuring smoothness use the Bekk and Bendtsen testers, both of which act by closing off a current of air by the paper test piece under a small pressure. The escape of air along the surface irregularities is judged by the time taken for loss of a given volume of air. The range of Bekk results is 12 sec. for lightweight mechanical offset paper to 1 043 sec. for wood-free art printings.

The Bekk instrument is not dear and is fairly simple to use, but it gives no indication of the nature of the irregularities causing the air leak and it is just these that affect the printing result. Such qualitative differences and the pressure conditions are often more important than the Bekk quantities and side air permeation through the paper can also occur with very smooth papers.

The Dutch Printing Research Institute (IGT) measures printing smoothness on its IGT tester by printing a paper strip with little ink and at low pressure. This means that only the tops of the irregularities are printed and choice of impression roller (usually rubber) brings out the micro-irregularity of the paper. This is more useful for the printer.

As the IGT tester is not always available, another simple technique is recommended for checking smoothness—the micro-contour test devised by R. F. Bowles and P. G. Richardson. In this, all the hollows are filled with blue priming ink specially prepared for this purpose. The ink is applied with a roller and the surplus removed with a soft cloth (as in French polishing) until the area ceases to become lighter in colour. Removal must be immediate with absorbent papers. The result is examined by the naked eye and under a magnifying glass ($\times 10$).

Differences show up over the sheet area and between top side and wire side for both art coated and machine-coated papers. When these observations are considered in conjunction with a simple absorption test (to be described in a later article), the printer can quickly estimate the print results for a particular paper. The micro-contour test can be used to give preliminary

information about the surface smoothness of a lot of paper and the IGT print proofer possibly used for its closer specification. Tubes of micro-contour test ink are now being marketed in Holland.

Experimental equipment for drying paper

V. V. Krasnikov and V. A. Danilov
Bumazh. Prom., 1959, **34** (10), 20–21

THE apparatus was designed for the experimental drying of paper samples 200 mm. (7.87 in.) square and consisted of two drying cylinders and two felts with guide and tension rolls plus measuring, recording and control equipment. There is also provision for extracting air and steam from the space between the cylinders and also a nozzle through which air can be blown into the apparatus. The drying cylinders are constructed from seamless steel pipe 195 mm. (7.7 in.) in diameter and with 6 mm. (0.24 in.) thick walls, the length of each drying cylinder being 250 mm. (9.84 in.). The rolls are polished and there are three contact points on the surface. The heating elements are made of 0.7 mm. (0.028 in.) diameter nichrome wire attached to the cylinder axle and cylindrical shields are fitted to ensure uniform heating of the drying cylinder surface. The maximum surface temperature attainable with these heating elements is 220–240°C.

The control equipment for studying changes in temperature and weight during drying consists of a high-sensitivity oscillograph, which provides a continuous record of temperature at the surface of the drying cylinder, in the specimen and of the ambient air; a potentiometer to control the surface temperature on the drying cylinders; a tachometer to measure number of revolutions and dynamometers to measure felt tension. The temperature in the inside of the moving paper sample is measured by embedding a thermocouple in the sheet when it is being formed and connecting this up to the oscilloscope.

With this experimental installation, the main controllable factors are—

1. Speed control up to 1 100 m./min. (3 609 ft./min.).
2. The length of the draw (by altering the distance between drying cylinders).
3. Contact time between sample and drying cylinder (by changing the position of the felt guide rolls).
4. The force with which the sample is pressed against the drying cylinder (by adjusting the tension rolls).

It has been shown that this experimental machine can give valuable information on optimum drying conditions for different grades of paper and for estimating the effect of drying on paper properties.

Papermaking wires from synthetics

M. Weinfurt
Bumazh. Prom., 1959, **34** (9), 7–9

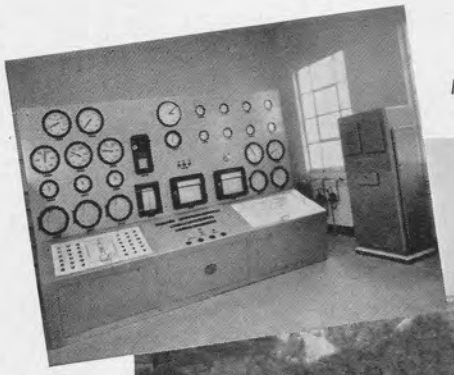
SILON wires have a high resistance to rupture and to abrasion, a low frictional coefficient and are resistant to bacterial attack. The density of silon is 1.5 g./c.c. and its melting point is 190–220°C. In practice, polyamides turn brown at temperatures over 100°C, but this does not change their basic properties. The tensile strength of silon is 26–32 kg./sq. m. and elongation at rupture is 26 per cent. Polyamide wires are hygroscopic and adsorb 3–4 per cent. of moisture. When soaked in cold water, the filaments stretch 4 per cent., but when they are dried again they return to their original dimensions. This is a factor of particular importance when this type of wire is run on a machine. Polyamide fibres are unstable in strong acids or alkalis and in the presence of high chlorine concentrations, but they are completely stable to all chemicals commonly used in the pulp and paper industries.

The first silon wires were woven on normal textile looms, but this method was found to be unsuitable, as the edges were weak and the weft fibres became distorted. It was impossible to weave under uniform tension and so the wires were heated either by steam or with infra-red radiation to remove the woven-in stress. Steam heating is inconvenient and a special two-roll calender was built on which the wires are stretched and run over six batteries of 900–1 500 watt infra-red lamps in a radiation chamber. The distance between the wire and chamber was 45 cm. and wire speed was 2 m./min. The temperature of the wire during heat treatment is about 165°C and is automatically controlled.

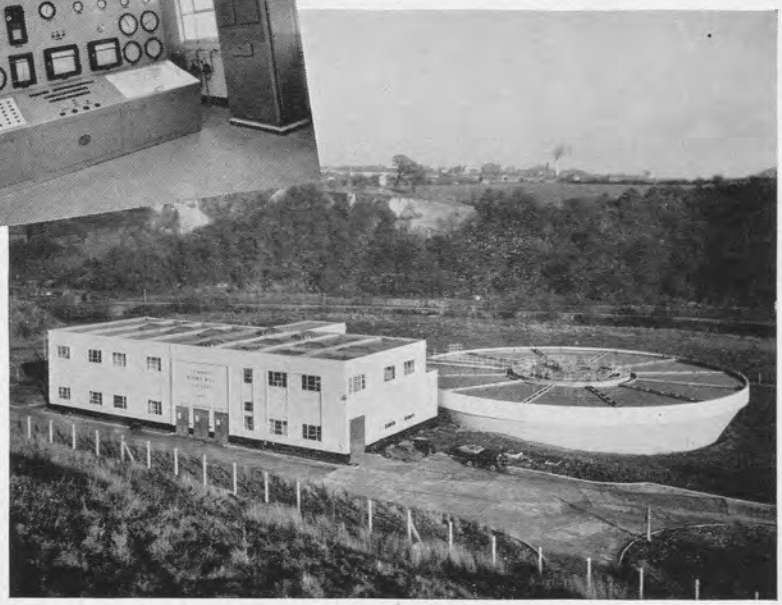
The strength and elastic properties of silon can be utilised in combined silon/bronze wires. In this work, a wire was woven with silon wires of 0.5 mm. diameter forming the warp and 0.42 mm. diameter phosphor bronze wire as the weft. The wire was of a single weave and was joined by a stitched seam. No heat treatment is necessary with this combined wire and its working life was found to be 40 per cent. longer than that of a conventional phosphor bronze wire.

From experience with synthetic wires, it was found that pitch could be removed from the wires by using alcohol, caustic soda solution or xylene and most other contaminating and clogging deposits were removable with trichloroethylene, chloroform, kerosene or benzole.

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General view of water treatment plant—7½ million gallons a day

The St. Anne's Board Mill Co. Ltd. derives its process water from the River Avon, a heavily polluted river subject to wide variation in character. The new water treatment plant installed by the Paterson Engineering Co. Ltd. has an initial capacity of 7½ m.g.d. with provision for extension to 22½ m.g.d., the chemical equipment being installed for the final figure.

Before filtration the river water is treated in a Paterson Centrifloc clarifier, of 130 ft. diameter, one of the largest constructed in the United Kingdom. This clarifier has certain unique features, including the ability to operate as an orthodox vertical-flow tank or as a "sludge-blanket" clarifier.

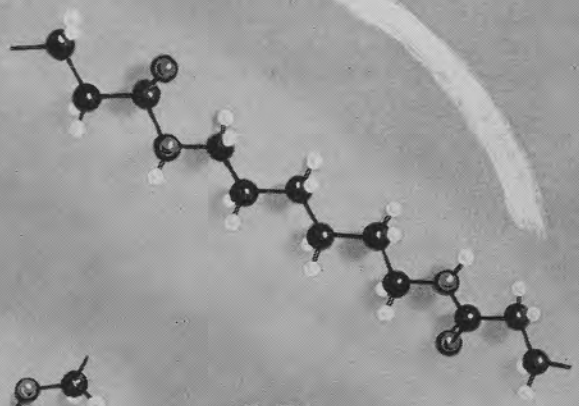
The modern water treatment plant is designed to reduce labour requirements to a minimum, and is equipped not only with fully automatic self-cleansing gravity filters, but also with chemical charging equipment, so arranged that all service tanks for the operation of the plant are filled automatically from bulk storage tanks provided in the upper floor of the chemical house. All chemicals are delivered in tankers and are in liquid form, including sulphate of alumina (probably transported in this manner for the first time to a water treatment plant in England).

An instrument panel placed in the power station about a mile distant informs the attendant of the quality of the water and of the quantity being purified.

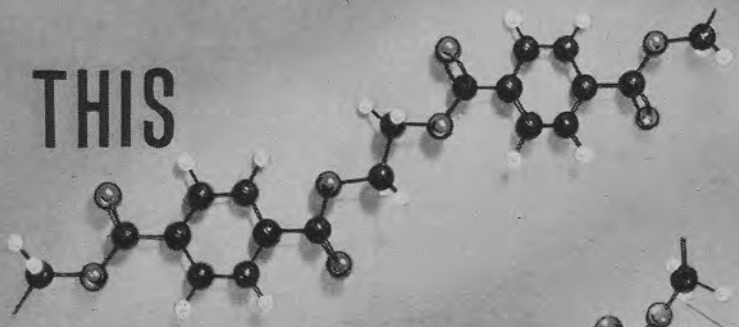
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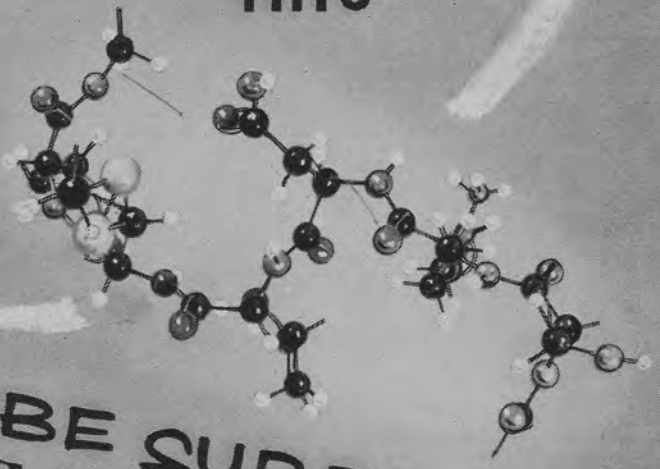
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for your reading

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

A study of the sodium aluminate/sodium abietate size precipitates

R. G. Guide
Tappi, 1959, **42** (9), 734–746

1. The composition of the size precipitates.
2. The relationship between the physicochemical properties of the size precipitate and sizing.

A study of the water retention of latex-bound pigmented coating colours

R. L. Hagerman, R. G. Jahn and W. H. Somers
Tappi, 1959, **42** (9), 746–751

A comparison of the carbohydrates of hardwoods and softwoods

J. K. Hamilton and N. S. Thompson
Tappi, 1959, **42** (9), 752–760

Secondary motions in flow between concentric rotating cylinders

D. W. Appel
Tappi, 1959, **42** (9), 767–773

Secondary flow phenomena in non-linear fluids

J. L. Ericksen
Tappi, 1959, **42** (9), 773–775

Two new methods for determining loadings of colloidal silica on paper surfaces

G. J. McEwan, R. P. Beimler, E. F. Kaelble and T. A. Taulli
Tappi, 1959, **42** (9), 776–779

Acidification of papermachine shower water with sulphamic acid to prevent blockage and increase felt life

K. A. Craig
Tappi, 1959, **42** (9), 782–786

Installation and maintenance of Jordans

W. B. Hayden
Paper Trade J., 1959, **143** (52), 18–20

New work on tensions developed in removing wet paper sheets from rolls

Paper Trade J. 1959, **143** (52), 23–26

Determination of starch in paper

J. L. Harvey, B. W. Forshee and D. G. Fletcher
Tappi, 1959, **42** (11), 878–883

A comparison of the TAPPI enzymatic and spectrophotometric methods.

Role of wire retention in whitewater recovery

A. H. Tifft
Tappi, 1959, **42** (11), 884–888

Improved paper strength by active aluminium hydroxide

P. Lagally and H. Lagally
Tappi, 1959, **42** (11), 888–898

Dimensional stabilisation of paper by catalysed heat treatment

W. E. Cohen, A. J. Stamm and D. J. Fahey
Tappi, 1959, **42** (11), 904–908

Measurement of compressibility as a factor in evaluating experimental stock furnishes for insulation board manufacture

E. J. Reichman
Tappi, 1959, **42** (11), 908–913

The influence of the contact area pressure on the results obtained by measuring the thickness of fibre building board

K. Helge
Norsk Skogind., 1960, **14** (1), 19–25

Production of paper and board by the dry process

S. A. Pusyrew and M. Dimitriev
Pulp and Paper Mag. Can., 1960, **61** (1), T3–T6

Papermachine lubrication

I. Bartik
Pulp and Paper Mag. Can., 1960, **61** (1), T25–T31

Which of the three possible kinds of stock chest agitation to use

Paper Trade J., 1960, **144** (7), 50

(continued on page 325)

TECHNICAL SECTION LIBRARY

✖ Publications received

TAPPI Routine Control Methods

(Technical Association of the Pulp and Paper Industry, New York, 1959)

RC–20	Moisture in paper (rapid oven)
RC–21	Moisture in paper (Emerson drier)
RC–22	Moisture in paper (Moistrite register)
RC–23	Moisture in paper (sword hygrometer)
RC–24	Moisture in paper (Hart meter)
RC–25	Moisture in paper (Dietert moisture teller)
RC–26	Oil absorbency of paper (heavy mineral oil)
RC–27	Oil absorbency of paper (light mineral oil)
RC–102	Excess chlorine during pulp bleaching
RC–103	Cleanliness factor of pulp

TAPPI Standards

(Technical Association of the Pulp and Paper Industry, New York, 1960)

T1 m–59	Water solubility of wood
T4 m–59	One per cent. caustic soda solubility of wood
T5 m–59	Ether solubility of wood
T6 m–59	Alcohol-benzene solubility of wood
T7 m–59	Weight-volume measurements of pulpwood
T11 m–59	Sampling and preparing wood for analysis
T12 m–59	Preparation of extractive-free wood
T15 m–58	Ash in wood
T20 m–59	Compression wood in pulpwood
T21 sm–59	Weight of unit volume of chips
T211 m–58	Ash in pulp
T218 m–59	Forming handsheets for optical tests of pulp
T227 m–58	Freeness of pulp
T231 sm–59	Zero-span breaking length of pulp
T413 m–58	Ash in paper
T427 m–59	Saturating property of roofing felt
T447 m–59X	Moisture expansivity of paper
T452 m–58	Brightness of paper and paperboard
T458 m–59	Surface wettability of paper
T490 sm–58	Smoothness of paper under 3 p.s.i. clamping pressure
T608 m–58	Calibration of volumetric glassware and analytical weights
T609 m–58	Indicators for volumetric analysis
T616 m–59	Analysis of sulphur
T630 m–58	Melting point of paraffin wax

Technical Section Proceedings: 1959

(Technical Section, Canadian Pulp and Paper Association, Montreal, 1959)

Contents — Technical Section officers; List of officers since formation; Committee Chairmen; Branch Chairmen; Annual Meeting; Reports of Branches; Reports of Committees; Gadget Competition Winners—Overcoming wear on elbows in air conveyors by G. Brosseau; Automatic chip sampler by M. J. Hudec.

Annual Meeting papers — Investigation of factors affecting Fourdrinier wire life; Study of newsprint-machine wire life by C. E. MacDonald, J. G. Buchanan, K. E. Vroom, R. M. Stuart and B. W. Burgess; Operation of wire tester and preparation of wear samples by G. W. Toop and J. O. Edwards; Reports of investigations of flat box cover materials by R. Fraser; Application of institute task force findings to new machines: Some factors influencing papermachine wire life by J. D. Boadway; Some studies of the abrasion and corrosion of Fourdrinier wires by J. D. Boadway, J. Friese and R. M. Husband; The permanganate consumption of pulp materials IV. The kappa correction coefficient by J. E. Tasman; Evaluation of a third press on a pulp drying machine by J. F. McCallum and H. D. Paavila; Advances in the design and operation of chlorine dioxide generators by W. R. Cale and H. C. Scribner; Alkaline pulping of poplar and birch: The influence of sulphidity and effective alkali on the rate of pulping and pulp properties by G. W. Legg and J. S. Hart; Operating experiences with the Kamyr digester on northern hardwoods by C. E. Ray; Acid cleaning of boilers: Acid cleaning of boilers at Gatineau by J. Fullerton; Acid cleaning at Cornwall by W. Boyd; Acid Cleaning at Polymer Corp. by Wm. Wessing; The interrelation of ink and paper by Dr. A. C. Zettlemoyer; The interrelation of ink and paper—a panel discussion; Palletisation—an industry-wide study by E. Mason; Dividends from industrial truck driver training—A case history at Spruce Falls by G. C. Thompson; Automation in pulpwood transportation—A report on special pulpwood cars by J. S. Forrester; A magnetic flowmeter stock proportioning system by W. E. Hawkings; Stock proportioning at Ocean Falls by B. Rosenbaum; Comparison of magnetic and area flowmeters by M. Krayewski and G. L. Cooper; Metallurgical factors affecting calender roll performance by G. Ewing Tait; Enclosed dryer gear drive installation by A. W. Burditt and I. W. Edwards; The uses of miracloextremultus belting in the paper industry by G. Pellicer and Foster P. Doane, Jnr.; The characterisation of couch draw stability by B. I. Howe, R. G. Lepine and I. R. A. Gregory; The manufacturing of dry crepe paper by Walter S. Dempsey; The manufacture of wet creped papers by C. T. Waldie; Infrared radiation applied to paper drying by K. M. Eisele; Improvement of reel moisture profile by dryer insulation by J. E. Campbell and G. D. Hughson; Operating experience with a steam generator burning wet bark and oil by J. Rockley; Bark burning installation at Canada Paper Company, Windsor Mills, P.Q. by P. V. Palmer and T. W. Houghton; The processing, handling and burning of bark at the Three Rivers Mill of St. Lawrence Corporation Limited by J. W. Burke; Discussion of drying problems—a panel discussion; Dryer drainage systems by R. E. Arbogast; The effect of superheat in steam by R. E. Arbogast; Dryer

siphons by L. F. Horne; Grewin system by F. A. Garrett; Hoods by H. J. Barton; High yield sulphite processing—a panel discussion: High yield sulphite processing at Fort William by J. W. Purdey; High yield sulphite processing by A. Marcous; High yield sulphite processing at Gatineau by W. Nettleton; High yield sulphite system at Riverbend by L. R. Beath; High yield sulphite panel—Belgo stock preparation by J. O. Kelly; The high yield pilot plant at Powell River by R. C. Bledsoe; Electrical insulating liquids by W. G. Matthews and W. B. Hall; Fundamentals of curl in paper by P. Glynn, H. W. H. Jones and W. Gallay; The effect of beating on pulp brightness by W. H. Rapson, C. B. Anderson and G. L. Avon; The mechanism of pitch dispersion by formaldehyde-naphthalene sulphonic acid condensation products by Dr. Frank J. Poschmann; Static rectifier comparisons and some typical applications to the pulp and paper industry by Raymond C. Scott; The manufacture of paperboard by Harry E. Hadley.

1958 Summer Meeting — Programme; Canadian industry too complacent faced with rising productivity in Europe, Need for labour-management co-operation, Dinner address by W. E. Soles; Recent studies of paper drying by H. Preston-Thomas; Cleaning groundwood with Vorjects by R. M. Sternberger; Cleaning groundwood with Vorjects at Port Alfred by C. D. McCulloch; Development of abrasives for pulp grinding by W. E. Barrett; Economics of nuclear reactors for process steam and power in the pulp and paper industry by R. L. Beck; Selection of medium voltage switchgear by R. V. Kovacs; Application of Cowan screens to cleaning sulphite, groundwood and kraft pulps by S. W. Hooper; Studies of dirt in sulphite pulp by J. Chollet, M. Duffy and O. Sepall; Anodic protection of alkaline pulping digesters by W. A. Mueller; Carbohydrate chemistry at Queen's University by J. N. K. Jones; Action of dimethyl sulphoxide on wood and sulphite pulps by S. Hossain; The behaviour of wood and wood constituents as acid-buffering systems by O. V. Ingruber; The principal fire risks in papermills —how they may be avoided by K. W. Jamieson; The application of the Bird Centriscreen on newsprint furnish by S. Salomon and S. Lukianovitch; Newsprint winding cycles by J. Truscott and C. E. Meili; Optical tooling and its use in the alignment of paper machines by A. J. Conley and J. L. Hanold; Optical methods can improve papermachine installation and maintenance by Dalton D. Tamney and C. G. Cook; Alkaline pulping—Spruce: Part II. The change in pulp properties throughout the cooking cycle by W. D. Kerr and J. S. Hart; Bleaching of alkaline hardwood pulp at Cornwall, Ontario by J. M. Ferguson and E. A. Macdonald; Three-stage bleaching of kraft pulps to high brightness by W. H. Rapon and C. B. Anderson.

Appendix; Third supplement to bibliography of articles on mechanical pulping; Index to technical papers; Index to authors.

For your reading (*continued from page 323*)

Matching load and drive characteristics

C. G. Helmick

Paper Ind., 1960, **41** (11), 770–771

Part 1—Load characteristics in papermills.

The use of pipe, fittings, pumps and valves in the pulp and paper industry

R. L. Allen, Jnr.

Paper Ind., 1960, **41** (11), 772–773

Part 11—Application of pipe, fittings, pumps and valves in preparation and handling of bleaching chemicals.

Adhesives in the paper industry

Paper Ind., 1960, **41** (11), 781

Measurement of wet-rub resistance of paper coatings

G. A. Hull

Paper Ind., 1960, **41** (11), 782–783

Treatment and control of boiler feedwater: new interpretations

E. C. Potter

J. Inst. Fuel, 1959, **32**, 218

The author discusses some aspects of boiler feedwater treatment in the light of recent developments and examines statistically the need for de-oxygenation of feedwater and the advantage of adding alkali to the feedwater. He suggests that pOH value would be a more useful parameter than pH value, as it is less dependent on temperature.

Method of and apparatus for manufacturing a filtering material and filtering material thereby produced

P. A. Muller

B.P. 796, 678

A process and apparatus are claimed for manufacturing a filtering material. The method involves continuous perforation of a single or multi-layer web of paper or similar fibrous frangible material in such a way that parts of the web are displaced but not detached and openings are formed having frayed edges. A multi-layer web can be assembled so that a space is maintained between the layers or so that the fibres of one layer project through the openings of another layer. For filtering liquids the web could be made of parchment-type or other impregnated paper. The apparatus and filtering material are shown diagrammatically.

Installation and maintenance improve screen performance

M. P. Hahn

Paper Trade J., 1960, **144** (5), 30–33

Principles of adhesion on a papermachine

B. Radvan and G. O'Blenes

Tappi, 1959, **42** (12), 921–927

(*continued overleaf*)

Book review

Recent Advances in the Chemistry of Cellulose and Starch—
Editor, J. Honeyman, with 13 co-authors
(*Heywood & Co. Ltd., London, 1959, pp. viii + 358, 60s.*)

THIS book is based on a course of postgraduate lectures held at the Manchester College of Science and Technology in 1958 and contains twelve chapters contributed by leading carbohydrate scientists from universities, research institutes and industry.

The material is up-to-date and the whole provides a balanced survey of recent developments. Cellulose receives much more attention than does starch, but the book will appeal almost exclusively to research workers and is unlikely to prove of direct interest to the majority of scientists in the paper industry.

The first chapter gives an excellent and comprehensive review of the chemistry and reaction of monosaccharides, though it suffers adversely from the grouping of structural formulae in twenty one pages at the end of the section—which may have facilitated printing, but scarcely gives the 'ease of reference' claimed. This provides an essential introduction to the second chapter on molecular structure with special reference to cellulose and starch, which is based on a lecture by Prof. Hirst and integrates the chemical, physical and biological methods available for the investigation of polysaccharides.

There follow six chapters that are devoted to detailed aspects of the chemistry and physical structure of cellulose, many of which are of significance and application in pulp and paper studies. The next two chapters deal jointly with cellulose and starch on the important subjects of water sorption and degree of polymerisation.

As might be expected from the list of co-authors, the subject matter on cellulose is confined almost exclusively to cotton and cellulose derivatives in the form of textile fibres and references to pulp and papermaking fibres—with regard either to chemical or physical properties—are conspicuously absent in most sections. This is particularly noticeable in the chapters on fine structure, sorption of water and mechanical properties, in which the problems relating to fibre bonding and strength of paper receive no mention.

It is unfortunate that of the few direct references to work in the paper industry, No. 31 on p. 145 flatly contradicts statements on crystal lattice structure made by a Swedish contributor to the Technical Section symposium held at Cambridge 1957: also that in Fig. 8, facing p. 64, the name of the senior author (Emerton) is misspelt and there is no indication that the micrographs, which derive from studies at the Research Association, depict woodpulp (sulphite) fibres—indeed, the inference from the text is that the subject is cotton.

The penultimate chapter, which is the only one devoted exclusively to starch, gives a useful if brief survey of the manufacture of raw and modified starches and their industrial applications and includes more direct references to the paper industry than in all the remainder of the volume.

Biological processes leading to synthesis and degradation of cellulose and starch are authoritatively surveyed in the final chapter and, although it is apparent that much remains to be elucidated of the mechanisms involved, it seems probable that there will be important developments in this field in the fairly near future.

The book is very well presented, with a good balance between the different sections and the useful and up-to-date (1958) bibliographies at the end of each chapter are combined in general author and subject indexes.

E. C. Allison

For your reading (*continued from page 325*)

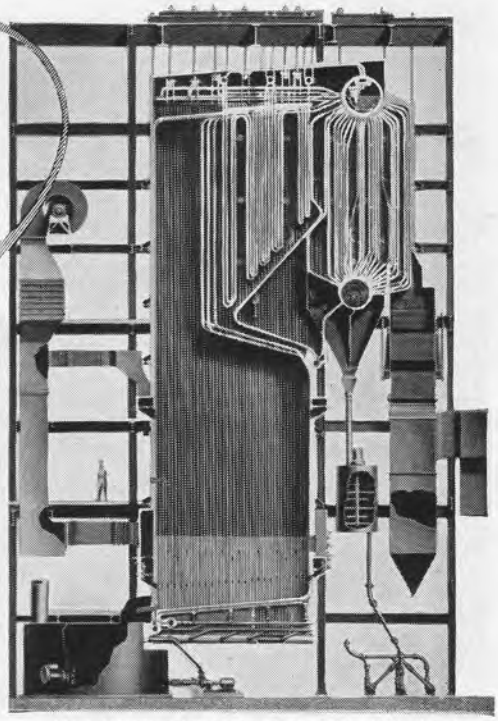
Fundamentals of adhesion from molecular forces in cellulose
A. H. Nissan
Tappi, 1959, **42** (12), 928–933

Dimensional stabilisation of paper by cross-linking with formaldehyde
W. E. Cohen, A. J. Stamm and D. J. Fahey
Tappi, 1959, **42** (12), 934–940

The network and viscoelastic properties of wet pulp
S. F. Kurath
Tappi, 1959, **42** (12), 953–959
1. Dynamic mechanical properties.

Wet-web strength of mechanical and chemical pulps of different form composition
W. Brecht and H. Erfurt
Tappi, 1959, **42** (12), 959–968

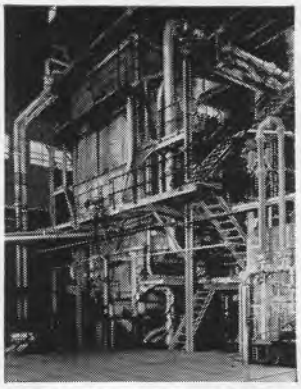
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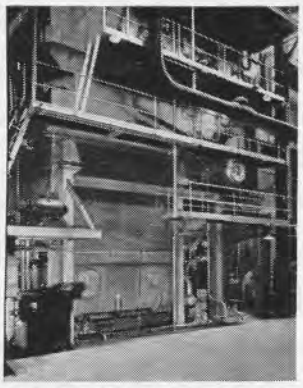
(Above) Sectional arrangement of a Babcock-Tomlinson Recovery Unit

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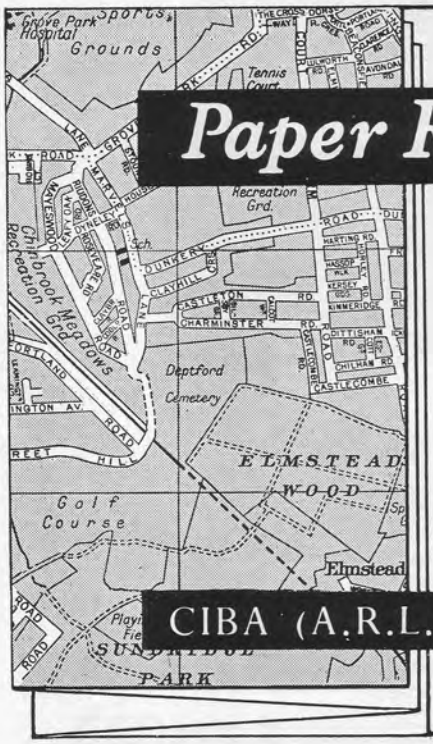




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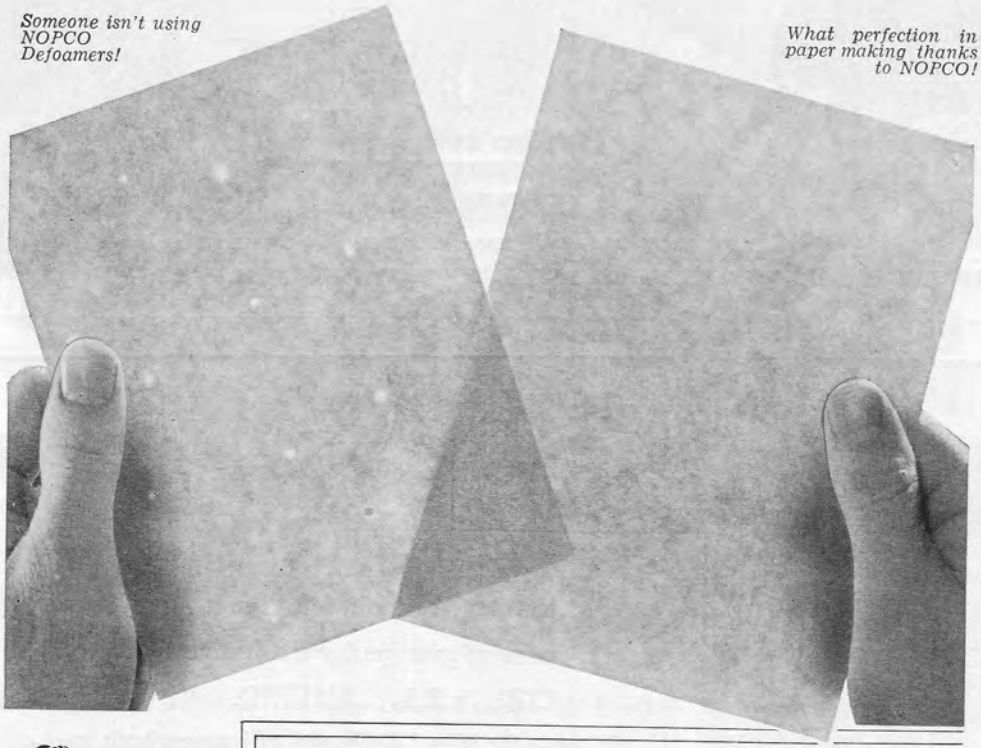
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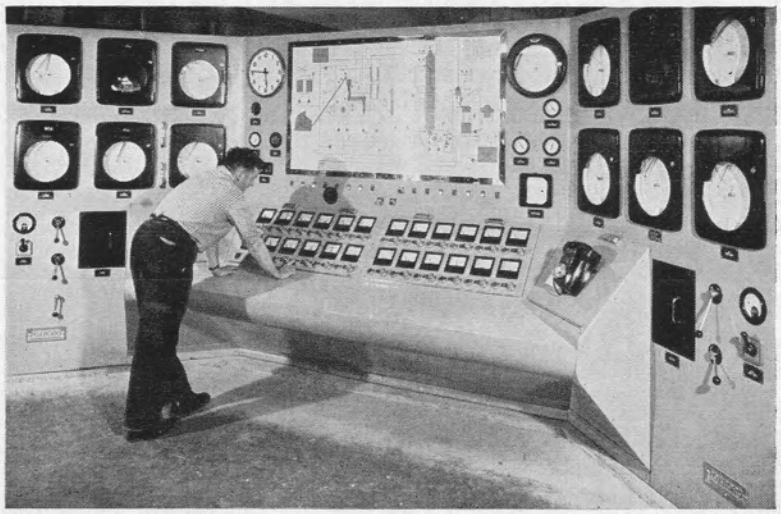
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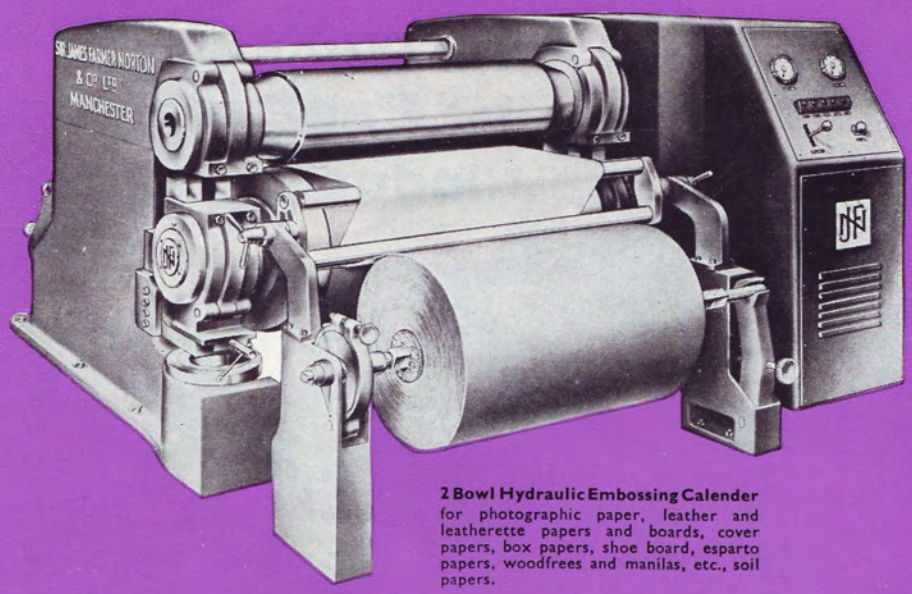
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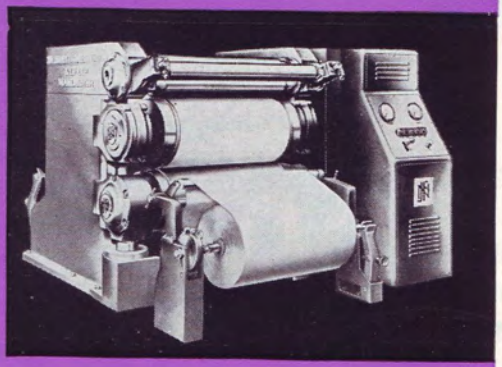
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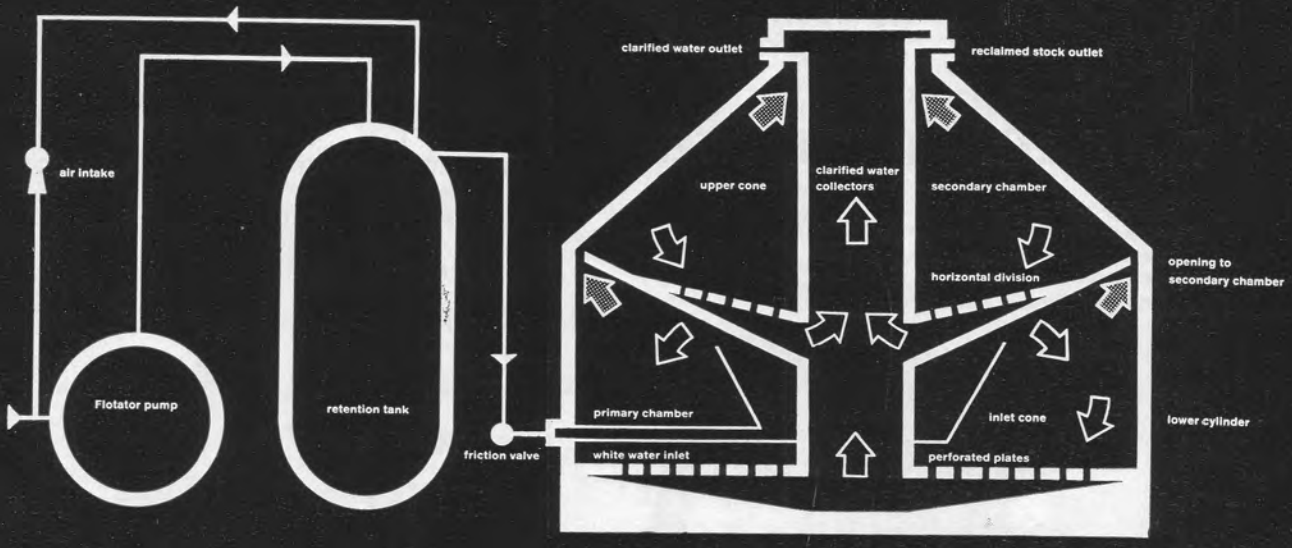


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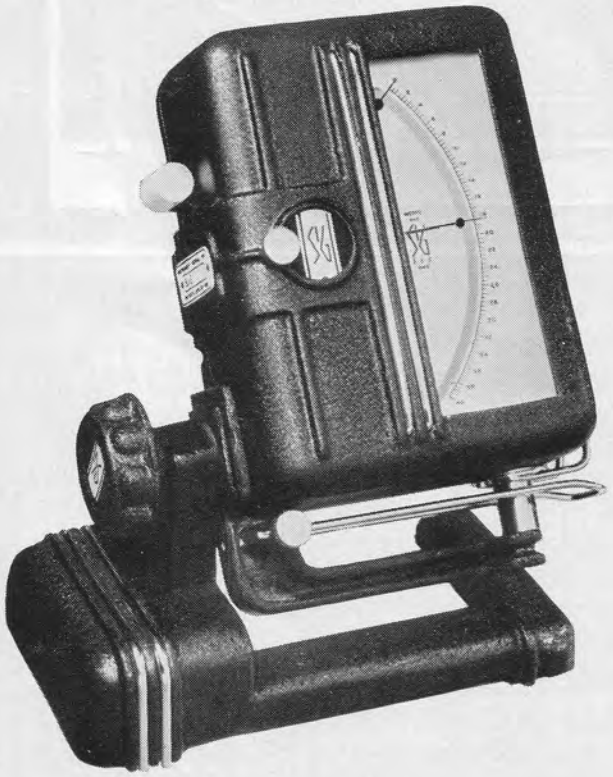
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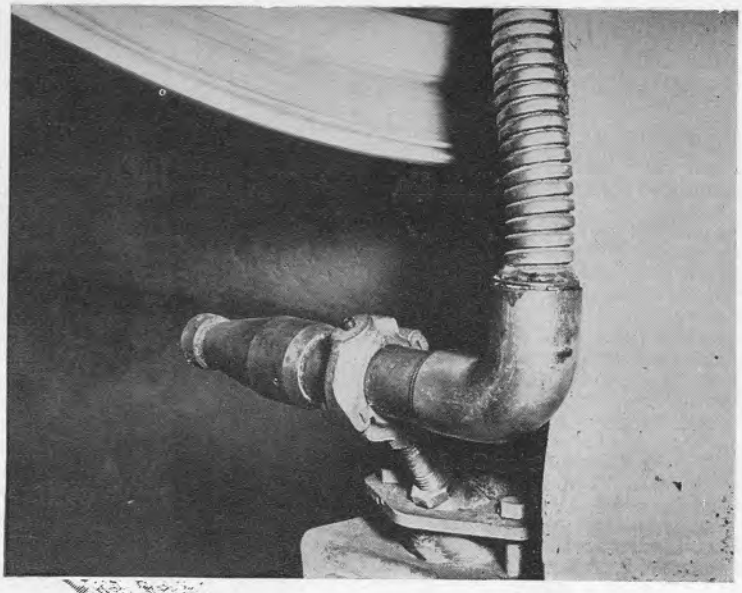
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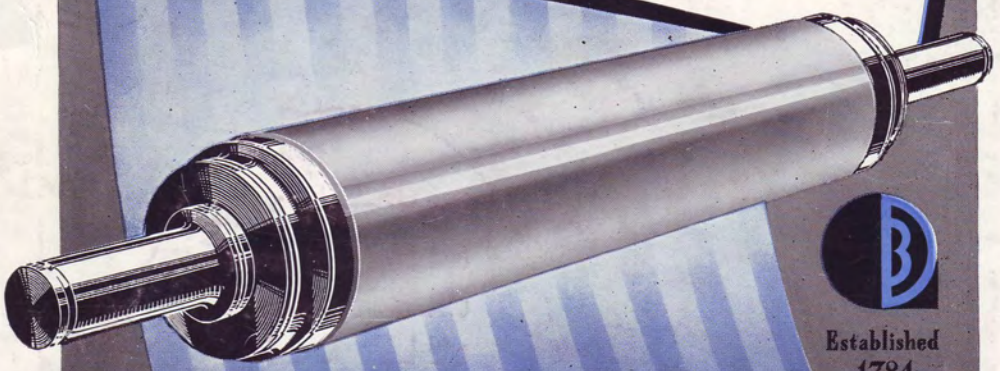

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