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# INTRODUCTION TO THE SYMPOSIUM

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IT seems appropriate at the outset of an introduction to our week's proceedings to spend a little time drawing attention to the particular characteristics of this series of meetings, the planning of which has now spanned 14 years.

When planning almost all other conferences at which research results are presented, it is usual, having chosen the theme, to approach one or two key speakers, then invite contributions quite generally. We approach it differently. Having selected our general theme, we proceed to break it down into subthemes (corresponding to our sessions in the programme) and, finally, to the specific topics that we consider it desirable to cover. At this stage—and not before—and from our knowledge of the work being carried out around the world, we start thinking who could contribute papers to these topics. In addition, we publicise the breakdown of the theme and invite those who think they may have something to offer to contact us with an outline of what they have in mind. There follows a dialogue between the committee and the potential contributor to ensure that the objective—the balanced exploration of the theme in depth—is going to be attained as completely as possible. Inevitably, this not infrequently leads to the withdrawal or rejection of the offered paper and, indeed, the thirty or so papers that will be presented this week represent a distillation of an appreciably larger number.

Of course, this method of mounting a research conference presents some difficulties, but it has certain advantages—

1. It reveals and highlights gaps in our knowledge of the branch of science and technology under consideration.
2. It has, in certain cases in our experience, stimulated research in advance of and for presentation at the symposium.
3. Additionally, it has stimulated subsequent research.
4. The published transactions of the symposium, together with the edited discussion material, constitute a work that brings together most of the current salient knowledge on the theme within the covers of one or two volumes. It is significant, for example, that even 12 years after the first symposium on

fundamental aspects of fibres and their treatment for papermaking, the transactions are still selling at a steady, even if modest rate.

So much for the series of meetings. Let me pass now to this one in particular —*Papermaking systems and their control.*

To a much greater extent than in earlier symposia, the subject has a validity that extends beyond the confines of papermaking. Hence, it was perhaps to be expected that nearly 40 per cent of those present today would come from outside the papermaking industry and its immediate suppliers. Even though expected, it remains very gratifying and I would like to extend a particularly warm welcome to those of you from other fields of endeavour.

To avoid semantic misunderstandings, it will be as well to define our terms.

Synthesising a few dictionary and textbook definitions, perhaps we may say that a *system* is a collection of parts that are dynamically related. Note the word dynamically; it is important. A collection of copper pipes, radiators and a boiler do not constitute a central heating system until they have been dynamically related. Perhaps it begs the question, though some may find it helpful, to think of a system as that which lies between an input and an output. Thus, we can speak of the papermaking system in its widest sense to mean that which lies between the forest (where the chief raw material grows) and the customer, the trees from the forest being the input and the paper to the customer being the output. In a more limited sense, we can use the term to mean that between, say, the head box and the reel of the papermachine. To minimise confusion, we have tended in setting out the programme to refer to the latter as a subsystem of the former.

The noun *control* has both a negative and a positive connotation. On the negative side is the implication of restraint, of holding in check, of maintaining some set of existing conditions. The last few decades have seen enormous strides in our understanding of the principles of control. University departments and disciplines have been set up and established around it.* The knowledge and insight gained have permitted the exploitation of the more positive aspect of control, namely, that of optimisation, the deliberate changing of existing conditions so as to get an even better result.

The control of any dynamic system requires an understanding of the system response to changes of input, control stimulus, internal state and environment.

* Science has moved away from a concentration on substance, qualities and properties to a concentration on *interactions*.(1) This is reflected in the realm of science in general. For centuries past and throughout the first half of the present century, the scientific stage has been dominated by the physical and mechanical sciences; today, however, it is generally accepted that it is now and will continue for some time to be overshadowed by the life sciences, by a concern with biological and social systems. Putting it another way, we may say that, at this moment in time, understanding the structure of the atom is child's play compared with understanding child's play.

In systems in which mass or energy can be locally accumulated and discharged, the relationships between the response and the determining variables may be complex and time-dependent. In these circumstances, a classical mathematical approach is usually too complicated to be of much value in analysis.

A purely empirical approach, on the other hand, is usually insufficiently precise to provide the control engineer with the data he requires for the design of control circuitry and hardware.

In the application of control, a dynamic model of the system must sooner or later be constructed either on paper or within a computer system in order to analyse the effect of control stimuli on system response and to select the appropriate stimulus to achieve the desired output from the system.

The discipline and techniques of system analysis provide a number of convenient methods of dealing with this situation. Above all, they provide a workable convention for expressing those basic dynamic properties of systems that are the design data for control circuitry.

It is these basic dynamic properties of systems and the principles by which they are to be controlled that we are considering this week. We are *not* concerned with details of hardware, the physical means by which control is to be realised in terms of instruments and controlling mechanisms.

Turning now to the programme, we have today to deal with the more general aspects of control, including its historical development, the need to allow for dynamic behaviour in our systems, the machine/man interface, together with a quite general treatment of problems of measurement.

Such a general introductory session, the organising committee considered altogether desirable. Tomorrow we turn our attention to the systems with which we are particularly concerned; first of all, from the forest to the pulp-mill. In the text of Mr Silversides' paper, the equivalence of this system to that of the papermachine emerges quite strongly, though the time constants differ considerably, of course, in magnitude. We move on to the system in both a chemical and a groundwood mill and to the integrated control of the pulp and paper mill.

At this stage, the committee thought it desirable to include a session devoted to the use of analog computers. It seemed altogether likely that at some time the merits and demerits of analog would be argued against those of digital computers and it was thought best to get this out of our system (that word again!) early on in the programme. What place is there for analog computers? What role have they usefully to play? Accordingly, we have three papers on Tuesday afternoon that will argue for analog control of the papermachine; for this purpose, we include coating as part of the papermachine.

We then draw still closer to the papermachine itself, first of all on Wednesday,

by considering its control as a whole. At this stage, the committee was faced by a problem, that of coping with what we expected would be a flood of 'how-we-did-it' contributions. In the event, these were not offered and we have arranged for one formal paper, to be followed by two formal contributions to the discussion, after which Dr Brewster, as sessional chairman, may well have difficulty in accommodating all the other would-be contributors.

The whole of Thursday is given over to the control of the papermachine subsystems and this session, together with that of the preceding day on entire papermachine control, may be thought of as constituting a symposium within the symposium. This session 7 covers the control of flow boxes, profiles and the drying section. It also includes a paper on design for control and let me forestall criticism by saying that it is recognised that the general principles that this paper enumerates would probably have placed it better in session 2. Yet practical problems of the timetable prohibited this and, as the principles are illustrated firmly in the context of the papermachine, the best solution seemed to be to include it at this point.

On Friday morning, we move on to the control of industrial systems and, here again, we are conscious that the first paper on entire pulpmill control would probably have been better taken in session 4. Once again, however, practical difficulties necessitated its inclusion at this stage.* The use of economic models, which is rapidly gaining ground in industry, is considered in this session together with the effect of customer reaction on the manufacturing subsystem. This is followed by the application to the paper industry of that treatment of the control of the total industrial system pioneered by Forrester at MIT and to which he has given the name *industrial dynamics.*

By this stage, you will probably have become increasingly aware that the weekend is at hand. The committee is anxious that you should remain in a state of intellectual stimulation to the end of the symposium and has therefore arranged for three speakers of great eminence and authority to point out where and how future work may be expected to solve present problems and perhaps some of the more exciting probabilities that await us. On the control engineering front, this will be done for us by Prof. Coales. Peter Wrist will speak more specifically on the future of process control in our industry. Finally, since management itself—and not just what is being managed—now receives the attention of the systems analyst, Prof. Eilon will speak on the future of control in management.

Having outlined for you then the thinking behind the programme in order to reveal its coherence, I would like to draw attention to a few aspects of the topic that will be engaging our thoughts throughout the week.

*For these transactions, the order of some papers in sessions 4, 7 and 8 (four in all) has been changed for, it is thought, a better result.

First let me point to the serial nature of control. The hierarchical nature of systems has already been touched on. Systems, often enough, are comprised of subsystems and clearly several systems can form a supersystem and so on,* but the means of controlling a system (or subsystem or supersystem) can itself constitute a system. We are thus led to a hierarchy of control and this permits control of local operations not simply to optimise them as discrete activities, but within the context of a total operation the optimisation of which is to be given priority. Such hierarchical control is illustrated in the paper by Al-Shaikh & Brewster and will be referred to by other speakers.

Notice also that control is concerned with analysing inputs and optimising outputs, but, as Annergren, Bohlin & Tellvik emphasise in their paper, the cost of control is an integral part of the total optimising problem. Clearly, too much can be spent on achieving a result.

One of the characteristics of the papermaking process is that from the flow box to the reel the materials undergoing fabrication are under observation. This, I believe, has been a disaster for our industry. Those of you present this week from outside our industry may be astonished as the inadequacy of our process instrumentation emerges. Those of us within the industry are of course aware of this, painfully so; though I hasten to add that considerable strides are now being made to overcome the deficiencies. For too long, it was taken for granted that the machineman did not need to measure conditions along the machine; he could see for himself. Furthermore, he could see the results of action he took to change conditions—or so it was thought! The fallacy of this assumption, which doubtless will be repeatedly underlined throughout the week, masked the incentive to develop the necessary instruments.

Then, too, the problem of control in papermaking is aggravated by the use of naturally occurring and, at some time, living raw materials—with all the variability that this implies. It is aggravated by the papermachine consisting of a number of unit processes—gravity and suction drainage, pressing, thermal drying, calendering and sometimes others—carried out in-line, at high speed, over a great width and, as I have said, with inadequate instrumentation.

Much will be said during the week about model building. One of the chief advantages of using a mathematical model is that it forces the model builder to make his assumptions explicit. Indeed, it may well be that the real value of mathematical models lies less in obtaining answers than in gaining insight. This echoes one of Sir Lawrence Bragg's remarks that how you think about nature is as important as what you do about it.

It is perhaps not entirely naive to ask why control is necessary. More

* 'Observe how system into system runs
What other planets circle other suns'—Pope: *An essay on man*

precisely, the question should be formulated as 'What is the incentive for a greater degree of control than that hitherto exercised?' In the last resort and speaking quite generally, it is of course a financial incentive that may be expressed in terms of savings in labour (though normally not where the *paper-machine* is concerned), in raw materials, in down-time on the process and the usually unquantifiable benefits of customer goodwill arising from improved and more consistent quality. As we gain confidence and experience in control, we eliminate the inertias from the system—for example, we reduce the capacities of machine chests of the process; the stocks and inventories of a production system; the delay in customer feedback in a commercial system. Finally, of course, advanced control permits operations that would otherwise be quite impossible.

This is a very general and doubtless incomplete assessment. In the course of the week, more detailed statements of the return in particular cases will probably emerge. Let me point to just one, quoted by Stout,[2] which relates not surprisingly to a computer installation. At Container Corporation's plant at Fernandina Beach, Florida, a computer controls, among other things, basis weight, moisture, refining and flow box variables on a large linerboard machine. As a result of this installation, it was possible to reduce the dry fibre weight of 42 lb linerboard from 40·69 lb, with a standard deviation of 0·42 lb, to an average of 39·3 lb and 0·119 lb. Similar improvements were obtained with the heavier grades. The reduced variability has permitted a 6·1 per cent increase in area, the annual value of which is stated to be more than half a million dollars.

It should not of course be supposed that I am suggesting that even with a computer such returns can readily or inevitably be obtained in other applications in our industry. The dangers and pitfalls that await the inadequately thought-out computer project are numerous; such as the feasibility study that lacks comprehensiveness, sometimes the product of a computer specialist unfamiliar with the operation of the company in question; the tendency for the specialist to produce the elegant and satisfying solution rather than the practical and profitable; the failure to discover hidden system complexities, the underestimation of core storage and a software requirements; and, in general, the high degree of sensitivity of the assumptions to error. Almost as many papers have been published warning of these as have appeared on the more constructive aspect.

When we began the planning of this meeting rather more than four years ago, the organising committee was far from confident that we could successfully mount a meeting on this topic at this time. Chiefly were we concerned about the timing. It is not easy these days to see four years ahead, to forecast in a situation of explosive change that the ground will not have been substanti-

ally worked over, that the interest will not have waned. I cannot do better to put this in perspective than quote from an article by Good published earlier this year. Writing of computer control in process industries, he says,[3] 'Twelve years ago, computer control did not exist. For example, in 1956, no major U.S. technical periodical discussed computer control nor did the subject even appear in the annual indexes of these periodicals. Regardless of the process industry, the entire history of computer control spans only a twelve year period.

'In addition, recognition and study of the supporting elements of computer control were just ten years ago practically non-existent. For example, the 'electronic versus pneumatic' controversy was just beginning and only one company even produced electronic instruments. Very few chemical industries owned or had access to computers. Systems engineering and process analysis groups were virtually unknown. Few, if any, university chemical engineering departments were equipped with any type of computer or taught process control. Plant dynamics were studied sparingly, then only by sinusoidal forcing. Data were manually reduced. Hence, in retrospect, neither computer control nor its supporting technologies existed as late as 1956, regardless of the process industry we discuss. This is indeed a brief span.'

A brief span indeed since 1956–57. Yet, today, we are in time half as far again as we were in 1965 when the planning of this meeting commenced and many times further forward when we consider the rapidly increasing rate of advance in this field. The very rapidity of developments made it difficult to compose a programme, along the lines that I indicated at the outset of my talk, without arranging for papers that in the event might prove out of date. As things have turned out, however, we believe that our timing, for the year 1969, was sound. Interest in the topic was never higher. At least three complementary meetings have been or will be held within a few months of this one. As for the up-to-dateness of the papers, we submit that to your judgment with confidence.

It only remains for me now to wish you all an exciting and stimulating week. Four years ago, a seed was sown. The plant germinated slowly; but this week it will be cracking concrete.

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