TAPPICON

APRIL 22 – 26, 2023 • ATLANTA, GA

THE EVOLUTION OF PROCESS AUTOMATION

The Past, The Present, and The Future – A Visionary Treatise

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VALMET

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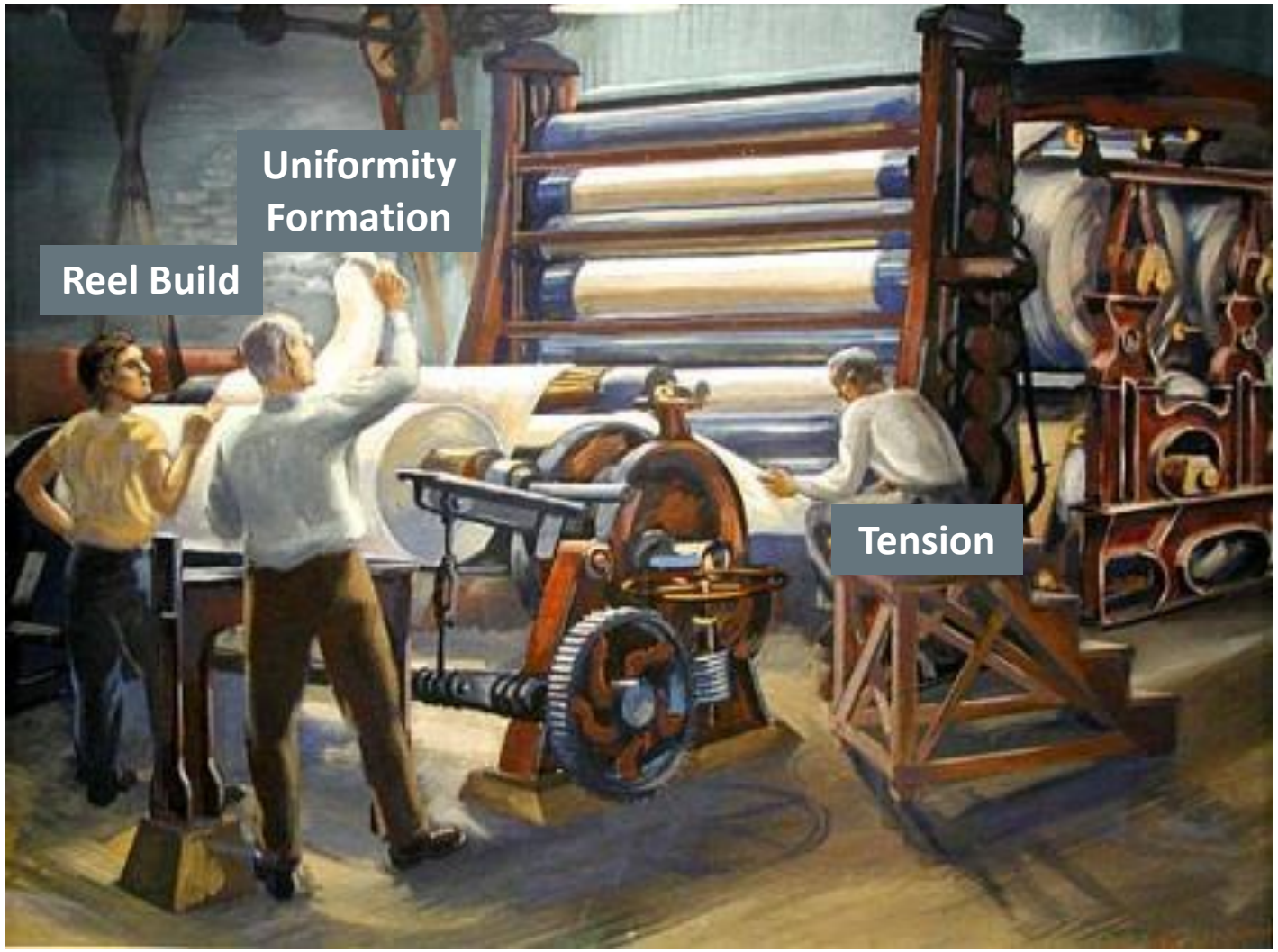
Valmet

In Not So Ancient Times

"In those days, the methods for checking how a paper machine was running were, to say the least, primitive. To inspect the open unsupported draw between the couch and the first press, the machine tender would simply lift his hand under the running web to feel the tension. … The uniformity of the reels was checked by the backtender, who struck the reels with a small bat across their width as they wound. Backtenders claimed they could assess the uniformity simply by the sounds the reels made when hit"

Eric Leaver: An Idea is Not Enough, 1998

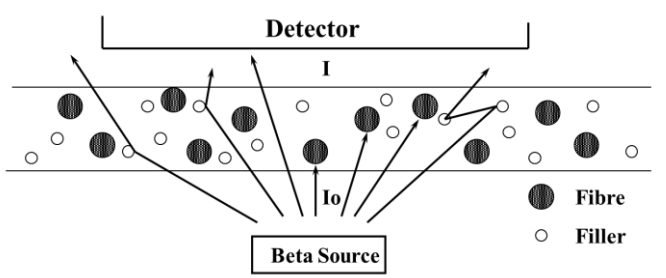


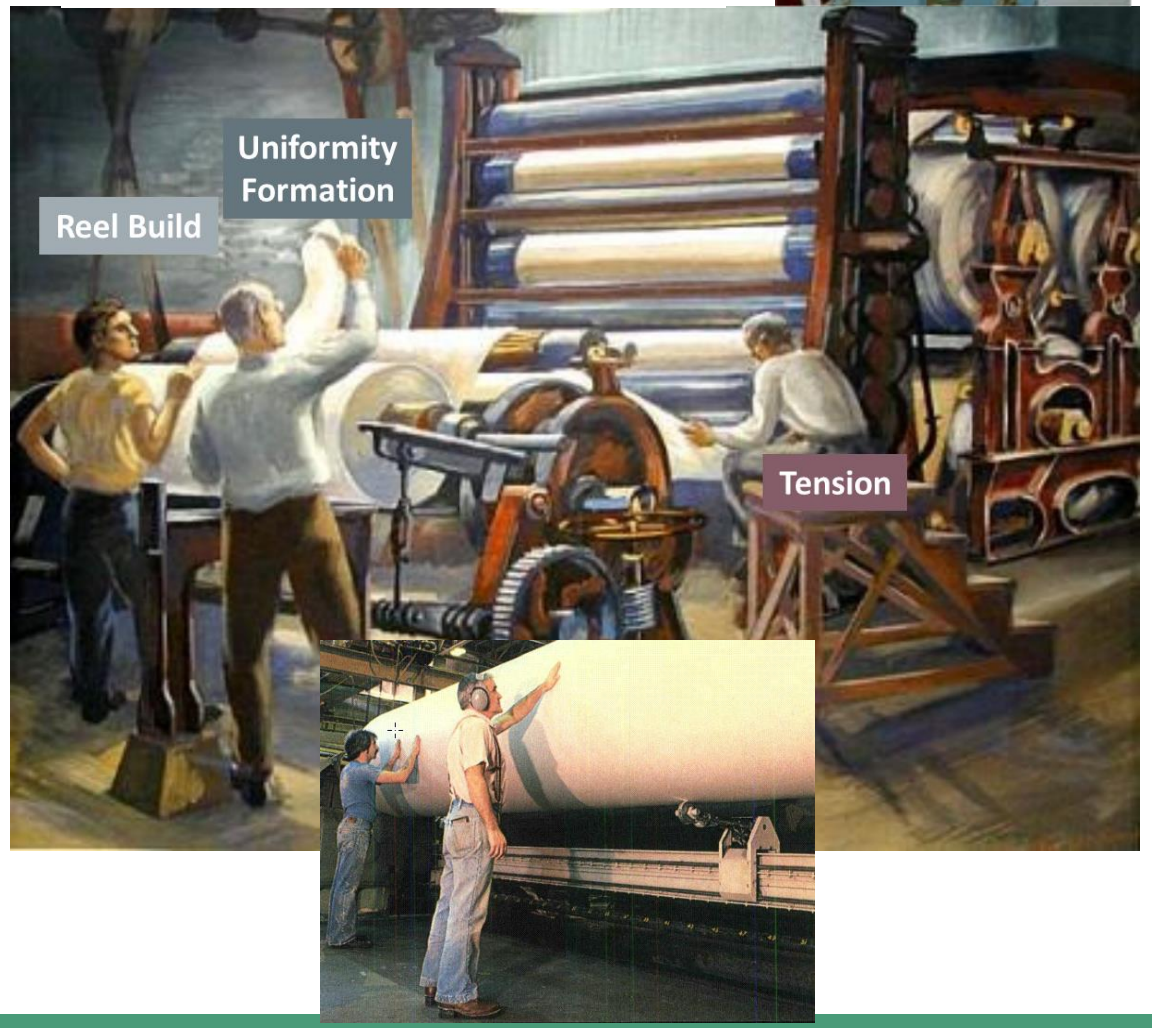
Picture from: Hellström, Å., 2015. *Paper Quality Measurements.* Atlanta, Proceedings, TAPPI PaperCon 2015, TAPPI Press, Atlanta, GA

Emergence of measurements

" … that they did not need all this newfangled measurement and control equipment. After all, they have been making paper for 200 years without it. All they need was a bat. Some mill managers at the time agreed with him"

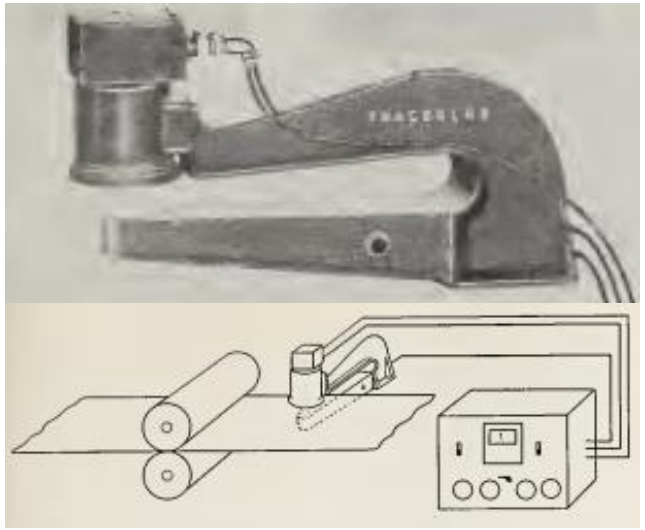
Eric Leaver: An Idea is Not Enough, 1998





The peaceful use of the atom – Late 1940's

Frieseke & Hoephner / Curtiss Wright– **Tracerlab** – Isotope Products



- Tracerlab beta gauge
- Continental Paper Co. BM Ridgefield Park, NJ (1948)
- Single point at DE

National Bureau of Standards, Circular 585, Jan 20, 1958
the measurement of thickness
GovInfo (.gov)*https://www.govinfo.gov › content › pkg › pdf*

The peaceful use of the atom – 1952

Frieseke & Hoephner / Curtis Wright– Tracerlab – **Isotope Products**

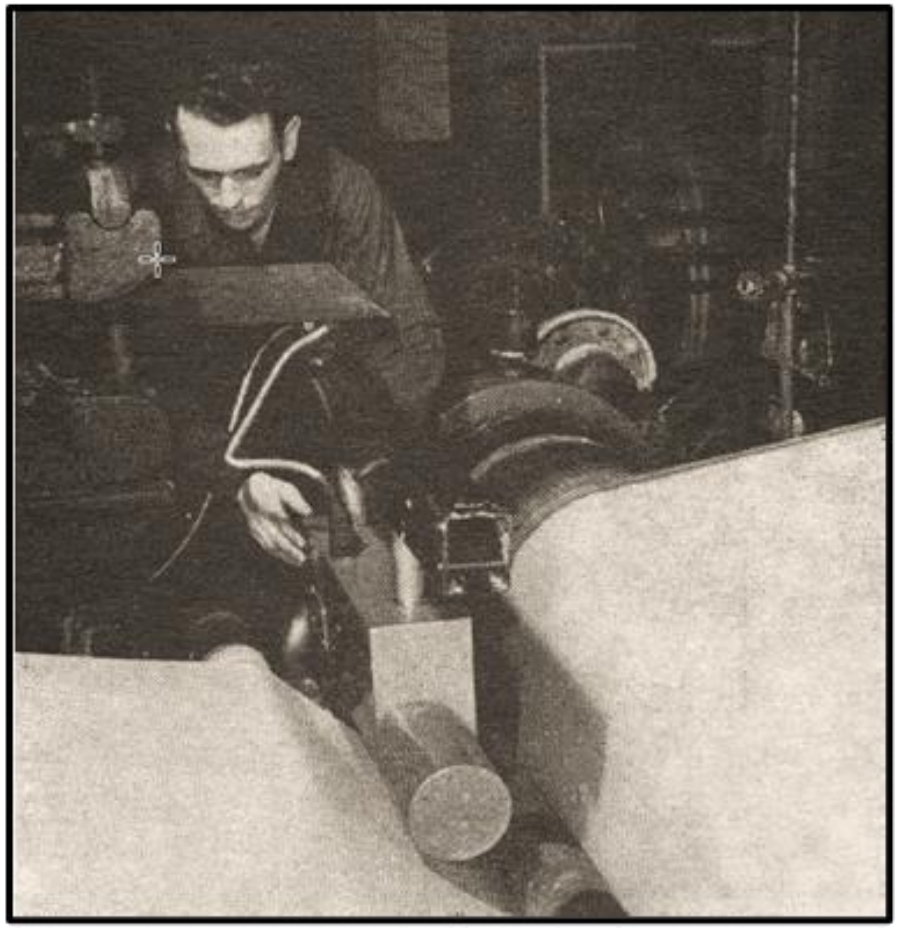


Figure 2: The 1952 beta gauge installed at Don Valley Paper Co., in Toronto.

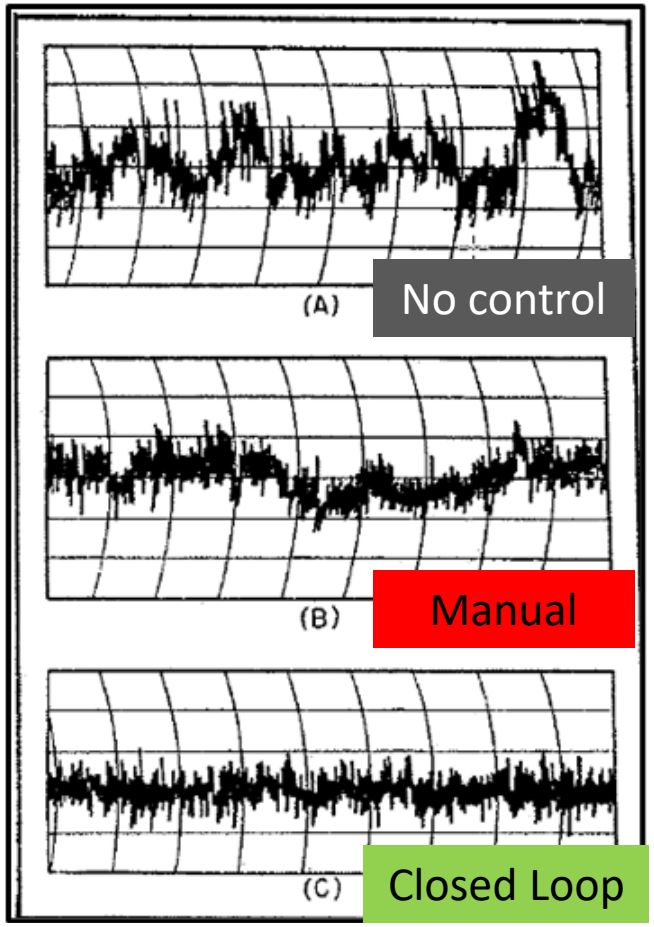
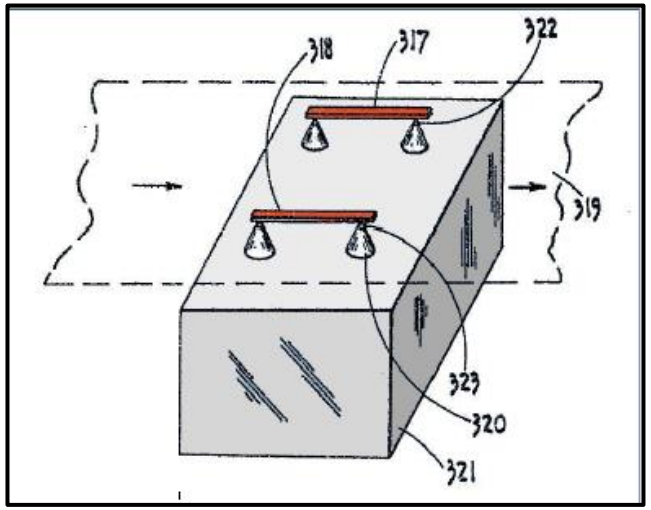


Figure 3: circa 1952, 5 lbs/subd. (Leighton, 1952)



Aquatel moisture (1955) scanning with betameter

Combination system (1956) (Scanning weight & moisture with control)

First profiling basis weight measurement (1954)

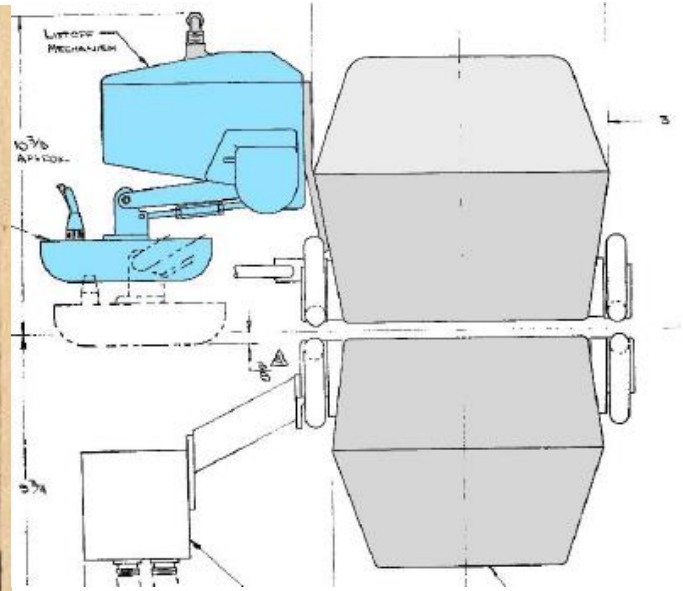
(Hellstrom, 2015)

Industrial Nucleonics

- Champion-Int., Lawrence, MA
- Beta-ray reflection gauge
- 166 inch scanned in ~4 min

Christian Science Monitor, July 28, 1954

Moistron, 1960, scanning with beta gauge



→ Combination system, 1960

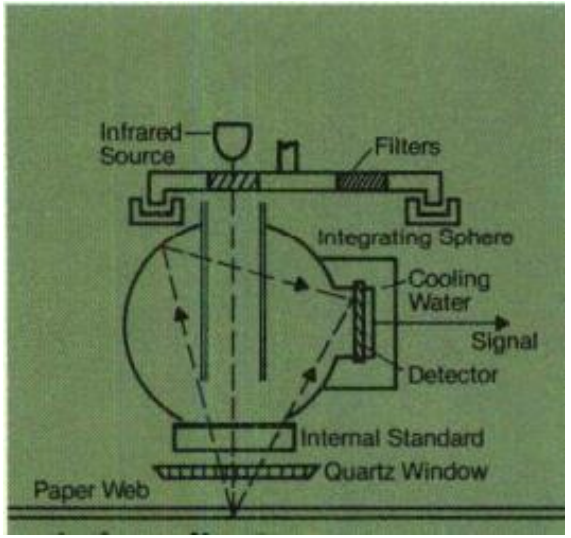
Caliper sensors appear in early 1960's in mills

Papermakers' solution lead the way:

- Great Northern, Millinocket, ME (Patent filed 1963)
- Consolidated Papers, Wisconsin Rapids, WI leads to Calitel (Picture, circa 1964)

IR and Microwave follow late '60's early '70's

- HMB of Switzerland in Europe
- Brun introduces Infra-Gauge in 1968
- Measurex transmission IR in Simpson Lee, CA
- GE's Inframike (early 60's) introduced in 1972 by EA



Early Measurements and Controls were Analog

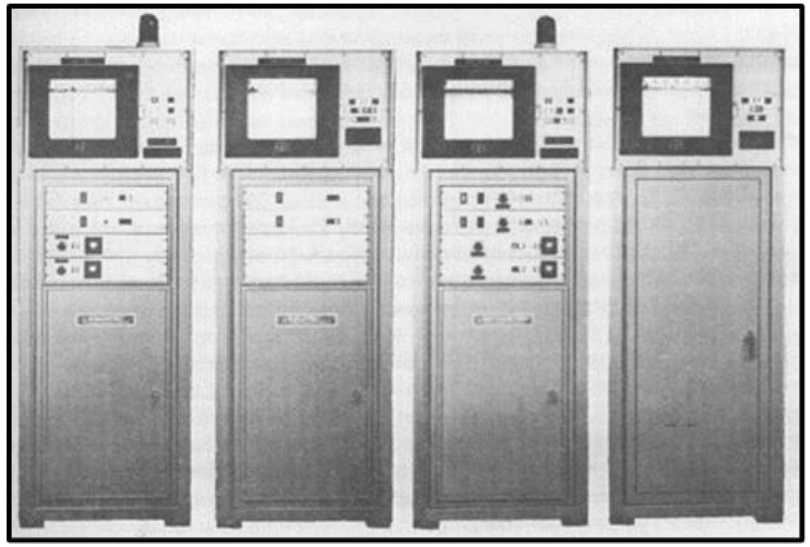
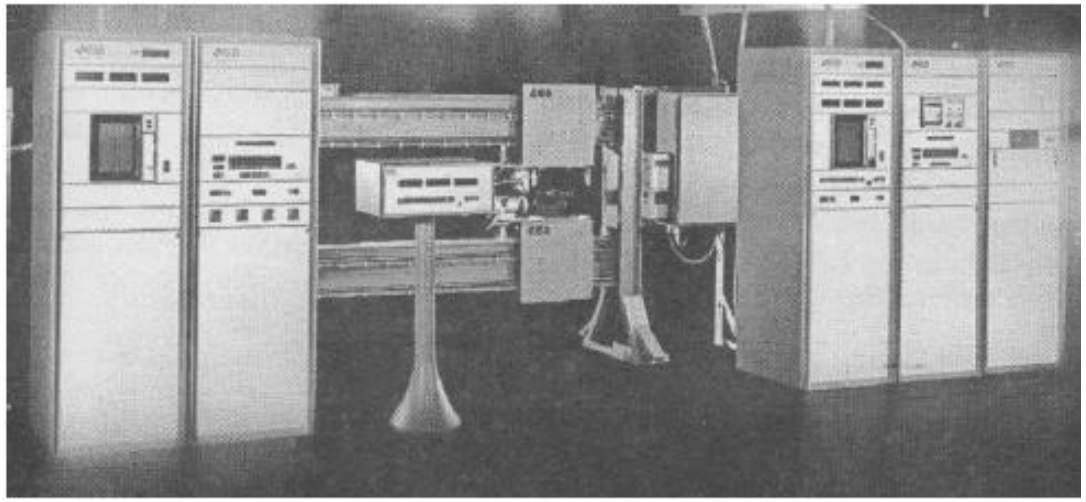


Figure 5: An early analog paper machine control system before computerization (Leaver & Scott, 1998)

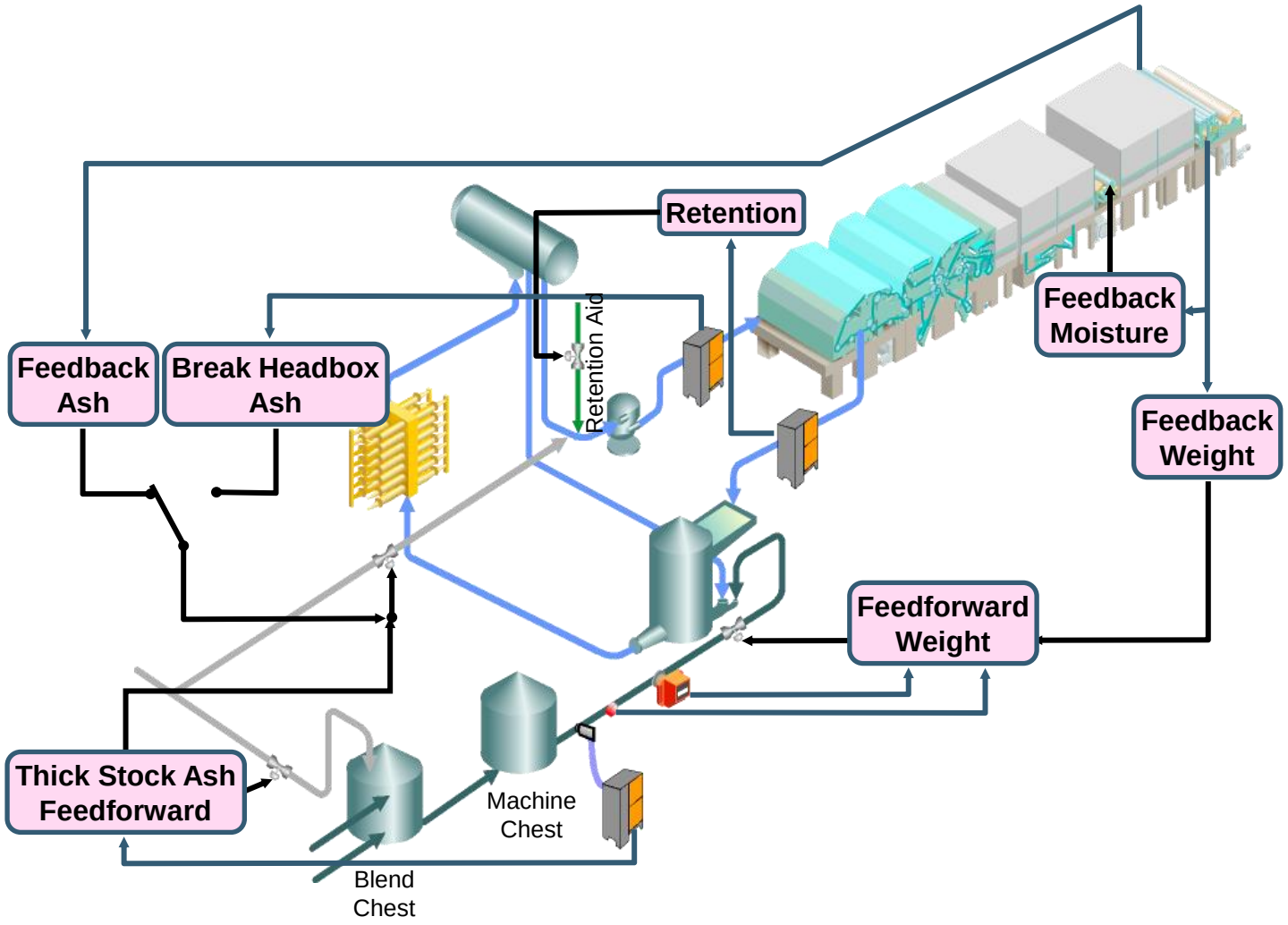
Figure 6: Series E analog control system before computerization

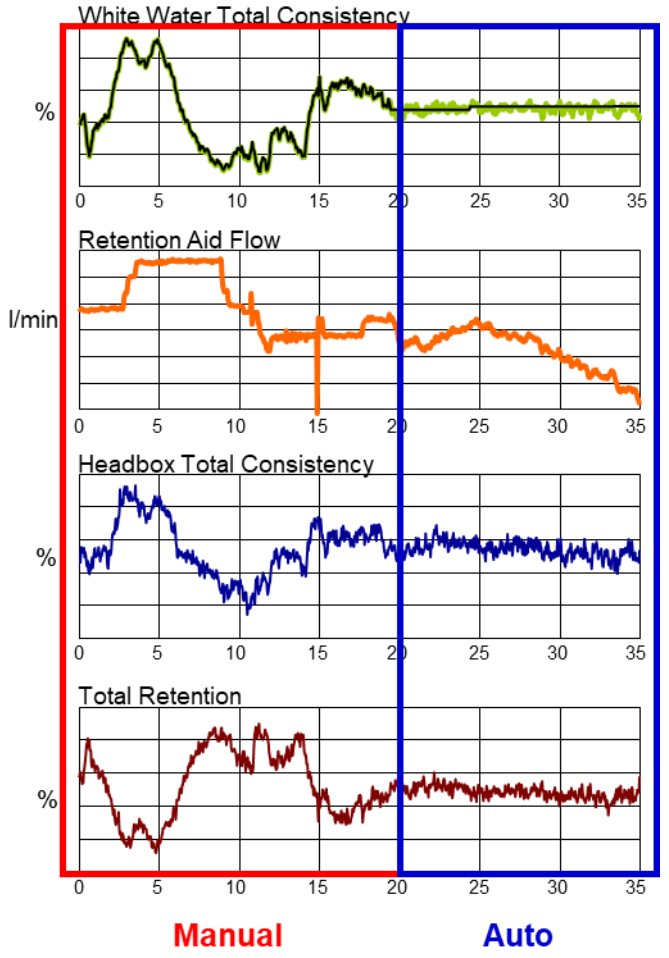
The Dawn of Digital Age

- Minicomputers to PPI in the ‘60’s
- QCS late ’60’s – first hybrid
- MX 1000 1st mini-based QCS (1968)
  - Installed in 1969 in 3 different grades
- EA 7000 installed in 1971
- IN 1180 concept in 1973-74
- Mini to Micro next step (1974-76)
  - MX 2000, Sentry 100, 1180MICRO



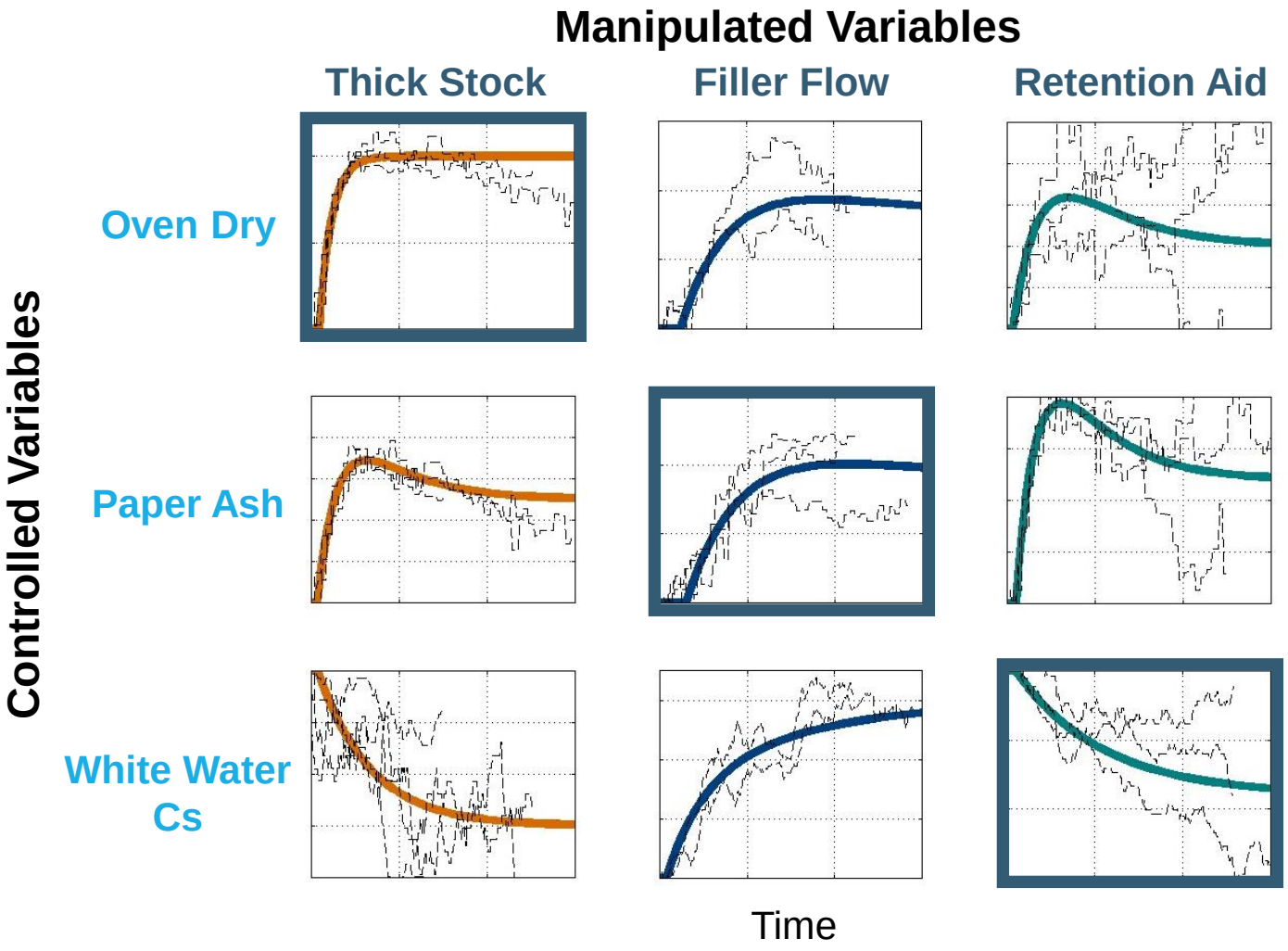
MD Controls: Evolution as single variable controllers

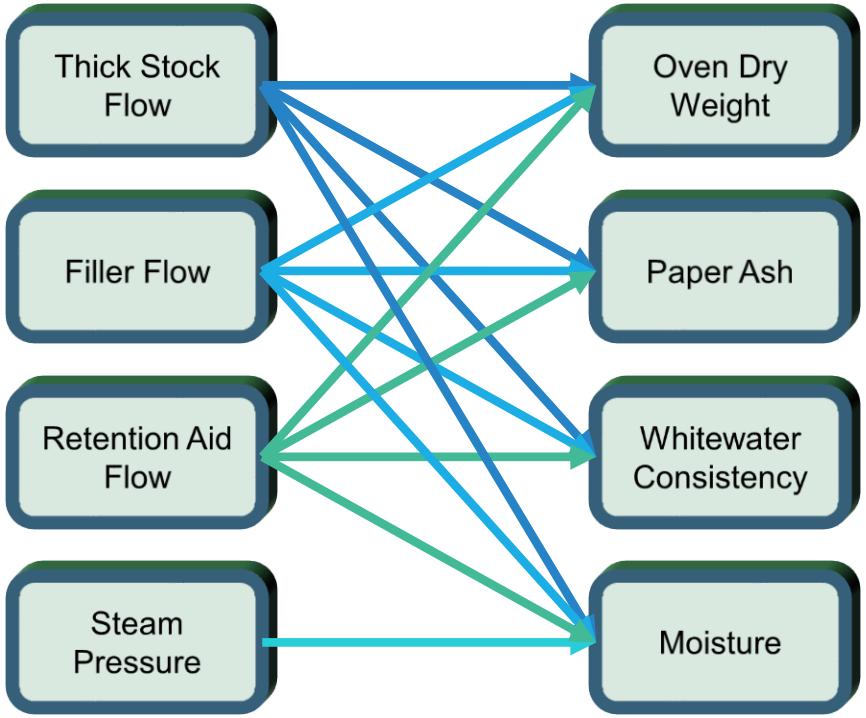




Retention control stabilizes the wet end

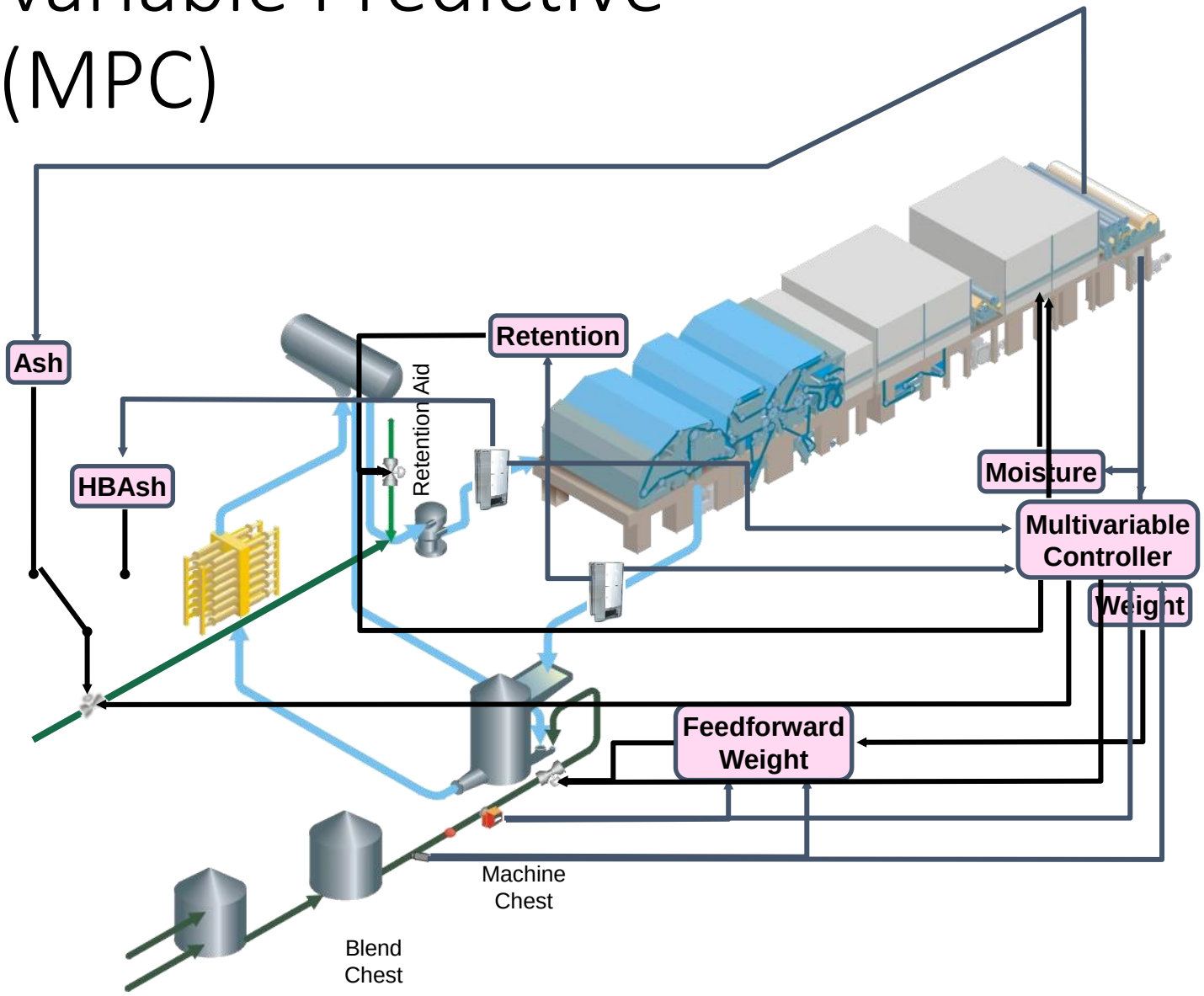
Weight - Ash - WW cons. Interactions





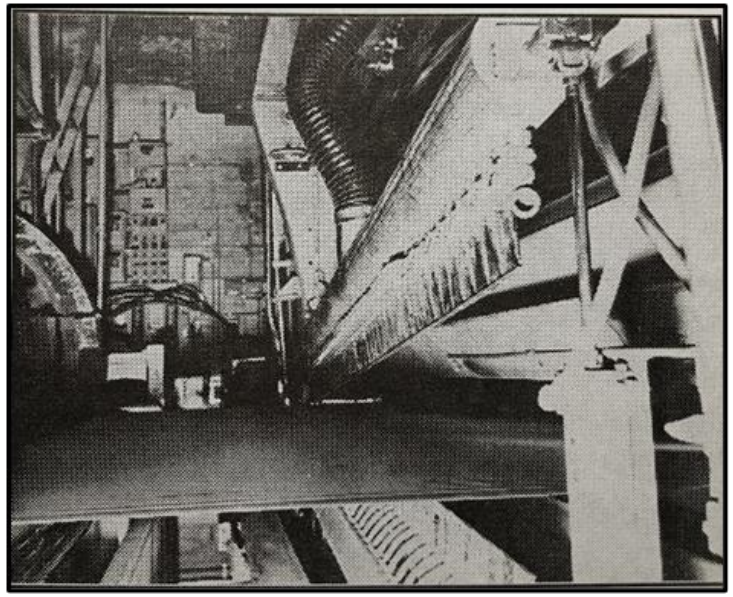
Difficult to control with separate loops

To Multivariable Predictive Control (MPC)

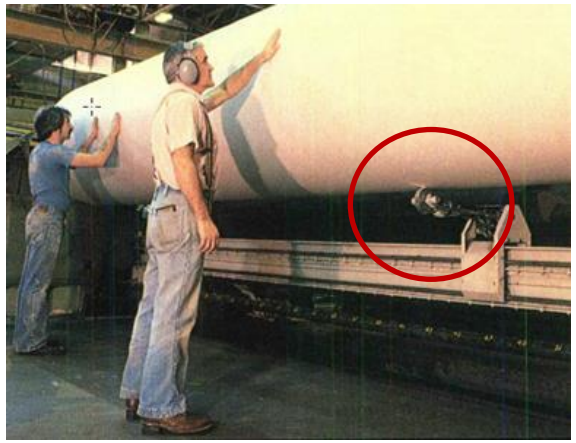


CD Controls: Evolution from simple to sophisticated

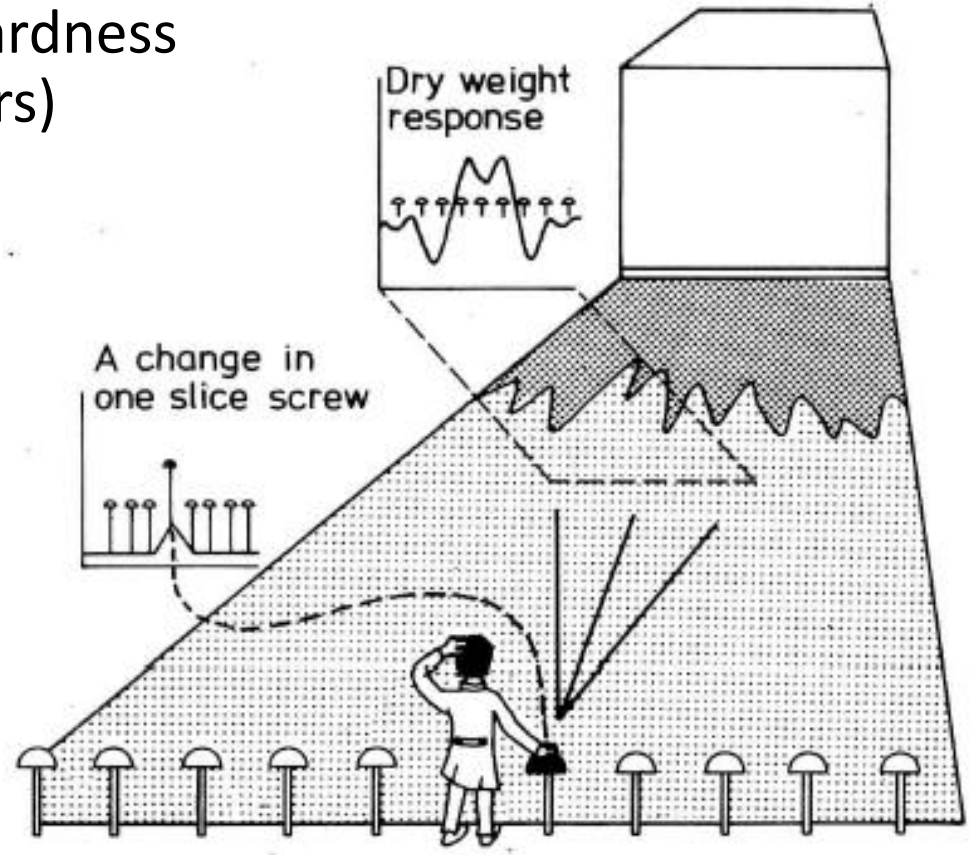
- Some protypes already in the mid ’60’s
- Calitrol air showers by Consolidated Papers
- The first widely successful CD control was that of hardness by controlling the calender stack (Calitrol air showers)



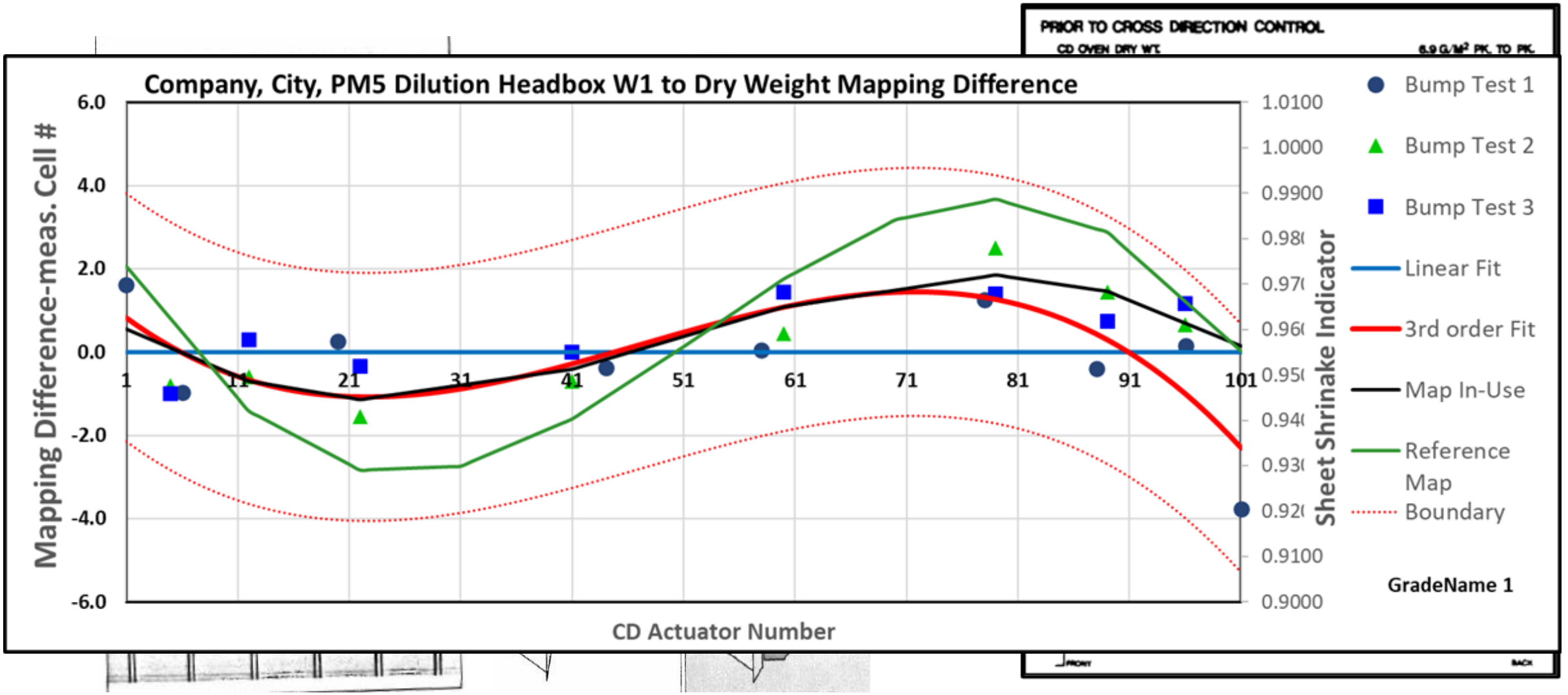
Calitrol air showers, Leaver & Scott, 1998



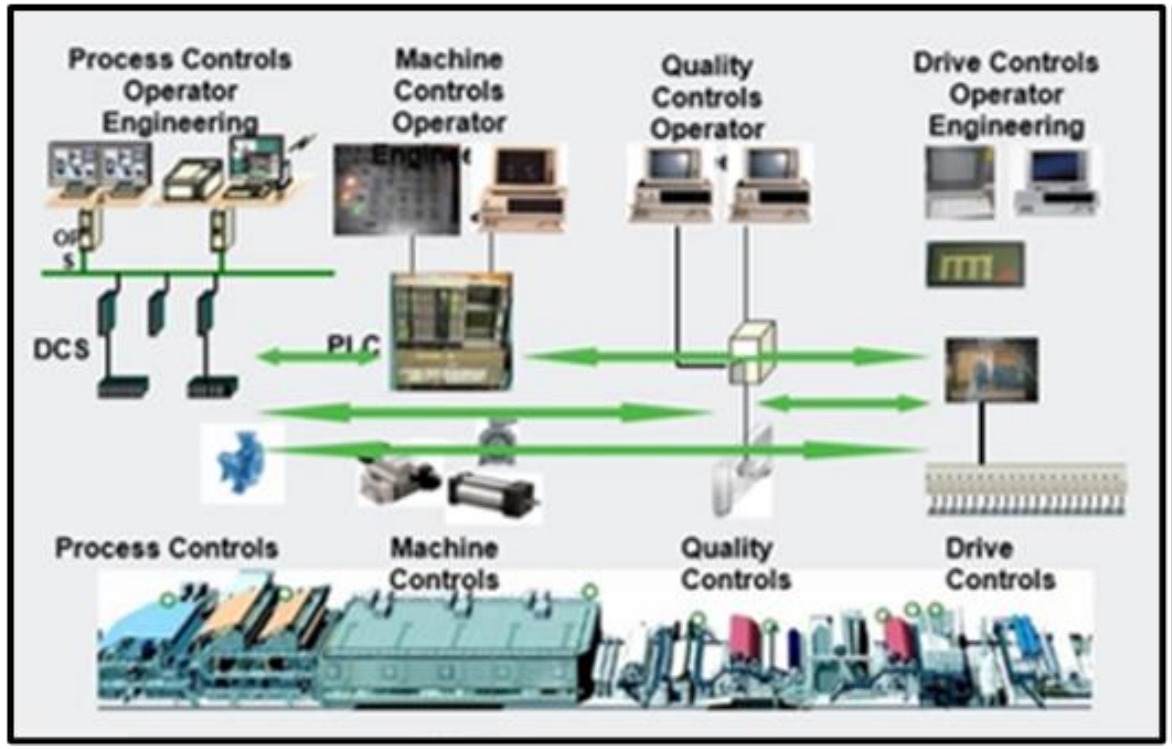
Hardness measurement

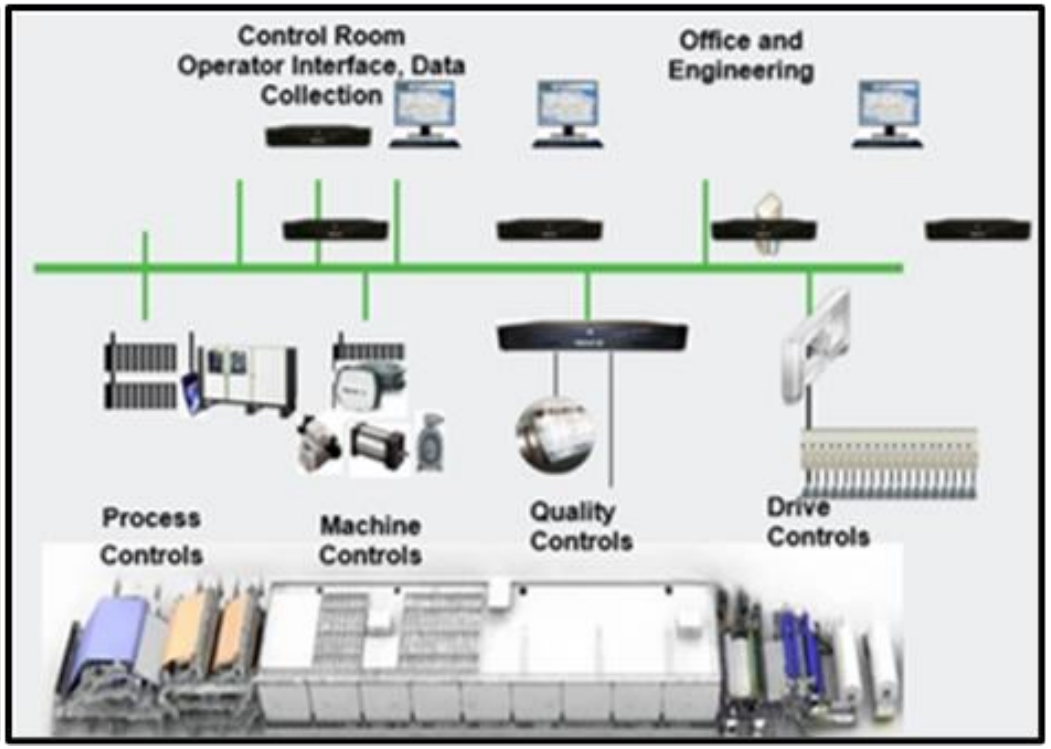


CD Controls (Weight)



Automation Platform late 1980's to '90's: From Standalone (Islands of Automation) to Integrated





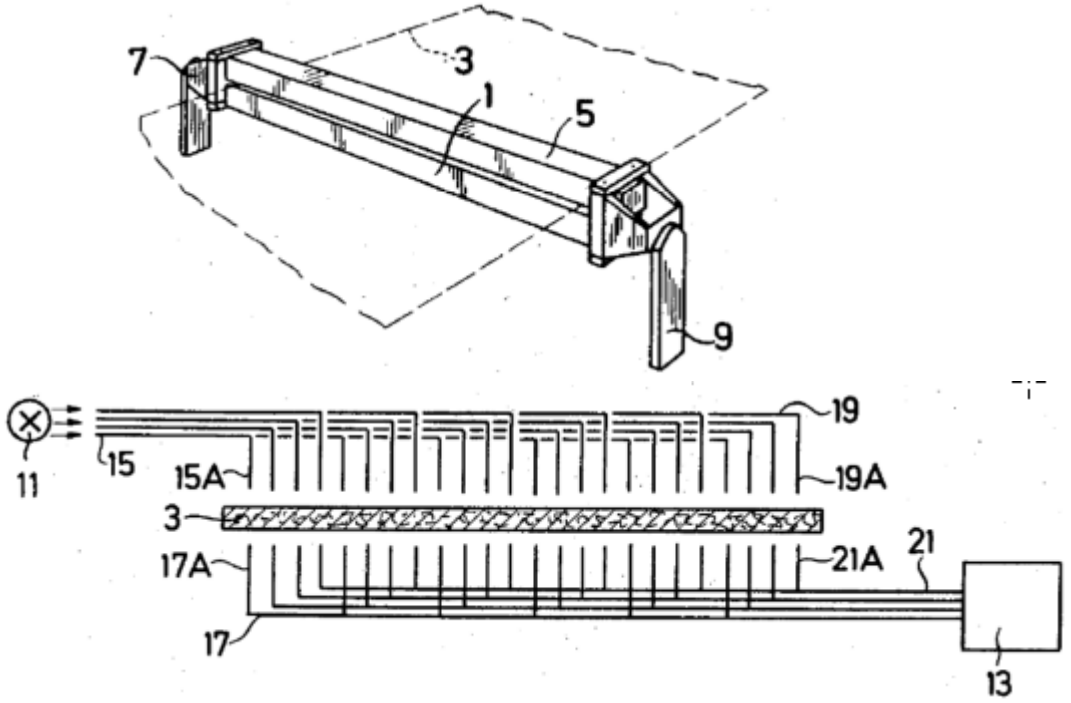
Full Sheet Measurement Effort (50 years ago)

By scanning web quickly through multiple stationary sensors

Tirkkonen & Typpö

Device for radiation measurement
- optically (light guide tubes)

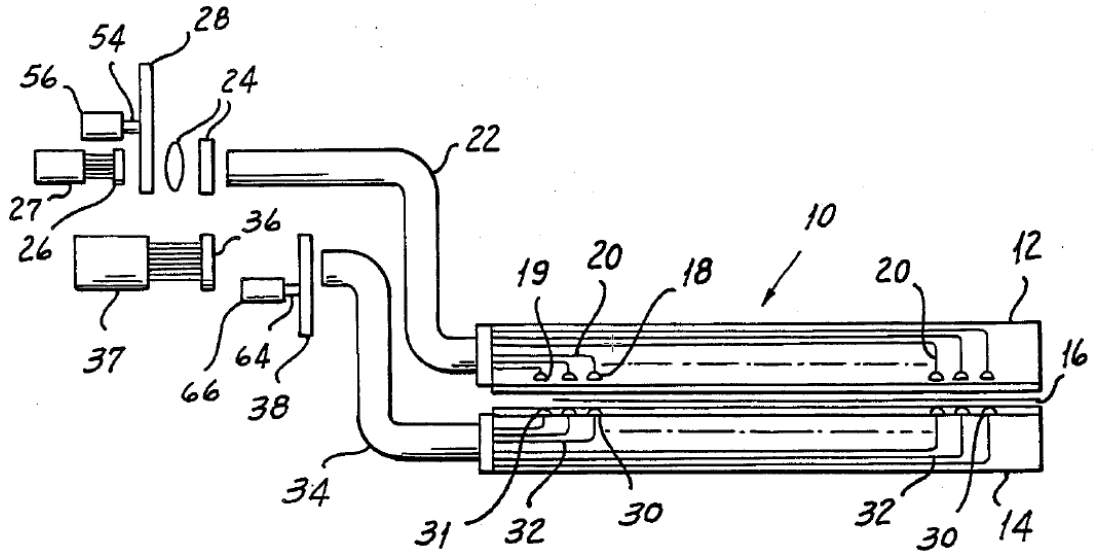
3,806,730
Apr. 23, 1974
Filed, 1971



Mactaggart

Electronically Scanned
Spectrometer Color, Br, & Op

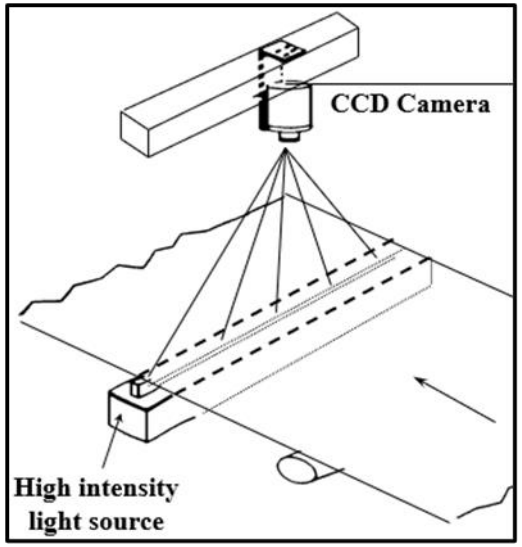
Patent Number: 4,565,444
Date of Patent: Jan. 21, 1986
Filed, 1982



Full-Sheet Measurement Effort

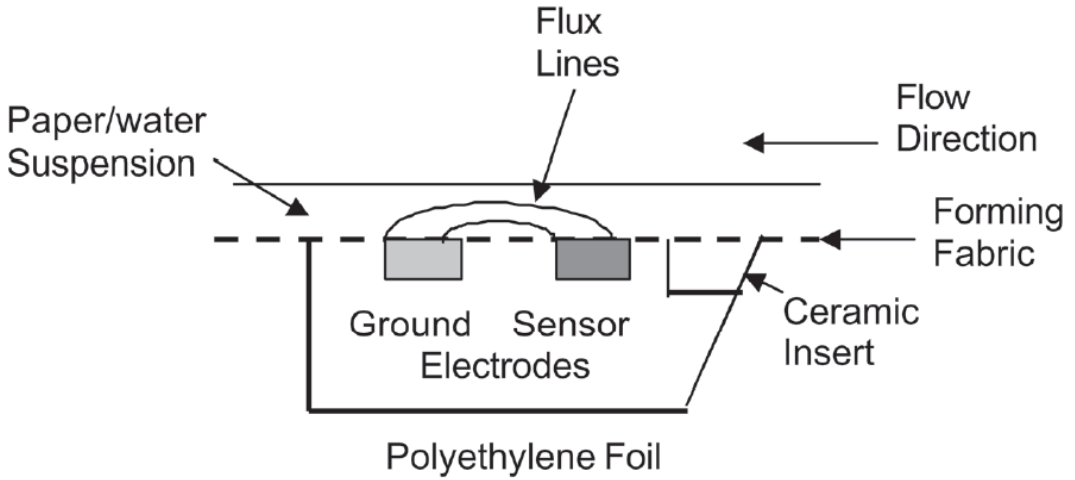
By viewing the sheet remotely

Formation measurement (1988)
50,000 candelas/mm^2 up-to 5,000 sc/sec



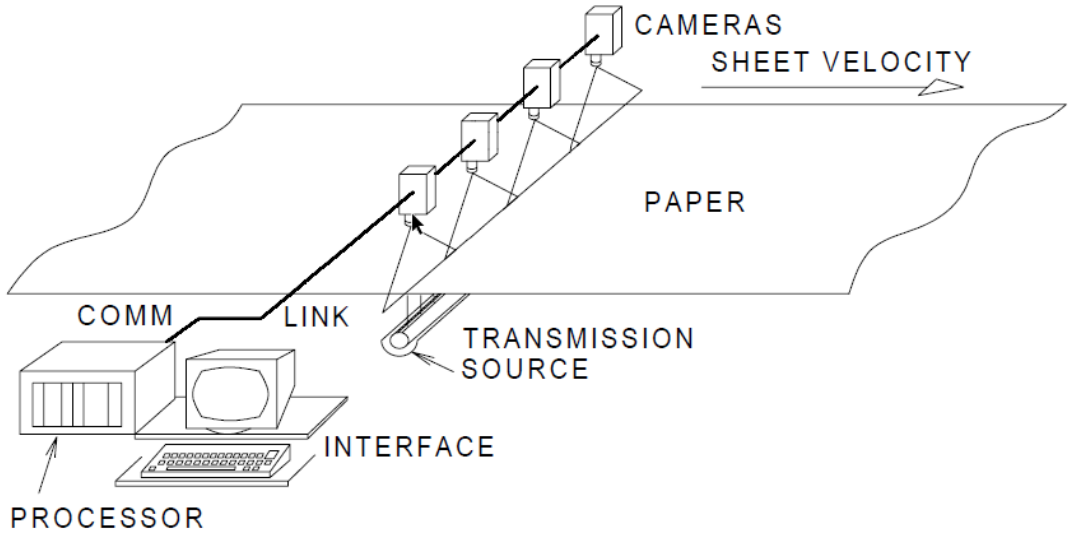
Multiple sensors in CD and MD

Drainage Profile both in CD (25mm) & MD
At 1kHz (1997)

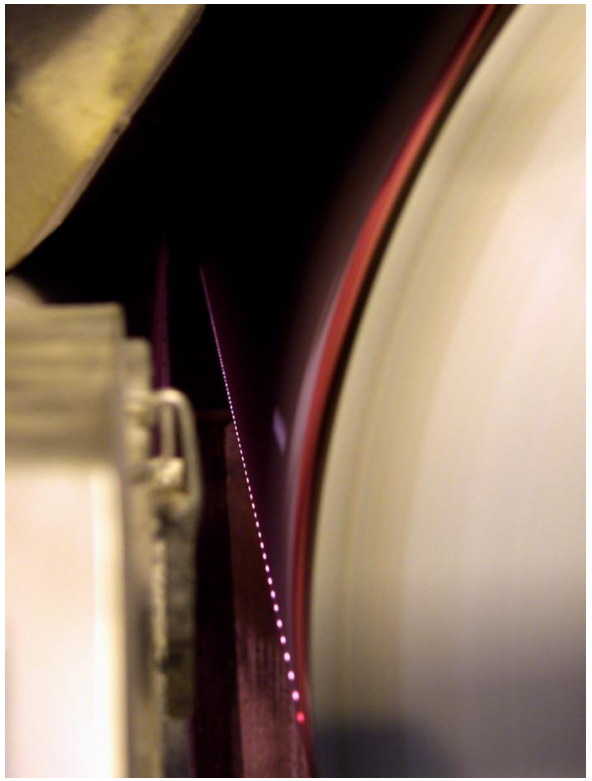


More recent developments

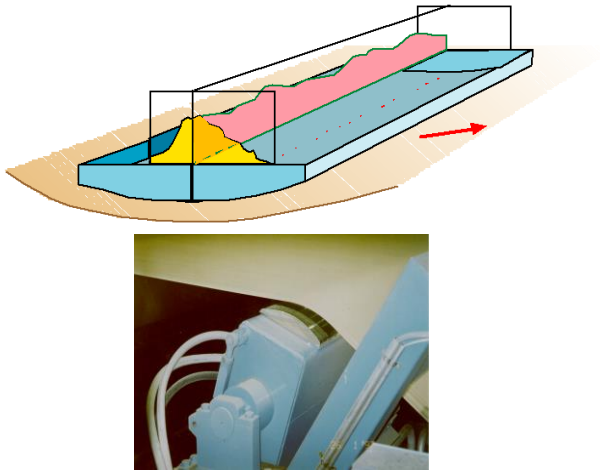
HyperScan (Viewing type)



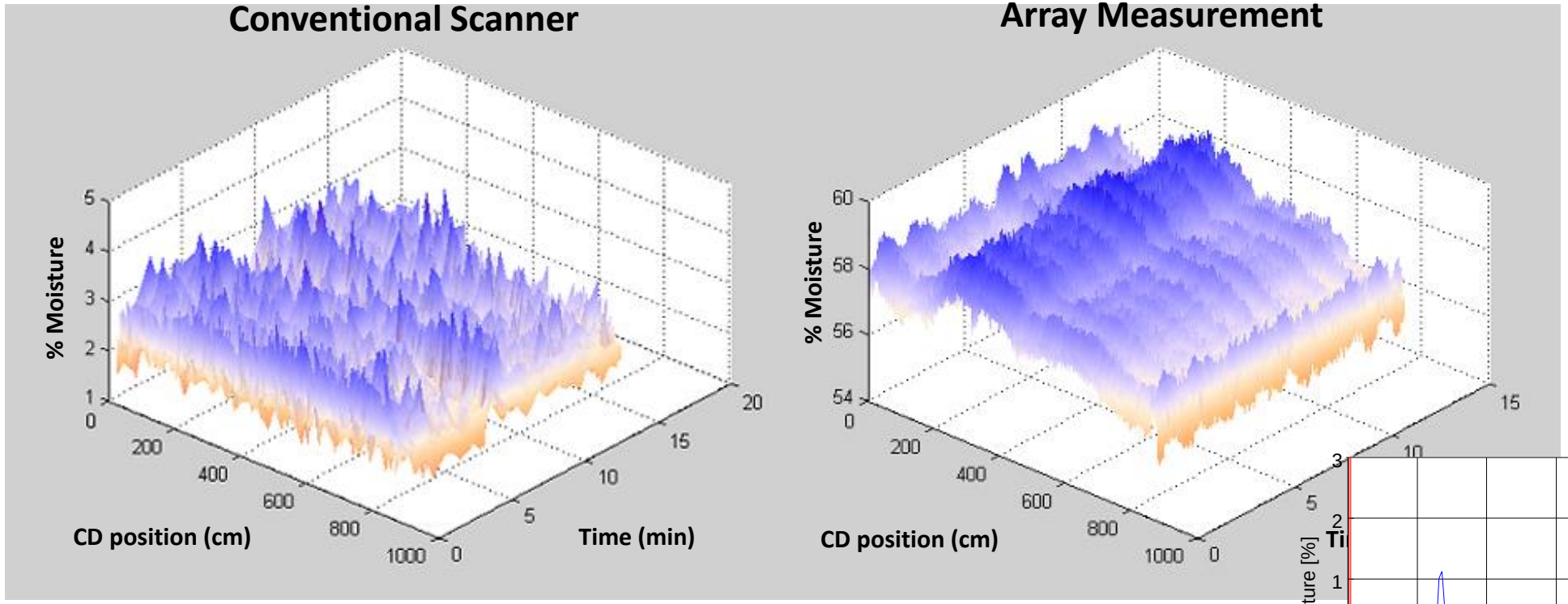
Press section moisture (Spectrometer)



Web Tension (Pressure)

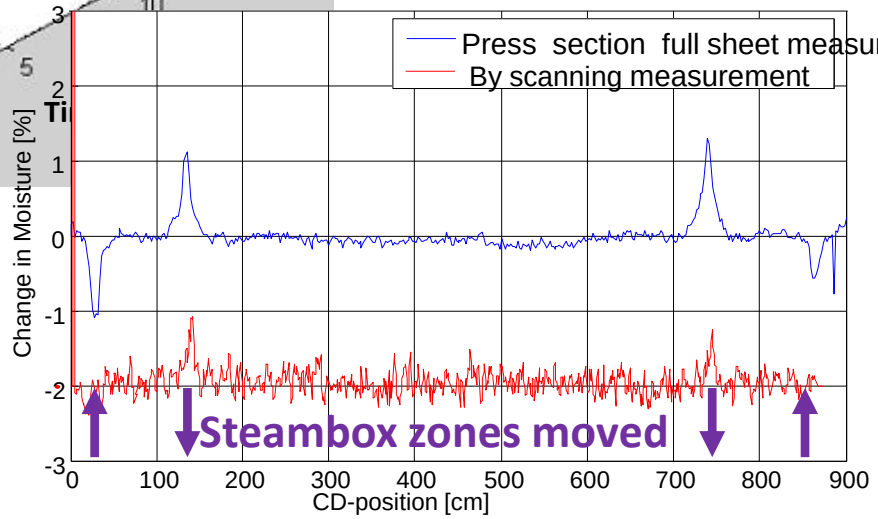


Significantly improved visibility



A confusing picture

MD cycle clearly seen

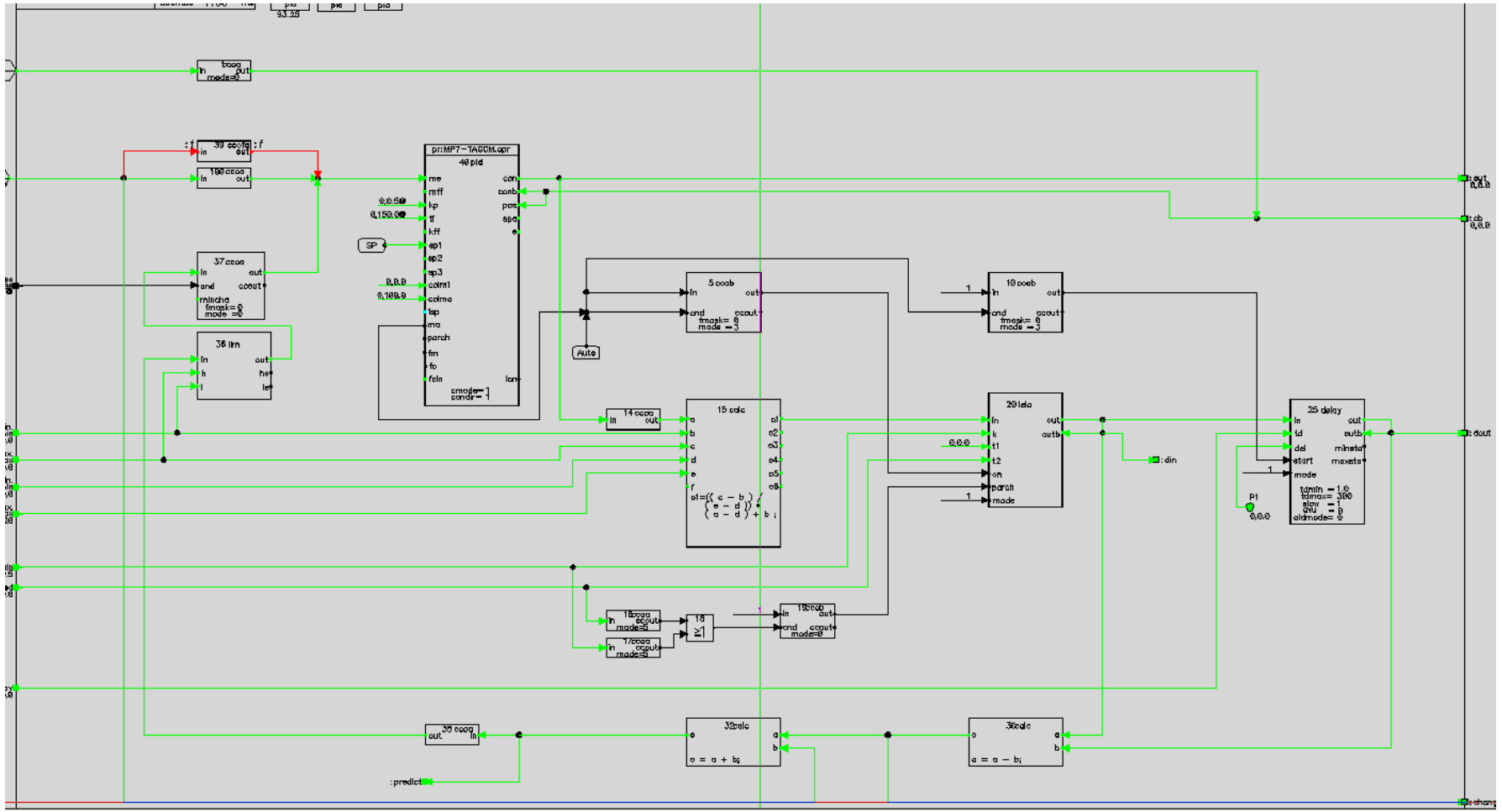


Chest Rotor Problem: Solution – Relocate the chest exit piping

Control Function Block

Before (Early 1990's)

- Developed by company A, by business division B, for product C, likely for all geographies
- Very specific to one type of application; for example, PM MD weight control
- Simple control, very little memory required
- Not very flexible, redesign when the process is different
- Application maintained by a small group of people familiar with the product C



Control Function Blocks

Before (early 1990's)	Present - Example MPC	Future – Example MPC
Developed by company A, by business division B, for Product C, likely for all geographic areas	Developed by company A, for all its divisions, all products, all geographic areas	Developed for all companies, all business, all products (Domain knowledge – Universal Dynamics 1988)
Very specific to one type of application, for example paper machine MD weight control	Widely used for all applications within the company; e.g., energy business, paper quality controls, …	Widely used for all applications for all companies
Simple control, very little memory required	Advanced controls, Require large memory, nowadays possible	Advanced control, require large memory, with self diagnostic features (tell when something is wrong & where it is wrong)
Not very flexible, redesign when the process is different	Flexible, different process can use the same algorithm	Very flexible, for all process control applications
Application maintained by a small group of people familiar with the product C	Application can be maintained by many experts within the company	Application can be maintained by any experts from many different companies
		Such products developed under industrial standards, guidance by all players

Biggest changes are likely in controls and tools

- New sensors only when critical, otherwise **soft sensing**
- Tighter integration with **machine vision**
- **New analysis & AI based methods** will emerge relying on advanced sensors (fiber morphology)
- More visualization, decision, & discovery **tools** (learning, prediction, insight, knowledge)
- Widespread **use of APC** (trackers, optimizers, schedulers)
- Increased use of **pattern recognition, data analytics, voice recognition, expert systems, neural networks**
- **Less reliance on human** intelligence for the day-to-day operations & field activities
- As tools get smarter and widen their knowledge domain, they will be more **able to take care of their performance**,
- The industry will get closer to **smart manufacturing** (IIoT)

In this journey, we can envision:

More setpoints being specified by data-driven & cloud-based apps,

Machine vision & learning applied to reduce field activities

- inspections, reacting on abnormal conditions, overseeing safe operations

Specific performance & economic objectives carried out by APC

The system alerting and advising on the best performance and optimum operating point of the process

Robots handling hazardous field tasks, and eventually …

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Thank You!

Questions? Or other remarks!

Presented by:
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Valmet