M&C technology history

More than a century of measuring

By Jim Strothman
Senior Editor

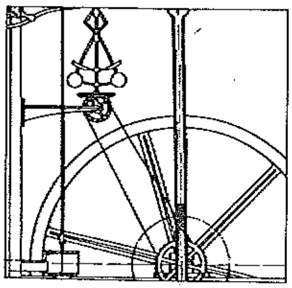
Measurement and control: A journey through time

circa 1750

Many instrumentation pioneers and leaders have hailed from the Philadelphia-Delaware Valley area. Among the first was Benjamin Franklin (1706-90), whose inventions included an instrument to show circulation of the blood. Franklin also showed an interest in devising a hygrometer, an electrostatic machine, and various electrical instruments.

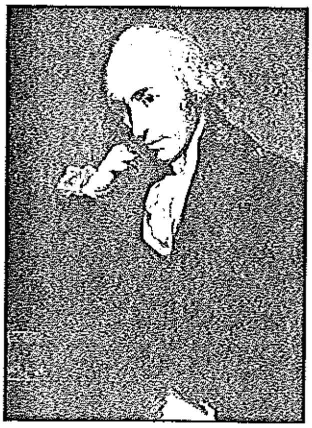
1774

Many believe the first significant "control" invention occurred during the Industrial Revolution when Scottish engineer James Watt devised the "flyball" governor for steam engine applications in 1774. It can be seen in this 1789 Watt steam engine design positioned just above the left-hand side of the circular wheel. Improved versions of the mechanical device are still in use today.



From pre-1800 mechanical instruments to today's desktop digital tools, civilization has depended on measurement and control practitioners and suppliers to help industries produce a steady stream of new and better products — pharmaceuticals, chemicals, foods, fuels, and many more. Along the way, these professionals and technicians helped win wars and grow economies. Here's a snapshot look at some significant M&C highlights and milestones.

A look back at the growth of measurement and control during the past century shows the field moving from a relatively imprecise art to a precise science. We've witnessed the transition from manual and mechanical to pneumatic, to electromechanical, to electronic, to today's digital and information-based world.



James Watt

No one knows exactly when instruments first began to be used to control processes. They were surely used by the Egyptian engineers who built the Great Pyramids about 2700 B.C. Engineers who built the aqueducts during the Roman Empire used rudimentary flowmeters.

What was the first "true" control device? A reasonable case can be made for the float valve on a water clock in the third century B.C. Early measuring devices included the pitot tube of the 1600s, and instruments devised by Benjamin Franklin that showed blood circulation and measured moisture. However, many believe the first significant "control" invention occurred during the Industrial Revolution when Scottish engineer James Watt devised the "flyball" governor for steam engine applications in 1774. That mechanical device, improved versions of which are still in use today, automatically controls the speed of a steam engine.

Until the 1920s, the primary focus in control innovation was on manual and mechanical devices to help control both process and discrete applications.

Mid-1800s:

Pioneers plant seeds

German inventor C. William Siemens, who with his brother E. Werner Siemens had invented a chronometric governor they thought improved on Watt's and others, set up shop in London in 1844 to sell the device. However, according to S. Bennett's *A History of Control Engineering, 1800-1930* (Institution of Electrical Engineers, London, 1979), the chronometric device was a failure, and a new device was designed based on a hydraulic brake. In 1866, Werner Siemens invented the first dynamo.

Founded in the mid-1800s just before the Civil War, Brown Instrument Co. was considered by many to be the first known U.S. maker of process instru-

and controlling industrial processes

ments. Founder Edward Brown invented and produced the first pyrometer to measure temperature. That invention was the first commercial industrial instrument. (Brown was acquired by Honeywell in 1934.)

In 1851, George Taylor, at the young age of 19, and David Kendall pooled their resources to form what eventually became Taylor Instrument Co. Their first products were a few tin-case and wood-case thermometers and mercury barometers. In 1866, George's brother Frank joined the business, and, by 1870, they expanded the line to include fever, brewery, and dairy thermometers.

The Taylor brothers soon recognized the need for thermometers for industrial processes, and began research and development around 1887. In 1908, Taylor Instruments made a significant contribution to the control industry by installing two experimental tube system type temperature recorders in a Chicago dairy.

Later 1800s:

Fisher, Foxboro, Honeywell

Honeywell traces its roots to 1885, when Albert M. Butz filed for his first temperature control patent. He formed the Butz Thermo-Electric Regulator Co., which was reorganized around entrepreneur William R. Sweatt in 1893. In 1906, Mark C. Honeywell founded Honeywell Heating Specialty Co., which built a hot-water system for homes. That company merged with Sweatt's Minneapolis Heat Regulator Co. in 1913.

Today's Fisher-Rosemount Systems got its start in 1880, when William Fisher invented the Type 1 constant pressure pump governor, designed to maintain pressure in Marshalltown, IA's water mains when fighting fires. Fisher later founded and incorporated the Fisher Governor Company in 1888 in that Iowa town.

The Bristol Co., forerunner of Foxboro, was incorporated in 1894 after moderate success with two patents, one for an improved pressure indicator or recorder design. Bristol family members were among the early directors of Industrial Instrument Co., founded in 1908 in Foxboro, MA. Its name was changed to The Foxboro Company in 1914, primarily to make it easy for customers. Foxboro claimed the first multiple pen recorder in 1910, the first accurate control instruments with calibrated setting dial in 1913; the first flapper nozzle on a pneumatic controller in 1914; and the first single-case industrial recorder-controller in 1915.

Meanwhile, the first course in chemical engineering was offered in 1885 by Henry Edward Armstrong at Central College (later Imperial College), London. The Massachusetts Institute of Technology (MIT) in 1891 awarded a BS in chemical engineering to seven individuals. A year later, a bachelor's program was established at the University of Pennsylvania.

Other instruments in the late 19th century, according to Eiju Matsumoto, curator, Yokogawa Technology Museum, Tokyo, included the 10A switchboard ammeter manufactured by Weston; an electromagnetic oscillograph to observe and record waveforms; and Cambridge Scientific Instruments' Calendar Recorder, the first self-balancing recorder. Instruments submitted for scientific committee approval during the 19th century included the cephalometer and inertial indicator.

Early 1900s:

Allen helps Bradley

Early temperature controllers existed about 1900. Tagliabue Co. introduced an air-operated temperature controller in 1902, followed by Bristol in 1903. Taylor Instruments' first controller was made in 1905.

In 1903, Lynde Bradley, aided by a $1,000

1800-1850

1844
German inventor C. William Siemens, who along with brother E. Werner Siemens had invented a chronometric governor, sets up shop in London in 1844 to sell the device.

1850-1899

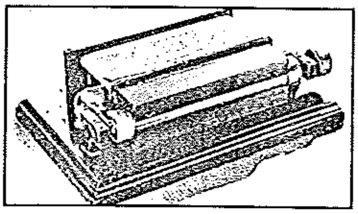
1851
George Taylor, below left, age 19, and David Kendall pool resources in 1851 to form what eventually becomes Taylor Instrument Co. Their first product offerings are a few tin-case and wood-case thermometers, and mercury barometers. In 1866, George's brother Frank, below right, joins the business.

1853
James W. Queen, below, establishes Queen & Co. in 1853, selling scientific iinstruments and apparatus well into the 1900s. Its forerunner was McAllister & Co., established in 1783 by a neighbor of Ben Franklin.

ISA's 50th Anniversary

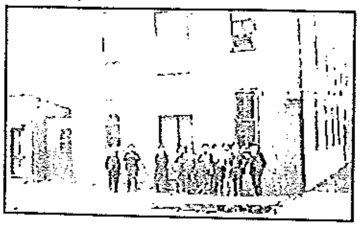
circa 1855
Brown Instrument Co. is considered to be the first known U.S. process iinstrument maker. Founded by Edward Brown just before the Civil War, it produces the first pyrometer to measure temperature. Some consider this invention to be the first commercialized industrial instrument.

1866
The dynamo machine is invented in 1866 by a German, E. Werner Siemens. He and his brother, C. William Siemens, in the 1840s had invented a chronometric governor they thought improved on Watt's and others, and William Siemens sets up shop in London to sell it.



1885
Honeywell traces its roots to 1885, when Albert M. Butz, below right, files for his first temperature control patent. He forms the Butz Thermo-Electric Regulator Co., which is reorganized around entrepreneur William R. Sweatt, below left, in 1893.

1888
William Fisher in 1888 founds the Fisher Governor Company in Marshalltown, IA, shown below in an 1897 photo. Its first product, the Type 1 constant pressure pump governor, is designed to maintain pressure in the city's water mains.



loan from Dr. Stanton Allen, one of Milwaukee's leading orthopedic surgeons, founded Compression Rheostat Co., forerunner of Allen-Bradley Co.

Leeds & Northrup, founded in 1899 by Morris E. Leeds, originally manufactured precision instruments for laboratory applications, such as galvanometers and resistance boxes, and expanded in the 1920s to include industrial instrumentation. In 1911, the company developed a mechanically sensing potentiometric recorder.

The Bailey Boiler Meter was invented in 1915 by Ervin G. Bailey, who, in 1916, founded Bailey Meter Co., forerunner of Bailey Controls. A breakthrough, the meter helped boiler operators achieve and maintain maximum process efficiency. The device combined both air flow and steam flow measurements on the same chart to let operators know how much steam the boiler was emitting, how much air was being used, and the condition of the fuel bed.

In 1921, Bailey introduced a multi-pointer gauge, the first instrument to indicate more than three related drafts and pressures on adjoining scales for easy comparison. A year later, the company installed the first recording instrument on a marine boiler aboard the S.S. President Harding.

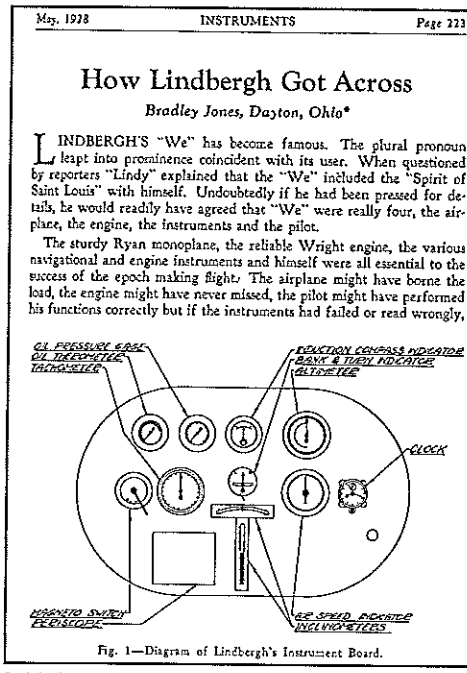
Hagan Controls was founded in 1916 by John M. Hopwood and Thomas Peebles as a supplier of boiler and combustion controls. Hagan was the forerunner to the Westinghouse Combustion Control Division which, in 1990, became the Orrville, OH division of Rosemount Analytical. Hagan acquired the first patents covering the control of forced draft from furnace pressure and also is credited as the first U.S. company to make possible the efficient use of blast furnace gas.

1915 - mid-20s:

Petrochemicals & WWI

World War I (1914-18) helped focus America's attention on conserving fuel and using energy efficiently. Demand for Bailey meters and other efficiency instruments increased. The instruments were installed or mounted directly at the process area, and relied on mechanical technology. To change the parameters of the device, a human operator was needed.

In 1919, Standard Oil of New Jersey established a research and development department to apply chemical engineering to the oil industry. In what is credited as being the birth of the petrochemical industry, Union Carbide in 1921


May, 1928 INSTRUMENTS Page 223

How Lindbergh Got Across

*Bradley Jones, Dayton, Ohio**

LINDBERGH'S "We" has become famous. The plural pronoun leapt into prominence coincident with its user. When questioned by reporters "Lindy" explained that the "We" included the "Spirit of Saint Louis" with himself. Undoubtedly if he had been pressed for details, he would readily have agreed that "We" were really four, the airplane, the engine, the instruments and the pilot.

The sturdy Ryan monoplane, the reliable Wright engine, the various navigational and engine instruments and himself were all essential to the success of the epoch making flight. The airplane might have borne the load, the engine might have never missed, the pilot might have performed his functions correctly but if the instruments had failed or read wrongly,

Fig. 1—Diagram of Lindbergh's Instrument Board.

Article from May 1928 *Instruments* magazine

began commercial cracking of natural gas at Clendenin, WV, producing ethylene as a raw material. In the 1920s, instrument companies expanded their product range from recorders and indicators to electrically and pneumatically operated feedback controllers. On-off controllers were widely used in the process industry by the mid-1920s.

In 1927, Tagliabue advertising manager Manoel J. Behar, of New York, organized an informal committee among instrument suppliers to cooperate on education programs. In January 1928, Richard Rimbach, from Pittsburgh, published the first issue of *Instruments* magazine. Later that year, a close relationship began between Behar and Rimbach after Behar wrote a complimentary letter to the editor. Behar began writing and editing the magazine, and he and Rimbach jointly began promoting the idea of forming a national society for instrumentation.

The May 1928 issue of *Instruments* carried an article on "How Lindbergh Got Across," describing instruments aboard that historic first trans-Atlantic flight.

Late 1920s:

'Instrumentation' means M&C

In 1927, Vannevar Bush and his colleagues at MIT launched a program to build a general-purpose mechanical analog computer. Leeds & Northrup that year introduced the first conductivity recorder.

Although the idea of proportional control was known as far back as the late 18th century in connection with windmills and steam engines, it was not until the end of the 1920s that it was used in the process industries.

During the mid to late 1920s, the term "instrumentation" began to be used to refer to devices specifically used to control and measure process variables. Pneumatic controllers were prevalent, using compressed air as the basis of their technology. Unlike mechanical devices, pneumatic controllers could reside in panels located *close* to the process rather than directly at the process. The instrument signal was transmitted to another, distant location in which the controller was located. The controller in turn transmitted the appropriate response signal to the actuator, which in turn would respond, explained Peter Martin in his book, *Dynamic Performance Management* (Von Nostrand Reinhold, 1993).

These developments were significant because they enabled control operations to move away from the process itself. From this development came the first "control rooms" and the first use of "reset" or integral control, which lessened the need to control the devices manually. "Rate" or derivative control was also developed, resulting in the first PID (proportional, integral, derivative) controllers, notes John Bernard in his book, *CIM in the Process Industries* (ISA, 1989).

Fisher Governor Co. in 1928 built its first test laboratory and developed the first authoritative capacity and sizing data charts, launching a reputation for having complete and accurate specification charts.

1930s:

Early PID

Since the 1920s, an amazing number of control techniques have developed, closely connected to social and technological events of the time. With the benefits of hindsight, we can observe distinct characteristics of each decade and witness the incremental improvement upon previous inventions as devices evolved from manual to pneumatic, electronic, and finally digital control.

By 1930, process control became the subject of scientific papers, including articles that dealt with difficult pH control problems and the application of controllers; the use of potential deviation and correction as an ingredient in the quantitative evaluation of control systems; and the effect of time delay on the stability and processing time of control systems, reports Peter Harriott in his book, *Process Control* (McGraw Hill, 1982).

The instrumentation industry grew rapidly during this period, with more than 600 companies selling industrial instruments by the mid-1930s. However, seven companies controlled 65% of all sales, with Foxboro, Brown, and Taylor among the biggest. Taylor in 1933 began marketing its Model 56R, the first truly adjustable proportional controller.

The first "servomechanisms" appeared during the early 1930s. These devices consisted of automatic systems that compared the output with the input through feedback, enabling the difference between the two quantities to be used to bring about the desired amount of control. Leeds & Northrup, during the same period, pioneered development of glass pH electrodes.

Foxboro began marketing its Model 40 in the early 1930s, the first proportional plus reset recorder/controller. It was primarily applied on flow control in the petroleum industry, where Foxboro had a strong presence. A year later, Foxboro came out with the first equal percentage valve. In 1937, Leeds & Northrup introduced the first thermal conductivity gas analyzers for recording such measurements as H_2, O_2, SO_2, and CO_2. That same year, Foxboro introduced the Cyclelog, the first programmable controller for discontinuous applications.

In March of 1937, a sign reading "Fischer & Porter Co." went up for the first time, in Philadelphia's old Germantown section. Founded by Kermit Fischer and his only employee, George Porter, its initial products were "rotameters," or variable-area flow rate meters. By 1940, a total of five houses and backyard shops around the neighborhood bore Fischer & Porter signs.

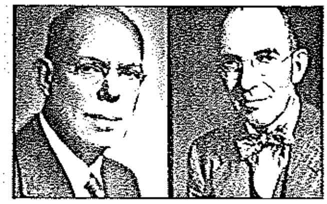
Honeywell in 1938 introduced the first electronic potentiometer, Class 15, which implemented servo drive indicators and recording pens. The next year, Honeywell announced the first remote optical temperature sensor, the Radiamatic, which used a thermo-pile sensor with selectable lenses.

At the very end of the decade, in 1939, the first digital computer, "Mark I," was developed by H.H. Aiken of Harvard University and IBM. The computer performed basic math functions and used punched math cards as inputs. Considered to be the world's first large-scale digital computer, it was officially dedicated in 1944.

1900-1909

1903

Lynde Bradley, below left, with help from a $1,000 loan from Dr. Stanton Allen, in 1903 founds Compression Rheostat Co., forerunner of Allen-Bradley Co. Younger brother Harry Bradley, below right, joins the firm a year later.



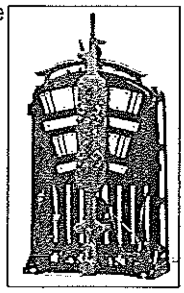
1906

Mark C. Honeywell founds Honeywell Heating Specialty Co. in 1906, which builds hot-water systems for homes.

That company merges with Sweatt's Minneapolis Heat Regulator Co. in 1913.

1907

Small crane controller, manufactured in 1907 at Allen-Bradley's Muskegon, WI plant. Invented by Lynde Bradley, the device is essentially a stack of carbon disks that provide graded control of electrical current when compressed.

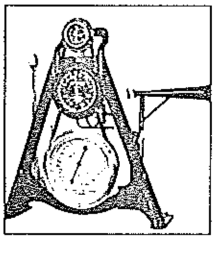


circa 1913

Foxboro triple Bourdon Tube pressure indicator mechanism.

circa 1915

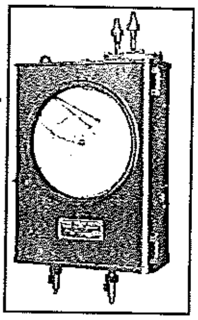
Foxboro dual (both knots and miles per hour) air speed indicator, manufactured about 1915, features a Pitot tube element.



ISA's 50th Anniversary

1915

Ervin G. Bailey in 1915 invents the Bailey Boiler Meter, a breakthrough device that shows and records continuously how much steam a boiler makes, rate of air flow through the furnace and thickness or conditions of the fuel bed. The next year, the Bailey Meter Co. officially opens for business.



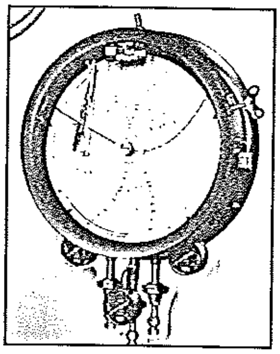
1920-1929

1926

Foxboro Temperature Controller, manufactured about 1926.

1928

Foxboro Duplex Recorder Controller



1930-1934

1930

Foxboro Wide Damping Range Controller, from about 1930, features automatic reset.

1931

Bailey Meters calendar card

Early 1940s:

First PID controller

No summary of measurement and control history would be complete without mentioning the Taylor Fulscope controller, which integrated previously separate PID functions for the first time. The Taylor Model 100 Fulscope was redesigned in the late 1930s as the result of efforts to improve operations in the viscose rayon industry. In a 1990 interview with *Control Engineering* magazine, Taylor engineer John Ziegler recalled the development:

"Someone in the research department (at Taylor) was tinkering with Fulscopes and somehow had got a restriction in the feedback line to the capsule that made the follow-up in the bellows. He noted that this gave a strange 'kicking' action to the output. They tried this on the rayon shredders and it gave perfect control on the temperature. The action was dubbed 'Pre-Act' and was found to help the control in other difficult applications, like refinery tube stills. The Pre-Act was the first derivative control and was incorporated into the Model 56R."

However, the new controller had one problem: tuning. Ziegler and another Taylor engineer, Nathaniel Nichols, set out to solve the problem, and the result of their efforts is the well-known "Ziegler-Nichols" method of tuning, still in use today (see their original paper on the subject, p.94 of this issue). The procedure involves increasing the proportional response until a sustained oscillation is obtained (also referred to as "ultimate sensitivity"), setting the proportional adjustment to half the value that caused the ultimate sensitivity, setting the integral rate equal to the ultimate frequency, and setting the derivative or Pre-Act to one-eighth of this frequency.

1940-1945:

WWII

The U.S. process industries, particularly the chemical industry, played a major role in winning World War II. Temporarily halting most consumer-oriented chemical development, competing chemical and equipment suppliers joined forces and rallied in response to the national emergency. They designed, constructed and operated chemical plants crucial to the war effort.

Four projects, in particular, were of unprecedented scope: The Manhattan Project (1942), which produced the atomic bomb, and development of high-octane aviation gasoline, synthetic rubber, and penicillin.

"Instruments in the War Effort" was a regular column in *Instruments* magazine during WWII.

Brown Instruments in 1941 introduced the popular Model 15 chart recorder. The instruments were heavily used during WWII in the Manhattan Project, as flight test recorders and, after the war, by the chemical, petroleum, nuclear reactor, and power industries. In 1991 the Model 15 chart recorder was honored with a 50th anniversary celebration by Honeywell, which had acquired Brown in 1934.

WWII had a dramatic impact on the pace of technological development in the U.S., including procedures and instruments used in the control industries. As a result of increased demand for aviation fuel, for example, refineries had to be redesigned and expanded to boost productivity. In 1940 the average production was 30,000 barrels per day; by the end of the war, in 1945, that figure had risen to 580,000 barrels per day.

The synthetic rubber industry also profited from the new demand for rubber products, using instrumentation technology as its core. Lead sulfide infrared detectors were developed by Gudden in Germany and Cashman in the U.S., enabling for the first time the development of devices to detect passive radiation emitted by military targets, such as aircraft.

Control technology not only helped aid American efforts during the war, it also played a significant role in ending the war. In 1943, Taylor Instruments was approached by a group of U.S. Army Corps Engineers working on the

In 1945, technicians didn't understand PI

By Len Griffith

Back in 1945, I was working in the instrument department of a chemical plant of Celanese Canada. At that time, most controllers used in industrial plants were pneumatic. Control mode was mostly proportional only, and there was no integral mode.

It was customary, before installing a controller for the plant services, that an instrument technician calibrate it. He fed, say, a 9 psi instrument air pressure as a process variable to the input (measurement) port, while setting the set point by turning the set point knob. After choosing a proportional band, he adjusted the output by turning the output bias screw so that the output took a typical value with which the plant controller operated. With a proportional-only controller, whenever the process variable continued to deviate from the target, the operator changed the set point until it reached close to the desired value.

When a controller of a new type, "proportional plus integral mode," was introduced to this chemical plant for the first time, our technician used the same calibration method as above. However, no matter how close he adjusted the process input with the set point, the output kept drifting slowly. At that time, I happened to walk in the instrument maintenance room. The technician said to me, while shaking his head, "Len, how in the world could this new controller work?"

I said that I did not know, so we consulted with everyone at the plant who knew something about industrial controllers. The only thing that we could agree on was that this was a rather unstable device, and we certainly should pose the problem to the instrument supplier before attempting to install it. After much careful explanation, not all of us were totally convinced that this was a workable instrument, until someone showed us how to handle it.

Len Griffith, now retired, was formerly manager of manufacturing technical service for Celanese Chemical Co. (now Hoechst Celanese Chemical Group), Corpus Christi, TX.

Manhattan Project. As explained in a 1990 *Control Engineering* article (Michael Babb, "Pneumatic Instruments Gave Birth to Automatic Control," Oct. 1990), project engineers were looking for a new method to control the flow of a highly explosive gas called uranium hexafluoride. The manufacturing site was to be in Oak Ridge, TN, and would involve more than 200,000 instruments. The demands of the project, which was known as K-25, helped spur Taylor's invention of the first pressure transmitters. K-25 contained several miles of instrument panels and helped produce U-235, which went into the making of bombs.

Without a doubt, WWII was pivotal in increasing the importance of instrument manufacturers to process and manufacturing industries. Writing his recollections of the era in "The Instrument Makers 1945-1965" (*ISA Journal*, Sept. 1965), R.A. Bristol commented they were regarded as "the manufacturers of precision equipment, rather than simply machine shop operators."

In June of 1944, Foxboro introduced the first all-electronic instruments, the Dynalog line of temperature and pH recorders and controllers. Coleman B. Moore founded Moore Products in 1940. A year later, the company sold its first standard product, a valve positioner. In 1946, Moore developed the Nullmatic "stack" controller, a sophisticated force-balance instrument. Measuring only five inches on a side, it eschewed the circular pen-and-chart recorder and allowed construction of dense control panels.

Computer technology also progressed. In

Group Photograph Taken Shortly After Opening of Conference (before Arrival of Delegation from Appalachian Instrument Society)

The Instrument Society of America Becomes a Reality

By RICHARD S. ROBERTS, Chairman Publicity Committee I.S.A.
136 Cleveland St., Orange, N. J.

Roosevelt Hotel

The third meeting of the Conference for the Formation of a National Instrument Society was held in Pittsburgh Saturday April 28th, 1945. Fifteen (15) Societies were represented by delegates, alternates, members, and guests, from the Societies located at—

Baltimore
Charleston (W. Va.)
Chicago
Cleveland
Detroit
Kansas City (by proxy)
Los Angeles
New Jersey
New York City
Northern Indiana (by proxy)
Philadelphia
Pittsburgh
Tennessee ("Appalachian")
Washington (D. C.)
Wayne County (Mich.)

Mr. R. J. S. Pigott, President of the American Society for Measurement and Control (Pittsburgh) presided as Chairman; and the first order of business was to formulate the basis upon which a National Society could be organized.

CONSTITUTION BEGINS TO TAKE SHAPE

Reference was made to the "Declaration of Policy" as shown on page 255 of Instruments for April 1945, and the following portions were voted on by the delegates and approved as noted:

(a) Article I—The name "THE INSTRUMENT SOCIETY OF AMERICA" was approved.

(b) Article II—All three paragraphs relative to "Government" were approved.

(c) Article III—Approval was given only to the following portion relative to "Objectives": "The objectives of the Society shall be to advance the arts and sciences connected with the theory, design, manufacture and use of instruments in the various sciences and technologies."

(d) Article V—Paragraph 1 relative to qualifications for membership was approved.

(e) Article VII—Paragraph 1 relative to the four officers only was approved.

(f) Article IX—All three paragraphs covering "Board of Directors" were approved.

Following discussion by delegates, the following were voted upon and approved:—

1. Society Officers (per Article VII above) are to be elected by letter ballot from the entire Society membership, and that such regular officers (except Secretary) shall not succeed themselves. Nominations to include two names for each office.

2. The Finance and Constitution Committees should work together on the subject of dues.

3. The Constitution Committee should create three grades of membership, as follows:—Honorary Member—Member—Student Member.

4. The pro tem officers (to be elected today) are to handle the Society affairs until a regular election can be held following preparation of a Constitution and By-Laws and the ratification of same by the local Societies; but this must be effected by March 1st 1946. In the event that ten (10) local Societies have not ratified the new Constitution within such time limit, another general meeting is to be called.

SOCIETY OFFICIALLY CREATED BY UNANIMOUS VOTE

Chairman Pigott then proceeded to poll the delegates. Upon receiving assurances that all had the power to act for their respective Societies, a vote was taken relative to the formation of a National Society. By unanimous vote "THE INSTRUMENT SOCIETY OF AMERICA" was created. Everybody then adjourned for lunch.

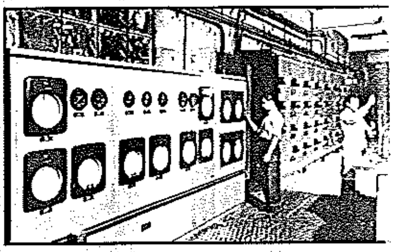
BEHAR GIVEN OVATION

During lunch Major M. F. Behar was honored by a rising vote of thanks of all those present for the many years he has devoted to the instrument movement which now has culminated in the formation of a national society. Major Behar expressed regret that owing to illness it was not possible for him to take part in the deliberations. He traced the development of the national society idea, outlined the various fields in which this and other national societies could work: industrial, scientific, educational, etc., and recommended that those present—mostly department heads and other successful men—see to it that this Society be devoted to the welfare

ISA 1st officers, shown in 1945

1932

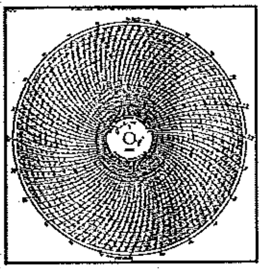
In the early 1930s Foxboro begins marketing its Model 40, the first proportional plus reset recorder/controller. It is primarily applied on flow control in the petroleum industry, where Foxboro has a strong presence. The photo below shows a Model 40 Control Panel in an early process plant.



1935-1939

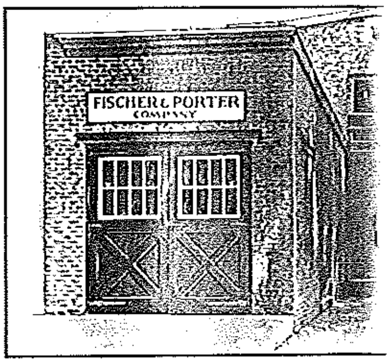
1935

A page from an October 1935 *National Geographic* magazine article, covering Admiral Byrd's Antarctica expedition, shows a Foxboro chart recording temperature of 65 degrees below zero Fahrenheit at 12:30 p.m. on July 19; at 3:30 p.m. it "warms up" a degree, the article points out.



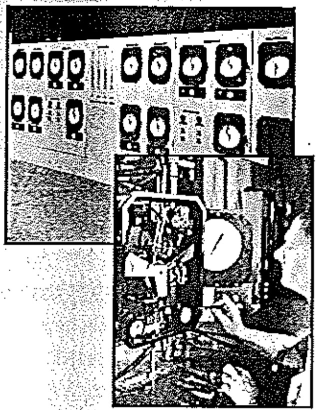
1937

In March of 1937, a sign reading "Fischer & Porter Co." goes up for the first time, in Philadelphia's old Germantown section. Founded by Kermit Fischer and his only employee, George Porter, its initial products are "rotameters," or variable-area flow rate meters.



circa 1939

The Taylor Fulscope controller integrates previously separate PID functions for the first time. The Taylor Model 100 Fulscope, commercialized in the 40s, is redesigned in the late 1930s to improve operations in the viscose rayon industry. The Model 56R is the first to incorporate derivative control, which is dubbed "Pre-Act" by Taylor engineers. The second photo shows a typical Fulscope installation.



1940-1944

Coleman B. Moore founds Moore Products in 1940. A year later, the company produces its first standard product, a valve positioner. By 1948, the company employs 90 people.

1941

Brown Instruments in 1941 introduces the popular Model 15 chart recorder, heavily used during WWII in the Manhattan Project as flight test recorders and, after the war, by the chemical, petroleum, nuclear reactor, and power industries. The long-lived Model 15 in 1991 was "honored" with a 50th anniversary celebration by Honeywell, which had acquired Brown in 1934.

addition to the Mark I, in 1946 the Moore School of Electrical Engineering and the University of Pennsylvania developed ENIAC (Electronic Numerical Integrator and Automatic Calculator). Requiring several large rooms for its wires and components, ENIAC was the first computer capable of integrating a simple system of ordinary differential equations.

1945:

Birth of ISA

Both before and during the war years, several groups had voiced a desire to form an international society for instrument and control practitioners. During the 1930s, there was enough momentum in measurement and control for several engineers to initiate committees and organizations specifically dedicated to the field. In 1936, for example, the Industrial Instruments and Regulators Committee (IIRC) was established to help promote the emerging technology for industrial processes, recalls P.M. Lynch in "Systems and Control Division," *Transactions of the ASME* (June 1993).

In August 1939, the American Society of Instrument Engineers was founded in Pittsburgh, with 24 members under the leadership of Frank McGough. The Chicago Society for Measurement and Control was formed in 1940. In 1942, the New York Society for Measurement and Control was founded. That same year, 35 men met in Philadelphia to discuss the need for a technical organization to serve the Philadelphia area instrument engineers. From that group, the Philadelphia Society for Instrumentation was created. By early 1944, about 15 regional instrument societies were active and communicating.

In other major cities and states across the U.S. — Hartford, Cleveland, Charleston, St. Louis, Baltimore, New Jersey, Tennessee, Northern Indiana, and California — local groups were also forming. It became clear that the time was ripe for a national society.

Representatives from regional societies gathered in New York on Dec. 2, 1944. At a second meeting, on Feb. 17, 1945, in Chicago, they adopted the name Instrument Society of America. ISA was officially founded at the third organization meeting on April 28, 1945, held in Pittsburgh, with 15 local instrument societies and about 1,000 members.

Albert F. Sperry was the first president; Prof. Karl Kayan of Columbia University, vice president; Clark E. Fry of Westinghouse, treasurer; and Richard Rimbach of Instruments Publishing Co., secretary. Temporary headquarters were established at Rimbach's office in Pittsburgh. The first ISA correspondence sent out over Al Sperry's signature was a distribution of ISA Policy Statements. The mailing was dated May 7, 1945 — the day Germany surrendered, ending WWII in Europe.

By 1949, ISA's membership had grown to about 4,000, distributed among 50 sections.

Late 1940s:

Transistor & seeds of digital control

The device that changed everyone's life in industrialized society — including the process control industry — was the transistor, invented in 1947 by John Bardeen, Walter Brittain, and William Schockley of Bell Laboratories. Arguably the most important invention of this century, the transistor opened the electronics age, driving out many pneumatic or air-based controllers of the 1920s and '30s. The transistor contained three electrodes and could amplify or vary currents or voltages between two of the electrodes in response to the voltages or currents imposed on the third electrode.

Meanwhile, Foxboro in 1948 introduced the first pneumatic differential pressure transmitter, commonly known as the d/p cell, which still is in use today in some applications. In 1949, Harry Matheson and Murray Eden of the National Bureau of Standards (NBS) developed a differential manometer to compare pressures of gases, organic vapors, and non-corrosive liquids.

A 1949 paper by G.S. Brown, D.P. Campbell, and M.T. Marcy of MIT is believed to be the first technical publication suggesting use of digital computers for industrial process control. In 1953, M.V. Long and E.G. Holzmann of Shell Development talked about computer applications to petroleum and chemical processes, describing what is now known as "supervisory control," in which the computer changes set points of analog controllers, and "direct digital control," in which analog controllers are eliminated.

Early 1950s:

Electronic control prevails

Greater transmission distances made possible by the higher speed of electrical signal transmission during the 1950s helped move control rooms further from the actual processes than was possible with pneumatic technology. Analog signals of the first electronic systems ranged from 4-20mA or 10-50mA, instead of the 3-15 psi typical of pneumatic control systems.

Typical control rooms in the 1950s contained large control panels, run by several operators handling several hundred controllers and instruments mounted and categorized by plant unit and area. To make it easier for human operators to become aware of alarm conditions, large annunciator panels were devised that would alert the operators to unusual process conditions.

First developed in the late 1940s by Eckert-Mauchly Corp., the UNIVAC (universal automatic computer) began to be installed commercially about 1951. It was the second commercially available computer, after Mark I. Its ability to process large amounts of raw data did not escape the notice of control engineers, although it would be a few years before its potential would be properly explored and applied.

Replacement of electronic tubes by semiconductors during the 1950s represented a major step forward in automatic control instrumentation. On the computer front, printed circuit boards replaced spaghetti-like wire bundles. Ferrite memories, magnetic drums, semiconductor diodes, and transistors ushered in a new era.

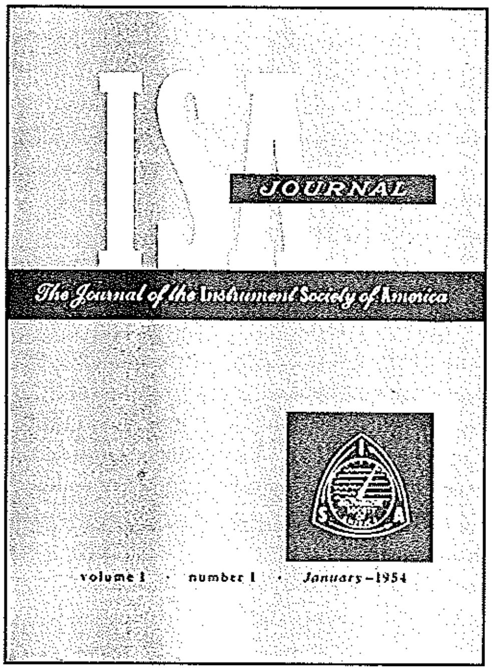
What's believed to be the first electronic controller, the AutroniC, was marketed in 1951 by Swartwout Co. of Cleveland. The next year, Leeds & Northrup introduced the first controller Automatic Transfer Relay (ATR) to provide bumpless transfer from manual to automatic control without manual balancing. Patent 2,679,022, awarded May 18, 1954, applied to both electronic and pneumatic analog implementations of the PID control algorithm. The technology was first applied to the boiler drum level control for Metropolitan Edison's Titus Station in Reading, PA, where the nature of the process made transfer to automatic particularly difficult with manual balancing.

Mid-1950s:

ISA grows, gas chromatography

In 1952, ISA officially established a national headquarters in Pittsburgh. The first issue of the *ISA Journal* was published in January 1954. ISA activities grew rapidly. The 11th Annual Conference and Exhibit in New York, in 1956, drew a record 36,000 registrants.

In 1952, A.T. James and A.J.P. Martin developed the process of gas-liquid chromatography, a technique for separating and analyzing a mixture, for which they later received the Nobel Prize.



***ISA Journal* debuts in January 1954.**

This technique dramatically improved the speed, accuracy, and sensitivity of previous chromatographic procedures. By 1956, a company called Beckman Instruments was marketing the first gas chromatograph.

During this period, flowmeters also came into their own, with the Tobinmeter Co. of Holland marketing the first commercial electromagnetic flowmeter. In 1954, Foxboro began marketing an electromagnetic flowmeter in the U.S. The next year, ultrasonic flowmeters hit the market, and, in 1957, ultrasonic level sensors were developed.

Y.T. Li and S.Y. Lee are credited for providing the specs in 1953 for what was to become the Coriolis mass flowmeter. As described by David Spitzer in his book, *Flow Measurement: Practical Guides for Measurement and Control* (ISA, 1991), "This meter consisted of two turbine wheels, each differently geared to the fluid and attached to each other by a helical spring. The torque, measured by the angular deflection of the spring, was proportional to the mass flow rate."

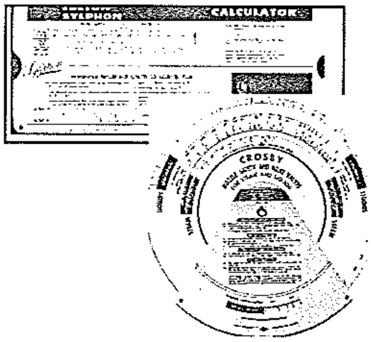
Yokogawa in 1952 developed the Electronic Servo Recorder, among the first instruments of that type from a Japanese manufacturer.

Bailey Controls Co. in 1954 supplied the controls and instrumentation for the first U.S. nuclear-powered submarine, the Nautilus. Ten years later, the company installed the first automated boiler control system on a Great Lakes steamship, the S.S. William G. Mather. That same year, Bailey outfitted the first fully automated sea-going vessel, a Canadian ship, the S.S.

1945-1949

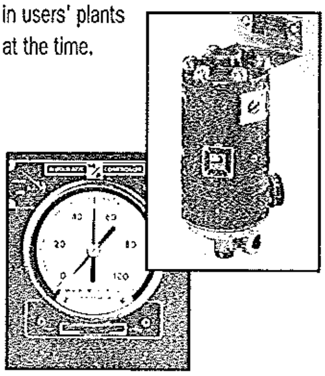
circa 1945

Slide rules and wheels showing all manner of control calculations — flow rates and capacities, pressure drops, etc. — are a popular promotional handout from companies in the 1940s, '50s, and '60s. The wheel, shown below, for determining valve capacities and nozzle areas, is copyrighted in 1945 by Crosby Steam Gage & Valve Co., Wrentham, MA. The slide rule for determining flow velocity and pressure drops is produced by Chemetron Corp., Louisville, KY, in 1947 and updated in 1965.



1946

Moore Products introduces in 1946 its Nullmatic "stack" controller, a sophisticated force balance instrument (below left). A year later, Moore stars at ISA's annual show in Buffalo with a new M/P (miniature panel) station (below right) that uses the Nullmatic controller as an alternative to large case instruments and attendant huge, unwieldy panel boards common in users' plants at the time.

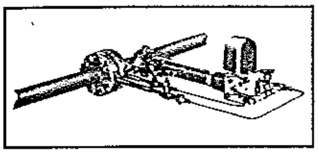


1947

WWII drives pneumatic control instruments technology to new levels.

1948

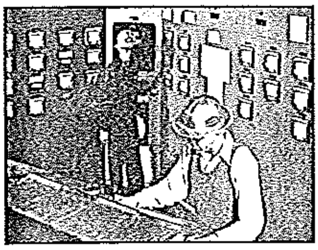
Foxboro in 1948 introduces the first pneumatic differential pressure transmitter, commonly known as the d/p cell, which still is in use today in some applications. This 1949 photo shows a d/p cell measuring steam flow without mercury.



1950-1954

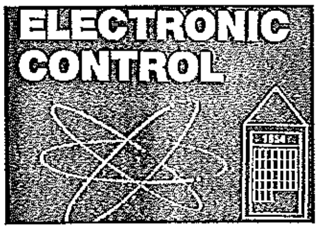
1950

Foxboro instruments at a Union Carbide plant typify a 1950s-era pneumatic control panel. .



1954

Electronic instruments for control increasingly emerge during the 1950s.



1954

Volume 1, No. 1 of the *ISA Journal*, predecessor to *InTech*, is published in January, 1954.

Cape Breton Miner.

The first computer system applied to process control is believed to be the DIGITAC machine developed in 1954 by Hughes Aircraft Co., which generated the first major patent in that field. In 1956, the first report appeared on results achieved by Donald P. Eckmann and his associates at the Case Institute of Technology regarding work on computer control of a batch hydrogenation process.

In 1956, ISA's first president and systems entrepreneur A.F. Sperry, and R.T. Sheen, then ISA president, testified on the subject of automation before the Joint Economic Committee's Subcommittee on Economic Stabilization, chaired by Rep. Wright Patman. They contended that measurement and control practice — far from replacing labor — was a necessity if the available labor was to produce a 37 percent increase in productivity forecast to be required in 1965.

Rosemount Engineering Co. was founded in 1956 by Robert E. Keppel, Vernon Heath, and Frank Werner in the small farming community of Rosemount, MN.

Late 1950s:

Electronic controllers emerge

Early electronic controllers were demonstrated at ISA's 13th annual show in Philadelphia in 1958 by vendors Foxboro, Taylor Instrument, Honeywell, and Leeds & Northrup, joining Manning Maxwell & Moore and Swartwout Co. in the electronic controller market. At the same show, the Minneapolis-Honeywell Regulator Co. showed its single-loop process controller, similar to the standalone type popular today. Bristol, Foxboro, Leeds & Northrup, Manning Maxwell & Moore, Motorola, Swartwout, and Taylor Instruments each launched solid-state analog single-loop controllers.

Meanwhile, Honeywell introduced in 1959 the 4-20 mA DC electronic signal, which became an industry standard a few years later. An important feature was the "live zero," 4 mA, which allowed the instrument to detect a failed transmitter.

The marriage of computer and electronic process technology began to bear significant fruit in the late 50s, with concurrent computer installation projects in both Texas and Louisiana. By 1958, a computer plant monitoring system manufactured by the Daystrom Co. had been installed at the Louisiana Power and Light Company in Sterlington, LA.

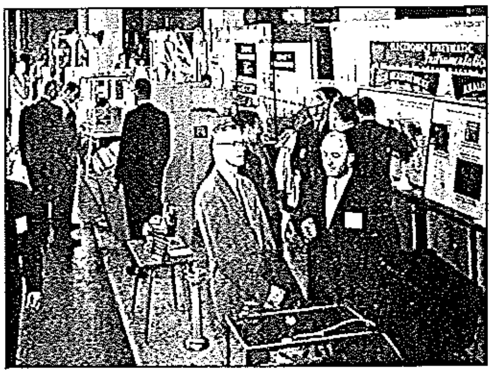
After a 15-month planning process, Texaco's refinery at Port Arthur, TX started up in 1959 a Ramo-Woolridge RW-300 industrial control computer system for closed-loop control, noted T.J. Williams' "A Short History of the Field and the Development of a Philosophy of Digital Process Control," *The Use of Digital Computers in Process Control* (ISA, 1984).

Pioneering work also came from the engineering department of Monsanto's Research and Engineering Division. The company wanted to create an automated chemical plant and at first considered electronic analog controllers as a solution. Later, after a meeting between the presidents of Monsanto and Ramo-Wooldridge Co., the two companies began a cooperative project using digital computers in 1957. Monsanto's 500-T/D ammonia plant in Luling, LA was chosen as the test site. System startup there occurred in January 1960.

According to *The Computer Control Pioneers: A History of the Innovators and Their Work* (ISA, 1992), the Luling computer had about 60 inputs and 17 outputs, all connected to the computer for compatibility with the plant's pneumatic instrumentation. Existing controllers were modified to allow remote pneumatic set points.

In a September 1977 *Control Engineering* article, "Two Decades of Change: A Review of the 20-Year History of Computer Control," Monsanto engineer T.J. Williams recalled that the RW-300 computer arrived in early 1960 and transformed Luling into the first chemical plant using computer control.

"Following much trouble with signal-noise problems and an almost complete reprogramming of the control algorithm, the digital control loops were closed on April 4, 1960," Williams reported. "This was, of course, a supervisory control system. That is, the computer changed the set points on the ammonia plant's regular analog controllers to achieve its control action. It did



Scene from ISA/61, St. Louis, MO

not actually move any valves itself. That type of control was to come later."

In 1959, at ISA's 14th annual show in Chicago, Bailey Meter Co. introduced its all solid-state controller, using transistors and magnetic amplifiers. The system's most notable feature was its automatic transfer from manual to automatic control — a predecessor to today's bumpless transfer. At a conference for the Society of Instrumentation Technology, ultrasonic, magnetic, and pulsating flow measurement were displayed.

Research conducted by Westinghouse in the late 1950s led to the discovery of a new group of substances called superconductors. These materials had the ability to permit an electrical current, once started in them, to flow forever with no degradation of strength.

Early 1960s:

Digital control arrives

Just as World Wars I and II had spurred R&D and manufacturing in control applications, the rapidly advancing space program — which accelerated after the Russians sent the first satellite into orbit in 1957 and the U.S. launched the first communications satellite in 1962 — helped advance digital control applications throughout the 1960s.

ISA's exhibitions grew at a rapid rate, requiring the society to conduct them only in major convention cities.

In 1960, an RW-300 digital computer system was installed at B.F. Goodrich's acrylonitrile plant in Calvert City, KY. The next year, IBM installed a special-purpose digital computer called the 1700 at American Oil in Indiana, Standard Oil of California, and DuPont Oil. Pneumatic controls were now being replaced by electronic and some digital controls. Also in 1961, Foxboro accomplished the first feedforward control of a distillation column.

Popular at the time was the notion of direct digital control (DDC), in which the computer would be responsible for moving the valves, bypassing the early analog controllers. Chemical companies in the U.K. and U.S. used computers in the early '60s to perform direct digital control. By 1963, a group within ISA had even been formed specifically for users of DDC.

Despite the growing number of installations, computer systems were extremely expensive and lacked backup when a failure occurred. The systems typically were large and had many functions crammed into them to justify the huge monetary outlay by vendor and user alike.

Mid-1960s:

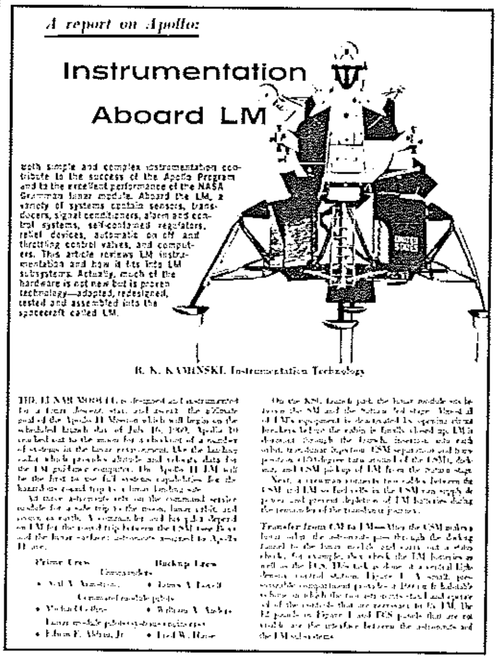
BIG, for computers

The years 1964 and 1965 were momentous for computer technology, thanks to both IBM and Digital Equipment Corp. (Digital).

IBM "bet the company" — and won bigtime — with the introduction of System/360, the first computer line to offer upward and downward compatibility from the smallest to the largest models. Its operating system initially was plagued with problems, but System/360's architecture eventually set an industry standard that has lasted to this day.

With the introduction of the PDP-8 in 1965, the world's first mass-produced minicomputer, Digital Equipment Corp. revolutionized computer design. Digital's PDP-8, 12-bit line was smaller than predecessor computers, less expensive, easier to program, and it fit in a compact equipment cabinet. It was the first machine with random access core memory to sell for under $100,000. It was a new generation in computers that used transistorized digital circuit micromodules produced automatically. The PDP series became a virtual industry standard.

Development of human-machine interfaces in process control also began about 1964, with Monsanto Chemical Co., Texas City, TX, being a pioneer. It developed an electronic, CRT-based system where an operator could read the relative position of process variables "at a glass," allowing the operator to develop a pattern recognition method of analyzing the current plant operating


A report on Apollo:

Instrumentation Aboard LM

Both simple and complex instrumentation contribute to the success of the Apollo Program and to the excellent performance of the NASA Grumman lunar module. Aboard the LM, a variety of systems contain sensors, transducers, signal conditioners, alarm and control systems, self-contained regulators, relief devices, automatic on off and throttling control valves, and computers. This article reviews LM instrumentation and how it fits into LM subsystems. Actually, much of the hardware is not new but is proven technology—adopted, redesigned, tested and assembled into the spacecraft called LM.

R. K. KAMINSKI, Instrumentation Technology

Article from July 1969 *Instrumentation Technology*, predecessor to *InTech*

1955-1959

1955
Data loggers

1956
Rosemount Engineering Co. is founded in 1956 by, from below left, Robert E. Keppel, Vernon H. Heath, and Frank D. Werner in the small farming community of Rosemount, MN.

1956
Systems entrepreneur A.F. Sperry, below left, and R.T. Sheen, center, then president of the Instrument Society of America, testify on the subject of automation before the Joint Economic Committee's Subcommittee on Economic Stabilization, chaired by Rep. Wright Patman, right. They contend that the practice of measurement and control — far from replacing labor — is a necessity if the available labor is to produce a 37 percent increase in productivity required in 1965.

1956
Beckman Instruments markets the first gas chromatograph, four years after the process of gas-liquid chromatography — a technique for separating a mixture — is developed by A.T. James and A.J.P. Martin, in 1952. James and Martin are to receive the Nobel Prize for their discovery.

situation. The concept had been pioneered by the Honeywell Vutronik "faceplate" analog display developed jointly by Honeywell and Monsanto for the Chocolate Bayou, TX project in 1961.

At the end of the 1960s, Honeywell officially introduced its Vutronik process control line, which allowed operators to make step changes in set point by manipulating the PID algorithm, without incurring process upsets. This capability was not previously available. Honeywell's TDC 2000, which arrived in 1975, and companion systems drastically changed the pace of operator console development.

Moore Products in 1965 marketed the Syncro Station, a self-synchronizing controller that allowed simple, bumpless transfer from automatic to manual control. The product represented the final significant achievement in pneumatic controls. In 1967, Moore and Foxboro developed pneumatic bumpless, balanced auto-manual transfer.

Late 1960s:

Auto makers spur PLCs

While the Department of Defense and NASA influenced control inventions, the automotive industry also played a significant role. In the late 1960s, General Motors prepared specs on what was ultimately to become the programmable logic controller (PLC). Requirements for the as yet undesigned product included the ability to replace electromechanical relays, which failed frequently, and to establish a system to easily identify where the failures had occurred.

Just as there is uncertainty about the "first" measurement and control instruments, there is debate regarding the "first" PLC. Most accounts agree, however, that while Digital had a PDP-14 at GM which used Boolean logic, the industry was significantly altered with the creation of Ladder logic by Bedford Associates in Massachusetts, the forerunner of Modicon.

Apparently initially operating in ignorance of the specs issued by GM, engineers at Bedford Associates developed a product to leverage the company's experience solving industrial control problems. Credited with the original design is Richard Morley, a Bedford engineer.

The result of efforts by Morley and his team of engineers was a solid-state, sequential logic solver, designed for factory automation and continuous processing applications: the first practical programmable logic controller.

It was called the "Modicon 084" because it was the 84th project at Bedford Associates. Upon learning of GM's requirements, the company demonstrated the Modicon 084 to General Motor's Hydramatic Division in November 1969, and delivered to GM the first commercial unit in 1970 to control metal cutting, hole drilling, material handling, assembly, and testing for the Hydramatic Model 400 automatic transmission. The new system replaced the large electromagnetic relay panels that had previously been used by GM to identify where problems had occurred.

Bedford Associates' Ladder logic incorporated symbols from electrical engineering to depict sequences of operations. In his article, "Ladder Logic Languishing?" published in the April 1992 issue of *Manufacturing Systems*, inventor Morley recalled:

"Ladder logic, as a control language, was first used in conjunction with silicon devices around 1969 at Bedford Associates. To support the control language, a hardware platform was devised that had three constituent elements: a dual-ported memory, a logic solver, and a general-purpose computer. Early at Modicon, we used a degenerate form of ladder representation. The great advantage was that the language could be understood by any working electrician in the world. Later the language was expanded to multi-node, and additional functions were added.... Ladder logic functionality and PLC adaptability quickly spawned an entire industry."

The advantage that the PLC brought to the control industry was the ability to program the system, which could not be accomplished with electromagnetic relay panels. The panels had to be rewired when control schemes changed. In contrast, the new PLC could be changed much more easily and faster, and also had the advantage of a much smaller footprint.

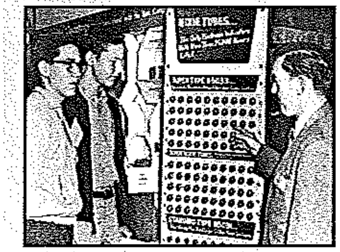
In 1969, when Neil Armstrong and Edwin "Buzz" Aldrin first walked on the moon, they bore Rosemount sensors to monitor suit pressure, temperature and oxygen. That same year, Rosemount introduced its capacitance-technology-based Model 1151 Analog Differential Pressure Transmitter, which went on to become an industry standard.

Also in 1969, Honeywell began R&D on a new distributed control system (DCS). The impetus for such a system came from the unmanageability and unreliability of the large, centralized computer control devices. The product, however, would not be unveiled for another six years.

Yokogawa in 1969 developed the vortex

1959
Monsanto, 1st DDC installation

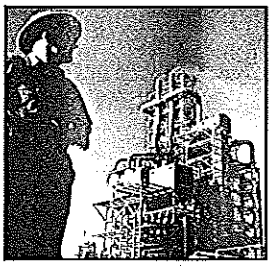
1959
Burroughs Corp. Electronic Division display, ISA show, Chicago



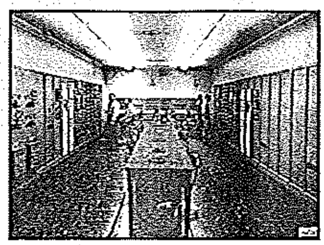
1959
GE 312 Digital Control Computer features analog and digital I/O.

1960-1964

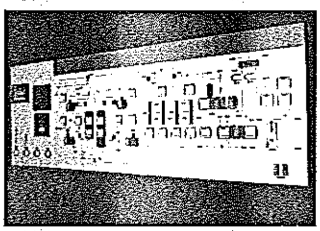
circa 1960
"Cat Cracker" in use at Wilmington-Dominguez Refinery, CA, about 1960



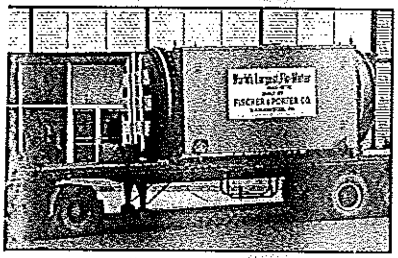
circa 1960
Telemetry installation, Ralph M. Parsons Co., about 1960



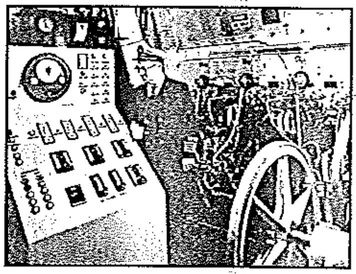
circa 1960
Foxboro full-graphic control panel, about 1960



circa 1962
In the early 1960s, Fischer & Porter Co. claims the world's largest (magnetic) flowmeter

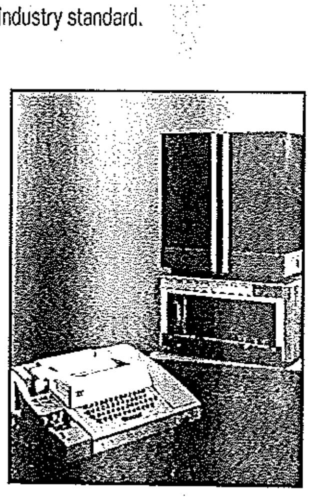


1964
Bailey Controls Co. installs in 1964 the first automated boiler control system on a Great Lakes steamship, the S.S. William G. Mather.



1965-1969

1965
Digital Equipment Corp.'s PDP-8, unveiled in 1965, is the world's first mass-produced minicomputer. It revolutionizes the way in which computers are designed, being smaller than predecessor computers, less expensive (under $100,000), and easier to program. The PDP series is to become a virtual industry standard.



flowmeter, which was used by the petrochemical industry.

The 1960s were important years for Fisher. After adding ball valves to its line in 1960, introducing throttling V-Ball valves in 1963, Easy E cage-guilded and Fishtail Disc butterfly valves in 1966, and Whisper and Cavitrol trim to minimize control valve noise in 1968, Fisher was purchased by Monsanto in 1969. Its name was then changed to Fisher Controls Co.

Meanwhile, on the ISA front, the *ISA Journal* was renamed *Instrumentation Technology* in 1967. Two years later, ISA welcomed its 20,000th member.

Early 1970s:

The hardware era

Following the success of minicomputers and PLCs in the '60s, the '70s brought an era of more advanced instrumentation, including computer control hardware and software. Distributed process control over several computers interconnected in networks became a goal for many industrial plants.

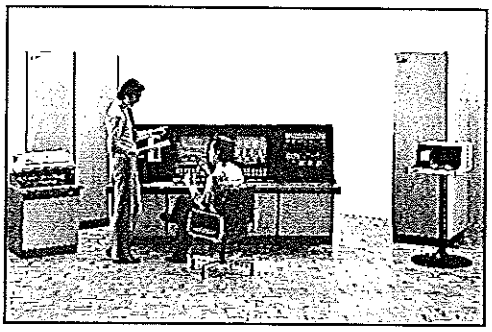
Communications technology charged ahead, with scientists at Corning Glass Works successfully manufacturing glass fibers, providing the foundation for future fiber optic cables.

On the process front, Technicon Corp. in 1970 introduced a water pollution monitor for multiple analysis, capable of measuring up to six water pollutants continuously and simultaneously.

Rosemount launched its Diogenes, configured by inserting pins into a matrix board. Rosemount helped introduce the concept of a DCS in 1972 with its Diogenes Channel Function Matrix, which featured control loop function and configuration capabilities with pins and links on a graphic diode pinboard.

Honeywell introduced the Cage Valve, the first with valve quick trim change technology. Now, multiple flow characteristics and trim materials could be quickly changed by simple bonnet removal. Westinghouse's Combustion Control Division (formerly Hagan Controls) introduced the first in situ excess oxygen sensor, using zirconium oxide technology, allowing measurement of excess oxygen content from directly within the combustion flue gas.

In 1971, Fisher Controls introduced the dc2 computer-based digital control center. Complemented by the pc2, the new digital system significantly improved distributed data control and supervisory control, plus batch sequencing. Fisher also received the industry's first N-stamp



Yokogawa's distributed control system was exhibited in Tokyo in 1975.

certification to manufacture nuclear valves.

In 1972, Foxboro marketed its SPEC 200, which featured a split architecture. In this design, the controller and I/O functions were included in one case and the display and operator functions were in another case. By splitting these two functions, more capabilities could be implemented into the operator panel and field wiring was simplified, explained John Bernard in his book, *CIM in the Process Industries* (ISA, 1989).

Sensor technology advanced significantly in 1973. NASA launched an Earth Resources Technology satellite to demonstrate the usefulness of remotely sensing conditions on and above earth's surface. The same year, the Shottky-barrier infrared image sensor was proposed by scientists Shephard and Yang, leading to the development of high-density infrared image sensors.

In the early 70s, IBM developed the first RAM (random access memory) computer chip. The semiconductor read-write chip structured cells or bits in the chip in such a way that they were independent of each other, enabling any one particular bit to be accessed independently of the other. The development accelerated access times and helped pave the way for the microprocessor revolution of the 70s.

Mid-1970s:

PLCs advance, DCS born

In 1974, at the urging of GM's Hydramatic Division, several firms developed more advanced PLCs. The first patented PLC with internal memory to store and recall several programs was designed by Goro Hamano and built by Matsushita Electrical Industrial Co. in Japan.

Analog and digital functions were combined by Beckman Instruments in the 8800 Series controller. Algorithms and settings were implemented in analog functions, while indication, transfer switching, and housekeeping were assigned digital functions.

Throughout the industry, 1974 was a boom year, with instrument makers reporting record sales, earnings, and backlogs. Shortages and escalating prices for energy and materials drove their manufacturing company customers to step up the use of cost-saving control equipment.

Electronic innovations continued, including the introduction of MOS (metal oxide semiconductor) technology by RCA for the fabrication of integrated circuits. This invention helped make circuits cheaper to produce and facilitated greater miniaturization.

Other significant developments in the mid-1970s included the first fully engineered microprocessor system for dedicated control and data handling, from Sturge Automation; demonstration of the piezotron concept for piezoelectric transducers; developments in gas chromatography which improved flexibility, maintainability, reliability, and data handling in industrial process control; and laser-based, non-contacting flowmeters from Cambridge Consultants.

About the same time in the mid-1970s, Yokogawa in Japan and Honeywell in the U.S. introduced the first distributed control systems, marking a significant and far-reaching change in the way that control systems would be configured and applied.

The Yokogawa Centum and Honeywell TDC 2000 were based on the concept that several microprocessor-based loop controllers could be controlled by supervisory minicomputers, with a push-button, CRT-based display for the operator rather than an annunciator panel. The controllers would be connected together on a data highway that would carry the information from the various nodes or stations. The highway, or bus, would serve as a signal route. The design would move the controllers back to the process, shorten the control loops, and save on wiring costs.

In 1977, Honeywell introduced the first redundant process controller in the TDC 2000 family of controls. It allowed a single on-line spare controller to provide complete redundancy for any one of up to eight other controllers. For the first time, operators could view data in the control room from one easy-to-read display, even though the process itself was located remotely. The concept of distributed control truly revolutionized the process industries and initiated a series of similar hardware introductions from other vendors over a period of ten years.

Each vendor developed a proprietary highway to run its DCS because the complexities of critical real-time process applications had no industry communication standard to fall back on, and end users needed some reassurance that their valuable installation was not going to be impacted by an unreliable, untested network. Even a short-term loss of functionality carried far more long-term implications than discrete applications.

The costs of these early distributed control systems to the end user were high, averaging hundreds of thousands of dollars for a complete system. This was because of the large investments individual control vendors had to make in order to establish secure, reliable systems.

Another significant development in 1975 was optical fibers, from AT&T's Bell Laboratories. These went into production during the 1980s. Also at Bell Labs, David Auston invented the fastest electronic switch devised to date by using laser light beams to start and stop an electrical signal. Also, Dr. Mahn Hee Hahn, of NBS Institute for Materials Research, invented a dew-frost point apparatus that made it possible, for the first time, to evaluate moisture in the airspace of sealed glass.

In 1976 a Digital Equipment Corp. arch-rival — Data General Corp., founded by one of the designers of DEC's PDP-8 — unveiled its microNOVA line, an upwardly compatible, 16-bit system that included a microprocessor chip set, a microprocessor on a board, and a minicomputer. As an integrated product family, microNOVA signaled a new direction in microprocessor control applications.

Hardware was certainly the focus of the 1970s, and it was designed to be plain and functional. "There's no reason in our business to have an ostentatious display. In fact, it's detrimental," observed Tracy Kidder, a Data General engineer, in the best-selling book, *The Soul of a New Machine*, 1981. A gap was created between the new computer "experts," who were comparatively few, and long-time instrumentation engineers who had cut their teeth in the control industries. More and more new engineers promoted the benefits of the new digital technology. However there remains to this day a hard core group of instrument engineers who bemoan the loss of analog technology.

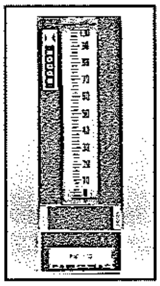
Later 1970s:

ISA accredited by ANSI

The American National Standards Institute (ANSI) in 1976 approved ISA as an ANSI-accredited standards-writing organization, mak-

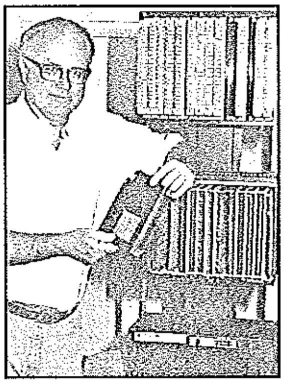
1965

Moore Products introduces SYNCHRO, a self-synchronizing miniature pneumatic control station which greatly simplifies the control room operator's task.



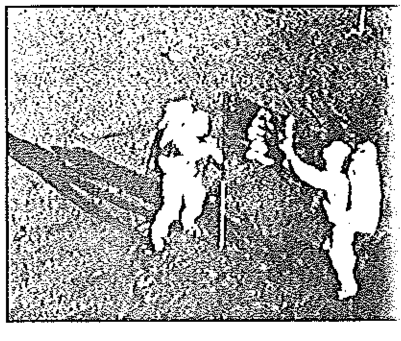
1969

Credited with the original laser-logic PLC design is Richard Morley, a Bedford Associates (MA) engineer in 1969. His Modicon 084, a solid-state, sequential logic solver, is designed for factory automation and continuous processing applications. Demonstrated at GM in 1969, it is considered to be the first practical programmable logic controller.



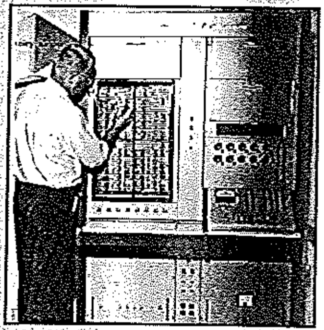
1969

When astronauts Neil Armstrong and Edwin "Buzz" Aldrin take the first steps on the moon on July 20, 1969, they carry Rosemount sensors in their backpacks to monitor pressure, temperature, and oxygen.

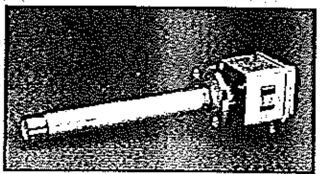


1970-1974

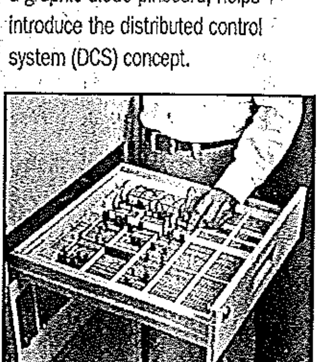
circa 1970
Analog computers continue to be popular in the early 1970s.



1971
The first in situ excess oxygen sensor is introduced in 1971 by the Combustion Control Division (previously Hagan Controls) of Westinghouse Electric. The development allows measurement of excess oxygen content directly within combustion flue gas, and leads to the development of today's 3000 Flue Gas Oxygen Analyzer.



1972
Rosemount's Diogenes Channel Function Matrix, featuring control loop function and configuration capabilities with pins and inks on a graphic diode pinboard, helps introduce the distributed control system (DCS) concept.



ing ISA only the fourth such organization to receive that recognition.

Also in 1976, Rochester Instrument Systems introduced Media, the first packaged digital implementation of conventional PI and PID control algorithms. Taylor Instrument introduced its MOD III, an advanced analog control and interactive digital display system especially designed for use by process plant operators. Fisher Controls marketed its Series 1000 dc2 panel-mounted instrument modules for split architecture control systems, representing a significant advance for operators, maintenance personnel, and applications engineers in power and process plants. Calspan Corp. developed a method of aerial infrared thermometry, which reduced the cost of mapping surface temperature of water bodies. Meanwhile, scientists at NBS developed a sensitive monitor to detect the total accumulated amount of mercury to which a worker is exposed over a workday.

In 1977, Taylor Instruments introduced its Taylor Micro-Scan adaptive gain controller at the Texas A&M Symposium on Instrumentation for the Process Industries. In contrast to previous controllers with a constant gain, the MicroScan generated a gain proportional to the error, plus the error squared from the desired set point. This reduced peak error and integrated error, compared to conventional controllers in a simple control loop. Foxboro introduced its Fox3 process computer, a user-friendly DDC system for use with SPEC200 systems.

Johnson Space Center in Houston constructed in 1977 a facility that could simulate an entire space shuttle mission, testing avionics and astronaut response under virtually all possible operating conditions.

Also that year, Honeywell invented the DCP7700 digital control programmer, the first microprocessor instrumentation to combine variable set point versus time programming with integral, three-mode control. Fisher Controls introduced its L-S series of signal converters, transmitters, and alarm modules, which rejected most unwanted signals and eliminated some special requirements.

On the computer front in 1977, IBM announced development of a 64-bit dynamic random access (DRAM) array, which achieved a storage element size of approximately one ten millionth of a square inch. Later in the 1970s, Texas Instruments marketed its PM 550, the first PLC with true process capabilities.

ISA's *Instrumentation Technology* magazine was re-named *InTech* in 1978. Two years later, ISA relocated to its current international headquarters at Research Triangle Park, NC.

USDATA in 1978, expanding on previous work, introduced REACT, the industry's first microprocessor-based, user-configurable, interactive color graphic workstation for use with PLCs and industrial computers. REACT consisted of an Intecolor 8001, to which USDATA added software/firmware and hardware boards — enabling users to create any color graphic display, add animation, and link the animation to registers in a PLC or process control computer.

Beckman Instruments introduced the first automated dichotomous particulate sampler to collect and separate aerosols into respirable and non-respirable fractions, spurring a 100-unit order from the Environmental Protection Agency. In 1979, Beckman introduced a DCS, the MV 8000, that combined single- and multivariable control loops.

Also in 1979, an advanced computer automation system was installed at the Philadelphia Water Department. This is believed to be the first major application of process control techniques to water treatment and distribution facilities.

Early 1980s:

The software era

The hardware focus of the 1970s continued into the early '80s, with IBM's introduction in 1981 of the personal computer (PC), using what was to become the standard DOS (disk operating system), created by Microsoft. This general-purpose microcomputer was designed to be used by one person at a time as an alternative or supplement to the terminals connected to a time-sharing system.

Books such as *Future Shock* in 1970 had predicted that ordinary households would have computers. Yet, even as late as 1981, that notion seemed somewhat fantastic. The cost of the PC was still prohibitive, although it represented a significant reduction in both cost and footprint over its larger PLC and DCS counterparts.

And, as instrument and systems hardware costs decreased, hardware per se became more of a commodity in the '80s. Lines between DCSs, PLCs, and PCs were blurring as each previously separate platform began to incorporate features of the other platforms. PLCs, for example, had already begun to incorporate distributed control functions so that they could be linked much in the way DCSs were linked. As the platforms themselves became less distinct, attention now turned to software as a way by which vendors could distinguish themselves from each other.

Companies whose primary product was software, not the computer or the instrument, sprang up in great numbers during this period. Suddenly, ISA shows were featuring niche software players who exhibited side by side with the traditional instrument and computer vendors that had dominated the measurement and control field for decades.

Neural networks and artificial intelligence (AI) applications, while not exactly exploding in popularity, began to emerge. Neural networks were used to model the action of human neurons on a computer screen, and were used in control systems dealing with reactors, modeling, vision, and voice recognition. They were designed to reflect or imitate the neural processes of the brain.

Expert systems based in AI technology were developed to help "capture" the expertise of long-term operators and to train new operators and shorten the learning curve. Fuzzy logic, based on theory developed in 1965 by Lotfi Zadeh, also saw increased interest in the '80s. Fuzzy logic is a method by which process control engineers can use words instead of precise numbers, such as "sort of hot" and "very slow."

Leeds & Northrup in 1981 introduced the first self-tuning automatic controller.

Honeywell in 1982 introduced its UDC 500 microprocessor-based, single-loop controller that served as three instruments in one: a precision controller, a versatile process controller, and a future communication link with central command. Leeds & Northrup installed, that same year, the first fiber optic data highway.

Mid-1980s:

Batch control, MAP catch on

A significant trend during the 1980s was the growth in emphasis on DCSs for batch control. In 1981, Honeywell enhanced its TDC 2000 line with a Batch Controller System and Extended Controller. In 1983, Honeywell introduced the TDC 3000 DCS, which integrated information and control. First installed at Esso Cold Lake in Alberta, Canada, it linked equipment, subsystems, and computers to a data highway. Fisher celebrated its own "Century of Control" with the introduction of its PROVOX microprocessor-based DCS.

Emphasis on DCS applications for batch control continued to grow as the cost of hardware came down and made the investment more manageable for frequently changing applications in the food and beverage industries.

Meanwhile, ISA's reputation as an international standards-setting body was bolstered in 1982 when its Standards and Practices Department served as administrative secretariat to the U.S. Technical Advisory Group for the International Electrotechnical Commission (IEC). The next year, ISA's Training Center opened in Raleigh, NC. ISA continues to train measurement and control technicians and engineers in numerous aspects of instrumentation.

Moore Products Co.'s MYCRO Multiloop Controller (MLC), introduced in 1983, was the first fully redundant DCS controller with integrated fault tolerance. Every component had a redundant twin, compared to other DCS controllers which only duplicated "critical" components. MLC's integrated fault tolerance allowed for automatic, bumpless switchover procedures.

Glutton Industries in 1983 introduced a four-inch, solid-state, digitally operated chart recorder. In other developments in the mid-1980s, seven Westinghouse-controlled turbines at three power plants used artificial intelligence for the first time. Kent marketed the first microprocessor-based chart recorder, the P105M, and Marconi Research demonstrated control valve positioning using fiber optics.

With all of the hardware developments of the 1970s, manufacturing plant sites were fast becoming a hodgepodge of multiple vendors' systems, with various "islands of automation" across the plant but no coherent or effective way of connecting the islands. Information for each island resided within the island's confines, and was not easily transmitted or transferred to other departments.

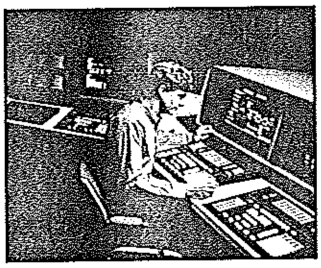
The terms MAP (Manufacturing Automation Protocol) and CIM (Computer Integrated Manufacturing) became buzzwords in the 1980s. The premise was laudable: that a common protocol or standard could be developed so various vendors' equipment could be connected and could communicate with each other easily. The problem was, while everyone talked about MAP and CIM, and wrote theoretical articles about the potential benefits, no one knew how to implement it under operational conditions.

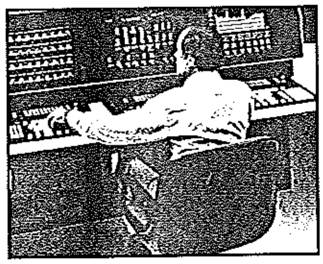
There were live demonstrations of MAP at trade shows such as AUTOFACT. In 1986, the MAP effort developed a body of standards to provide a universal communications method among different types of digital equipment. However, vendors were reluctant to throw away the huge investments they had made in their proprietary systems, and were loath to jump on the bandwagon of competing vendors' products. While CIM and MAP clung on throughout the '80s, the terms languished into the '90s.

1975-1979

1975

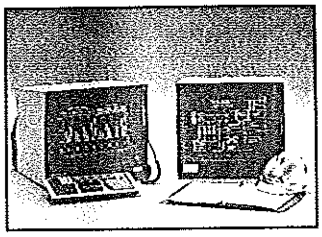
About the same time in the mid-1970s, Yokogawa in Japan and Honeywell in the U.S. introduce the first distributed control systems, marking a significant and far-reaching change in the way control systems can be configured and applied. The Yokogawa Centum, below, and Honeywell TDC 2000, further below, are based on the concept that several microprocessor-based loop controllers can be controlled by supervisory minicomputers, with a push-button, CRT-based display for the operator rather than an annunciator panel.





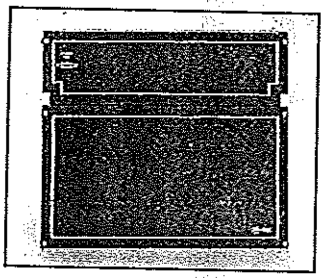
1978

USDATA in 1978 introduces REACT, the industry's first user-configurable colorgraphic workstation (hardware and software) providing a human/machine interface for programmable controllers.



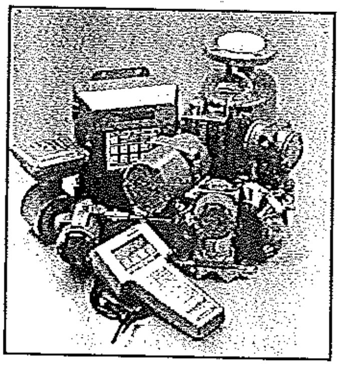
1980-1984

1983
Moore Products' MYCRO Multiloop Controller (MLC) is the first fully redundant DCS controller with integrated fault tolerance. Every component in the MLC has a redundant twin, compared to other DCS controllers which only duplicate "critical" components. The MLC provides automatic, bumpless switchover procedures.



1985-1989

1986
Rosemount's "Smart Family" line of microprocessor-based pressure, temperature, and flow measurement instruments is introduced in 1986.



1986
USDATA in 1986 introduces FactoryLink, one of the industry's first PC-based application enabler software products providing human/machine interface and supervisory control and data acquisition functions.

Smart transmitters appeared in 1983, beginning with Honeywell's ST 3000, which eliminated the need for digital-to-analog and analog-to-digital conversions to improve system and loop accuracy. Digitally integrated with the TDC 3000 DCS, the ST 3000's diffused silicon sensor technology allowed remote diagnostic and range change capabilities with no-moving-parts reliability. The same year, Honeywell introduced Digital Enhanced (DE) field transmitter communications, which improved signal accuracy while allowing remote diagnostics and re-ranging.

Siemens' modular Simatic S 5-115U programmable controller systems entered the market in late 1984. Meanwhile, Rosemount, which had been acquired by Emerson Electric Co. in 1976, introduced in 1984 what's believed to be the world's first microprocessor-based process monitor, the Series 4000. It produced a reliable, flexible, and economical multi-channel alarm system. In 1986, Rosemount introduced its SMART FAMILY line of microprocessor-based temperature, pressure, and flow field instruments. That same year, Emerson combined Rosemount, Beckman Industrial, Brooks Instruments, Kay-Ray, Micro Motion, Uniloc, Varec, and Xomox into the Rosemount Measurement and Control Instrumentation Group.

Rosemount in 1985 introduced its System 3, and Taylor Instruments released its MOD300, based on Motorola 68000 hardware. About the same time, Intellution introduced the FIX, a software product for the PC/XT and AT, originally targeted at direct monitoring and control applications, as opposed to human-machine interface for PLCs. IBM began promoting both CAM (computer-aided manufacturing) and the FIX to its customers. A year later, in 1986, USDATA introduced FactoryLink for the PC/XT, designed as a human-machine interface for programmable controllers. Other companies offering automation software products during this time included Iconics, Teledenken, and TA Associates.

In 1986, Gould Electronics introduced its Gould Cell Controller, which replaced makeshift cell control solutions with minicomputers and advanced programmable controllers. The same year, AccuFiber, Inc. was assigned a patent for an optical fiber thermometer developed at the National Bureau of Standards (NBS) in 1981.

Late 1980s:

Smart devices, fieldbus

Foxboro in 1987 introduced the 760 and 761 controllers, the first to use artificial intelligence (AI) technology, and Texas Instruments introduced an AI-based system used for instrumentation training and maintenance, as well as improved productivity in a variety of industry applications. Also in 1987, an ultrasonic sensor for measuring depth and proportions of treated surfaces of steel and metal alloys was developed at NBS.

Fieldbus became the talk of the industry in the late 1980s, with standards developments having been under way since the mid-1980s by ISA and the IEC (International Electrotechnical Commission). Although IEC/ISA SP50 committees have labored over fieldbus standards specifications, market politics — fueled by vendor-led organizations seeking to protect their own technologies, installed base and bottom lines — have delayed the process to date. Users, meanwhile, have remained largely on the sidelines, frustrated over a lack of consensus.

In 1988, a light bridge sensor that not only detected the presence of objects in the sensing field, but also accommodated any changes in the field without considerable downtime, was invented by Harold Phillips.

A SCADA (supervisory control and data acquisition) system was installed at the Denver Water Department, simplifying complex water treatment. Acromag introduced its Series 4000 I/O processor, a modular data acquisition system featuring up to 16 analog and 24 digital channels. It featured built-in signal capabilities to simplify data handling by a host computer. Saab Tank Control pioneered a non-contact radar method, known as radar level measurement, to measure levels of liquids in storage tanks.

Honeywell in 1988 introduced its Process Manager controller, said to be the first multiprocessor controller. The technology distributed controller processing among dedicated processors, improving reliability and performance.

Also in 1988, the American Association of Engineering Societies and its Soviet counterpart, the All Union Council of Scientific and Engineering Societies, ratified an exchange agreement to develop cooperative relationships to promote engineering knowledge and practice in the public interest.

The late 1980s were characterized both by the increasing number of software packages for the DCS, PLC, and PC platforms and the number of joint ventures that were formed. With industry standards coming into play, companies which previously had maintained "separate but equal" stances were beginning to consider partnerships and other strategic agreements with vendors whose products and expertise supplemented their own. Hitherto staunch competitors began to consider seeking complementary alliances to increase business for everyone involved.

For example, in 1989, Johnson Controls and Yokogawa Electric Corp. formed a joint venture, Johnson-Yokogawa, to strengthen their penetration of the North American industrial automation market. Also that year, Allen-Bradley in alliance with Digital Equipment developed a new generation of industrial control systems called the Pyramid Integrator to unite communications between the plant floor and management offices. The same year, Hewlett-Packard, Fisher Controls, and Coopers & Lybrand opened a computer-integrated manufacturing technology center in Minneapolis to offer midwest area manufacturers a real-world look at a fully integrated CIM production system geared to the process industry.

Meanwhile, H-P introduced its 3563A control system analyzer that simplified test and analysis of advanced closed-loop control systems. Allen-Bradley began shipping the batchmaster batch process control system, a fully integrated batch process control system that offers significant cost savings automating batch processes.

Bailey Controls unveiled in 1989 a smart transmitter technology, SMARTPORT transmitter management software, which allows configuration, monitoring, and tuning of up to 535 devices via a PC.

Early 1990s:

Communications & open systems

While the '70s and '80s were dominated by proprietary systems and software, the current decade has witnessed a revolution in hardware-independent packages, leading the way to open systems.

The value of true open system architecture has been debated for some time, with vendor and user opponents alike fearful of degrading security and reliability. However, many control vendors today are spending R&D dollars developing open architectures and ensuring connectivity with other systems, while continuing to support a dwindling installed base of proprietary systems.

One of the most significant developments spurring open systems has been object-oriented programming, or OOP. This approach differs from traditional programming in its modularity. OOP is structured in such a way that blocks of code can be used again, saving sometimes as much as 30-40% of development time. OOP serves to make software more reliable because consistent blocks are used over and over again.

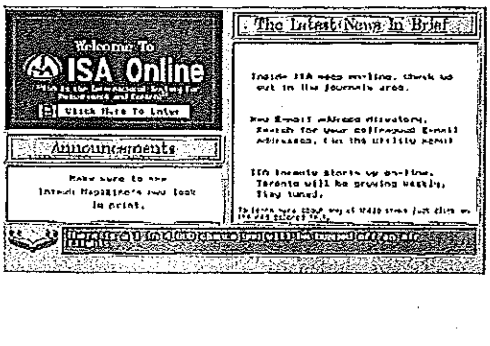
"Modern corporations are faced with a profound dilemma. Increasingly, they are becoming information-based organizations, dependent on a continuous flow of data for virtually every aspect of their operations. Yet their ability to handle that data is breaking down because the volume of information is expanding faster than the capacity to process it. The result: corporations are drowning in their own data....," wrote David Taylor in *Object-Oriented Technology: A Manager's Guide* (Servio Corp., 1990).

"We need a new approach to building software, one that leaves behind the bricks and mortar of conventional programming, and offers a truly better way to construct systems," Taylor continues. "This new approach must be able to handle large systems as well as small, and it must create reliable systems that are flexible, maintainable, and capable of evolving to meet changing needs."

Along with OOP, Microsoft's development of Windows and Windows NT operating systems is helping promote open systems in control applications. Windows NT's present and promised benefits include 32-bit processing, portability, security, compatibility, scalability, connectivity, and reliability. It is object-based and provides multitasking, so that critical tasks take precedence over routine tasks in plant operations.

Just as MAP and CIM were buzzwords of the '80s, MES (Manufacturing Execution Systems), a term coined by Advanced Manufacturing Research, is a buzzword of the 90s. Unlike its predecessors, however, MES is more than a theoretical philosophy of how to approach plant integration. It is an approach to integrating a business from operations data to the business management/management information system (MIS) level — areas that previously were separate.

Whereas CIM focused on integrating horizontal islands of automation, MES is more of a top-down (or alternatively, a down-top) approach. The ability for key process and business data to be accessed and/or manipulated provides several key benefits, including better scheduling

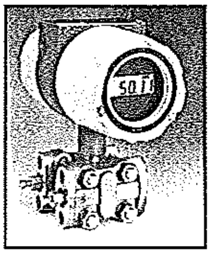


ISA OnLine

1990-1994

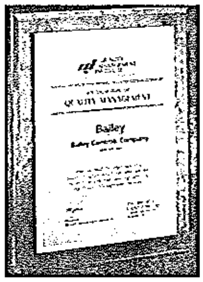
1990

Moore Products' XTC Transmitter-Controller, considered to be the first field-mounted transmitter to include a built-in PID controller, is introduced in 1990. Actually a family of "smart" pressure and temperature transmitters, XTC gains a following for standalone loops because of the transmitter's built-in control capabilities.

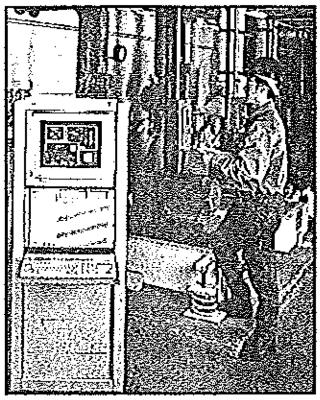


1990

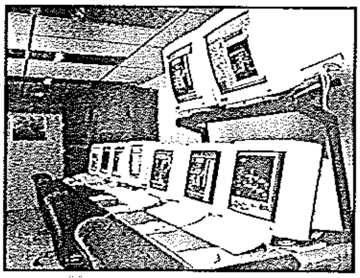
Bailey Controls is the first U.S. controls supplier to achieve dual quality management certification from ISO and CSA.



The 1990s has brought desktop technology to the plant floor, led by software suppliers such as Wonderware, Intellution, USDATA, Iconics, Teledenken, and TA Engineering Co., among others.



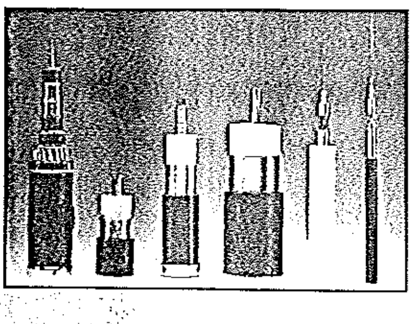
1992
Moore Products Co.'s APACS, introduced in 1992, is the first control system to provide built-in combined DCS/PLC capabilities. It incorporates the IEC 1131-3 standard for configuring programmable controllers, which allows DCS function blocks, PLC ladders, sequential function charts, and structured text to be used and combined within a single control module.



1994
In 1994, ISA launches ISA OnLine, which provides updates about ISA conferences and exhibitions, industry news and technical articles, and forums for members to discuss important issues.

1995-2000

1996
Early telephone submarine cables from the 1950s (below, far left) carried up to 36 simultaneous phone calls. During the 1960s and 70s, cables between the U.S. and Europe (next three cables shown) grew in capacity from the equivalent of 138 to 845 to 4,200 simultaneous phone calls. Today, fiber optic cables (second from right) carry up to 40,000 simultaneous phone calls per fiber pair. By 1996, undersea fiber optic systems will carry up to 320,000 simultaneous phone calls per fiber pair.



of resources, higher product quality, and better documentation, which is particularly helpful to the pharmaceutical industries and plants with OSHA concerns. Hardware independence is essential to MES success so that information can be transmitted throughout the plant.

Other significant technical developments and trends in the 1990s include the rapid evolution of graphical user interfaces; ISO 9000 certification of process control suppliers; increased popularity of auto-tuning, with companies such as Control Techniques and Eurotherm entering the multi-algorithm adaptive control tuning market with their Expert 460 and Series 900 products; continued development of batch standardization; more neural network activity, such as Gensym's NeurOn-Line; and increased use of fuzzy logic.

Kicking off the 1990s, Wonderware, incorporated in 1987, introduced InTouch, the first Microsoft Windows-based human-machine interface application generator. The product, which allows operators to manage computer-controlled processes from their PCs, sold well and fanned fierce competitive flames among human-machine interface and SCADA software suppliers, particularly between Wonderware and Intellution.

Raytek introduced its Thermalert 5 Plus (T-

For further reading

Books

Bennett, S., *A history of control engineering 1800-1930* and *A history of control engineering 1930-55* (Institution of Electrical Engineers, London).

Bernard, John W., *CIM in the Process Industries*, ISA, 1989.

Buckley, Page S., *Techniques of Process Control*, Wiley, 1964.

Considine, Douglas M. and Ross, S.D., ed., *Handbook of Applied Instrumentation*, Robert E. Krieger Publishing Company, 1982.

Durden, W.P., "Analog Versus Digital Instruments," *Instrument Engineers' Handbook: Process Control*, Bela G. Liptak, ed., Chilton Book Company, 1995, pp. 170-172.

Feldman, H.L., Kaminski, R.K., and Liptak, B.G., "Electronic Versus Pneumatic Instruments," *Instrument Engineers' Handbook: Process Control*, Bela G. Liptak, ed., Chilton Book Company, 1995, pp. 173-176.

Harriott, Peter, *Process Control*, McGraw Hill, 1982.

Lavigne, John R., *Instrumentation Applications for the Pulp and Paper Industry*, Miller Freeman Publications, 1979.

Martin, Peter G., *Dynamic Performance Management*, Van Nostrand Reinhold, 1993.

Matsumoto, Eiju, "Research in the Development and History of Measuring Instruments," translated from *Journal of the Society of Instrument and Control Engineers*, Volume 31, No. 2, February 1992.

Miller, R.W., *Flow Measurement Engineering Handbook*, McGraw Hill, 1983.

Murrill, Paul W., *Fundamentals of Process Control Theory*, ISA, 1981.

Platt, George, *Process Control: A Primer for the Nonspecialist and the Newcomer*, ISA, 1988.

Spitzer, D.W., *Flow Measurement: Practical Guide for Measurement and Control*, ISA, 1991.

Taylor, David A. *Object-Oriented Technology, A Manager's Guide*, Servio Corporation, 1990.

Williams, T.J., "A Short History of the Field and the Development of a Philosophy of Digital Process Control," *The Use of Digital Computers in Process Control*, ISA, 1994, pp. 11-27.

Magazines

Babb, Michael, "Pneumatic Instruments Gave Birth to Automatic Control," *Control Engineering*, October 1990.

Babb, Michael, "The Coming of the Standard Machine Controller," *Control Engineering*, October 1989.

Boston, Joseph F., Britt, Herbert I., and Tayyabkhan, Michael T., "Software: Tackling Tougher Tasks," *Chemical Engineering Progress*, November 1993, pp. 38-49.

Bristol, R.A., "Instrument Makers: 1945-1965," *ISA Journal*, Sept. 1965, p. 40.

Brule, Michael and Chronister, Robert, "Computers: The Next Decade," *Chemical Engineering*, August 1993, pp. 74-84.

Plus), the first infrared thermometer that allows users to save, recall, and print information in graphic form.

Moore Products in 1990 produced an industry first: a combined smart transmitter and controller that offers remote bi-directional communication using the HART (Highway Addressable Remote Transducer) operating digital communications protocol, in use since 1986. An early fieldbus technology for simultaneous analog and digital communication with smart field instruments, the technology was transferred in 1994 to a 60-member HART Communication Foundation. Moore Products' APACS, announced in 1992, was the first control system to provide DCS/PLC capabilities. It incorporated the IEC 1131-3 standard for configuring PLCs, which allows DCS function blocks, PLC ladders, sequential function charts, and structured text to be used and combined within a single control module.

Emerson Electric purchased Fisher Controls in 1992 for $1.275 billion. Fisher's Process Instrumentation Division and Rosemount's Control Division merged to form Fisher-Rosemount Systems, officially incorporated in 1993 and headquartered in Austin, TX. Last month, Emerson purchased PC automation powerhouse Intellution, with plans to have it

Editor's note

Due to space limitations, it is not possible to provide an all-inclusive history of measurement and control technologies. We realize that we may have overlooked events and technical developments that others believe should be recognized. We encourage readers to send their comments, recollections, corrections, and any historic artwork to *InTech* magazine. If sufficient material is collected, we'll consider a follow-up article. The material also will be used to prepare for the 55th, or 60th, ISA anniversary.

Craig, Lynn W., "SP-88 Defines Batch Control," *InTech*, March 1994, pp. 34-37.

Fusaro, Dave, "The Dark Side of Open Systems," *Control*, May 1993, pp. 18-22.

Hill, Bob, "MES on the Road to Total Quality in the Process Industries," *I&CS*, November 1993, pp. 61-69.

Kompass, Edward J., "A 40-Year Perspective on Control Engineering," *Control Engineering*, September 1994, pp. 68-69.

Kompass, Edward J., "Changing Control Technology: The Past and the Future," *Control Engineering*, October 1989, pp. 27-28.

Ledgerwood, B.K., "The Business of Control," *Control Engineering*, October 1989, pp. 17-23.

Levine, Peggy Sharp, "Automation Software 1995: Moving Toward Total Solutions," *Industrial Computing*, January 1995, pp. 16-18.

Lynch, P.M., and Healey, A.J., "Systems and Control Division," *Transactions of the ASME*, Vol. 115, June 1993, pp. 223-233.

Morley, Dick, "Ladder Logic Languishing," *Manufacturing Systems*, April 1992, p. 54.

Morris, Henry M., "Electronic PID Controllers Shrink While Features Grow," *Control Engineering*, October 1990, pp. 31-34.

Rubin, Steve, "Operator Interface Software Keeps Getting Better," *I&CS*, May 1994, pp. 26-33.

Samdani, Gulam, "Fuzzy Logic: More than a Play on Words," *Chemical Engineering*, February 1993, pp. 30-33.

Scott, Mike, "Flowing Through: 50 Years of Flow," *Process Engineering*, Volume 75, Issue 9, September 1994.

Sinduh, Azhar U., "Object-Oriented Programming Cuts Development Time, Boosts Reliability," *I&CS*, March 1991, pp. 53-55.

Verity, John W. and Schwartz, Evan I. "Software Made Simple," *Business Week*, Sept. 30, 1991, pp. 92-100.

Waterbury, Robert C., "Software Trends Lead to Control Forefront," *InTech*, June 1994, pp. 16-19.

Williams, T.J., "Two Decades of Change - A Review of the 20-Year History of Computer Control," *Control Engineering*, September 1977, pp. 71-76.

Newsletters

James P. O'Connor, "Philadelphia Celebrates 50th Anniversary," Ed. Jack Grenard, *Inside ISA*, December 1992, pp. 1-2.

Transducer, ISA, Philadelphia Section, Volume 40, No. 2, September 1992.

Company Brochures and Special Editions

Bailey Controls Company, Celebrating 75 Years of Excellence 1916-1991, brochure, Bailey Controls, 1991.

Covey, Charles W., ed. *Taylor Technology, Centennial Issue*, Vol. 3, No. 4, Spring 1951.

Honeywell: The First 100 Years, author unknown.

The *InTech* staff would especially like to thank the following people for their contributions to the research of this article: Ken Ball, David Bishop, George Blickley, John Bernard , W. Spence Bloor, Jim O'Connor, Don Gillum, Keith Herbst, Peter Martin, and Ross Forman. We also thank Linda Vande Vrede, a Phoenix-based freelance writer and consultant who did considerable initial research and writing for this article.

closely affiliated with Fisher-Rosemount.

Other significant developments in this decade include Siemens' 1992 introduction of the SIMATIC Process Control System of integrated control, designed to help users make the transformation from control to automation. Featuring both DCS and PLC technologies, communication and windowing environments, the system's unifying thread is a real-time relational database management system (RDBMS) providing global availability of process information for multi-disciplines across a plant.

New chips, such as the RISC (reduced instruction set computer)-based Alpha chip, Pentium and PowerPC lines, have the ability to execute more instructions than previous processors. The client-server architecture, conceived several years ago, is now coming into its own in the process world. In this architecture, information is shared and distributed equally throughout a network.

Mid-1990s:

SCADA, Batch, ISA grow

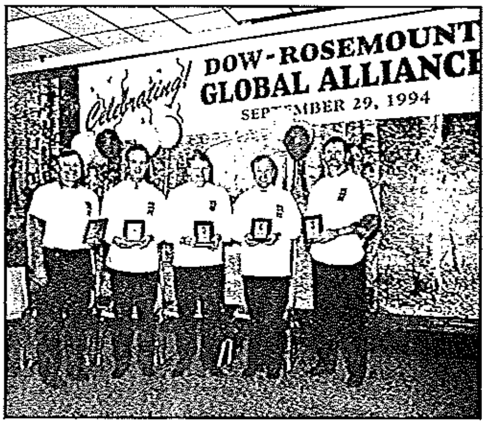
In 1993, Sara Lee sponsored a SCADA software "shootout" at the North Carolina State University School of Textiles. There, for the first time, process software suppliers were pitted head-to-head in a public arena, with results widely publicized.

In 1993, ISA/93 Chicago was attended by more than 30,000 people. By 1994, ISA's membership stood at 49,000 professionals, distributed among 164 sections.

Significantly for batch control, in December 1994, the first part of the ISA SP88 Batch Control Standard—is sent to ISA for Standards and Practices Board approval. Work in in progress on Part 2: Data Structures and Guidelines for Languages.

Explained Lynn W. Craig, vice chairman of ISA's SP88 batch control committee, in a March 1994 *InTech* article: "The standard officially defines terminology and conceptual models for batch control, but can also be treated as a compendium of control functionality needed for a broad range of process control. The functionality is described in models which are implementation independent, and can be applied to simple continuous process control, as well as to total automation of batch processes. Emphasis throughout is on modularity and hierarchy...."

In the largest single contract in Rosemount's history, with a $50 million potential, Dow



Dow Chemical and Rosemount Measurement Division agree to a global alliance for Dow to buy Rosemount pressure transmitters. With a $50 million potential, it represents the single largest contract in Rosemount's history.

Chemical in 1994 agreed to a global alliance, standardizing on Rosemount pressure transmitters. This "global alliance" helped set a purchasing pattern that's being increasingly adopted by users and other vendors today.

Advances in communications technologies continue to have a significant impact on the process industry. According to AT&T, fiber optic cables in use today carry up to 40,000 simultaneous phone calls per fiber pair. By 1996, undersea fiber optic systems will carry up to 320,000 simultaneous phone calls per fiber pair.

Future control engineers will need to be even more computer literate, and flexible enough to withstand the demands that "instant information" creates upon operations. Competition among vendors, particularly computer- and software-based suppliers, is certain to intensify. The large, monolithic vendor companies that dominated earlier decades will need to continue to make room for smaller, more flexible and specialized vendors.

Meanwhile, technology marches on, and measurement and control practitioners continue to become increasingly sophisticated, and less dependent on a single, or small number of, vendors. Today, users have yet another powerful tool — emerging global on-line information services that can help them locate solutions to their problems.

Consolidation—big companies gobbling up smaller ones—is currently a major trend among control hardware and software suppliers. The measurement and control field is indeed getting "curiouser and curiouser," to borrow a line from *Alice in Wonderland.* **IT**