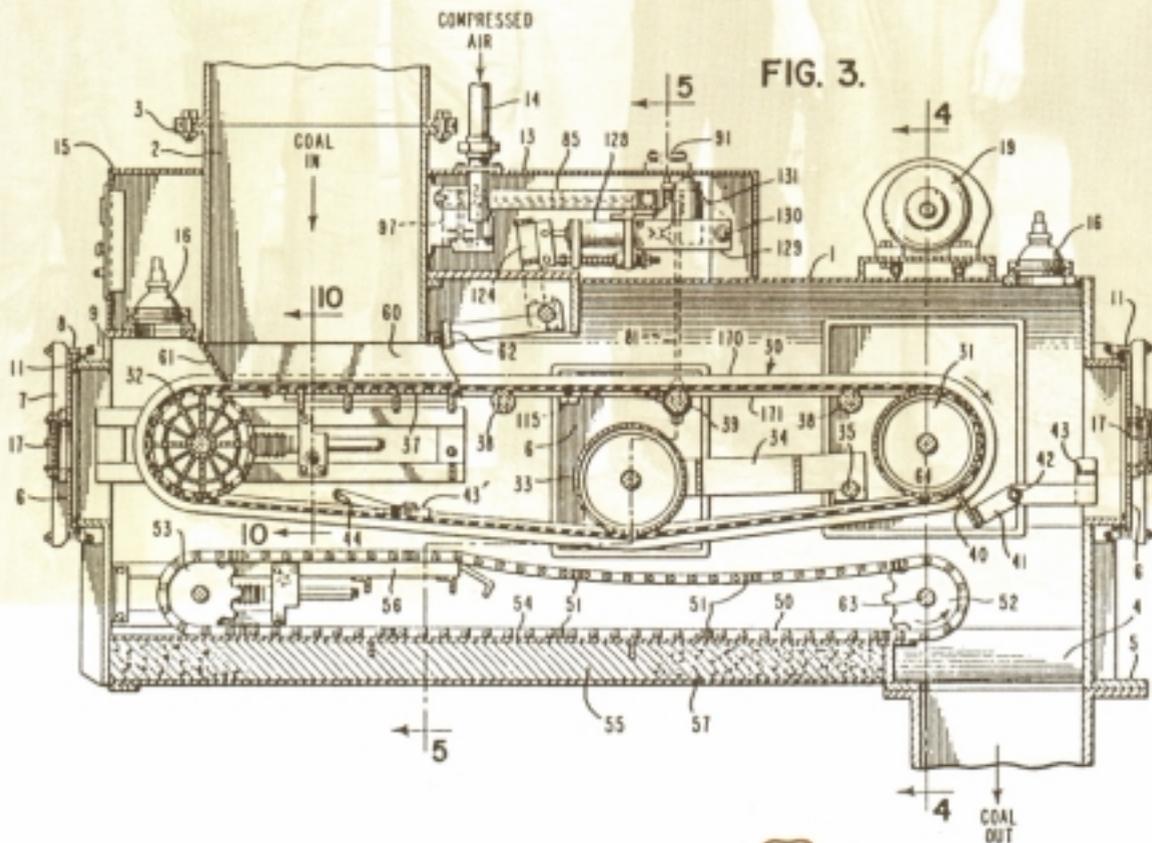
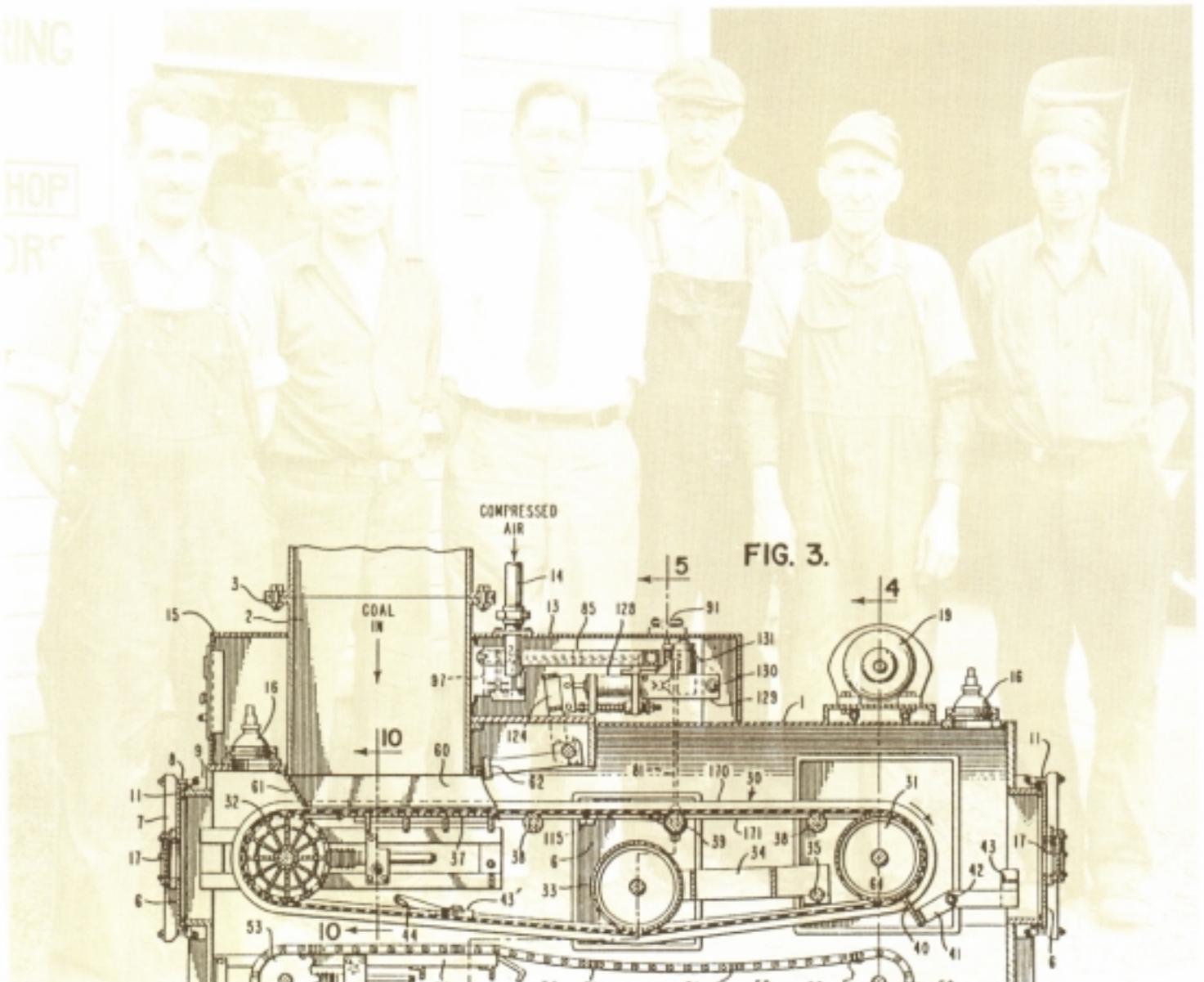


The STOCK® Gravimetric Feeder

An International Historic Mechanical Engineering Landmark

Stock Equipment Company

May 4, 1995 - Chagrin Falls, Ohio



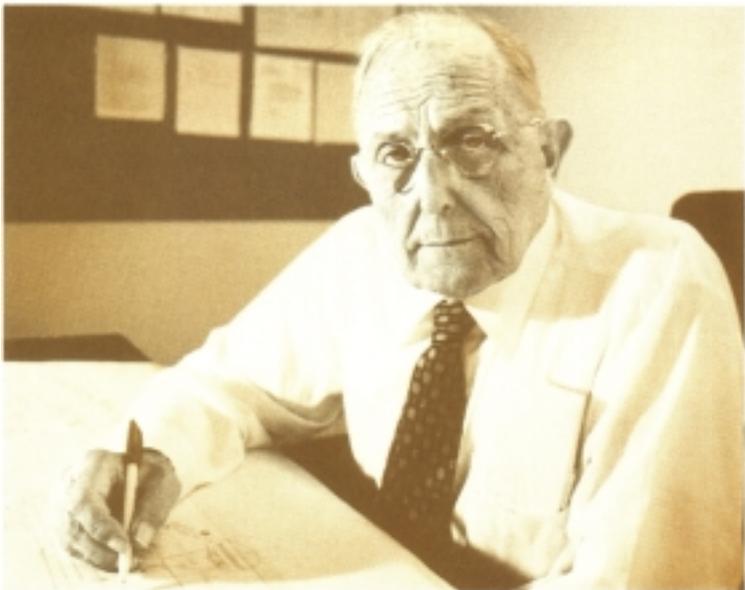
The American Society of
Mechanical Engineers

Historical Significance and Technical Background

With the introduction of practical electrical power generation and distribution during the 1880s, demands were created for larger and more efficient boilers. Most power generation in the United States relied on (and continues to rely on) the burning of fossil fuels in steam boilers to drive high-speed turbine generator sets. Low cost and ready availability have made coal the fuel of choice for most electrical power generators. During the 1920s, commencing with Lakeside Power Plant of Wisconsin Electric Power, pulverized-coal firing (the burning in suspension of finely ground coal particles) evolved as a means of providing more complete fuel combustion, higher system efficiencies, and facilitated the use of larger boilers than had been practical with stoker firing.

About this same time, Arthur J. Stock, a 1922 mechanical engineering graduate of the University of Michigan, was applying for patents on a nonsegregating coal distributor to supply coal in even-sized distribution to stoker-fired boilers. During the next few years, Stock made patent applications for designs as diverse as staplers, hollow rubber balls, and self-venting baby bottle nipples before committing fully to the power generation industry.

Just weeks before the 1929 stock market crash, Arthur Stock formed a company to supply products to the power industry. During the 1930s, the company developed a series of innovative shut-off valves, followed by batch-type weighing scales for use in stoker feed systems. From a single welder in the basement of a downtown Cleveland, Ohio building, Stock Equipment Company grew and earned a reputation for innovative thinking and high-quality manufacturing.



Arthur J. Stock - 1900-1986

The demand for larger, more efficient boilers continued throughout the first half of the twentieth century. A typical pulverized-coal-fired unit fuel system consisted of storage bunkers holding two-inch or smaller sized coal, feeders to control the flow, pulverizers to dry and grind the coal to a fine powder, pneumatic transport lines (burner lines), burners, and the boiler furnace in which combustion took place. Air supply fans, control dampers, and combustion control systems supplied combustion air as required for optimum combustion.

A variety of mechanical feeders, including drag chain conveyors, table feeders, and rotary pocket feeders, historically have been used to volumetrically control the flow of fuel to the pulverizers. In any firing process, accurate fuel feed is required to correctly proportion combustion air and thereby ensure total oxidation of all combustible elements. There would have been no need for gravimetric feeding by weight if coal were a more uniform material. However, coal is a blended mixture of coarse and fine particles, exhibiting dramatic changes in flow density (material bulk density under flowing conditions) with small changes in surface moisture. At any point in the transport and storage of coal, the coal is likely to be rained upon. Under other weather conditions, drying of the coal may occur and change its bulk density. Changes in the bulk density of coal limit the accuracy to which combustion fuel-to-air ratios can be held, unless compensated for by the feeder ahead of the combustion process.

As early as 1930, Ralph Roe of Burns and Roe had experimented with feeding coal using automated weighing equipment at the South Amboy Station of Jersey Central Power and Light Company. By monitoring weight indications at a scale dial and manually adjusting delivery rates, evidence was obtained that feeding on a weight rather than volume basis could significantly improve boiler control and combustion efficiency.

During this same period, increased emphasis was being placed on the need to maintain accurate inventory records as to total fuel consumed. These inventory records provided valuable data for calculation of unit operating costs and system efficiencies. In response, batch-type weighing scales, such as those manufactured by Stock Equipment Company and others, were finding use in pulverizer feed systems placed ahead of the volumetric feeders. Problems were encountered with the inherent complexity of such systems, including coal pluggage at transfer points. The increased building elevations required for such multiple component systems were also expensive.

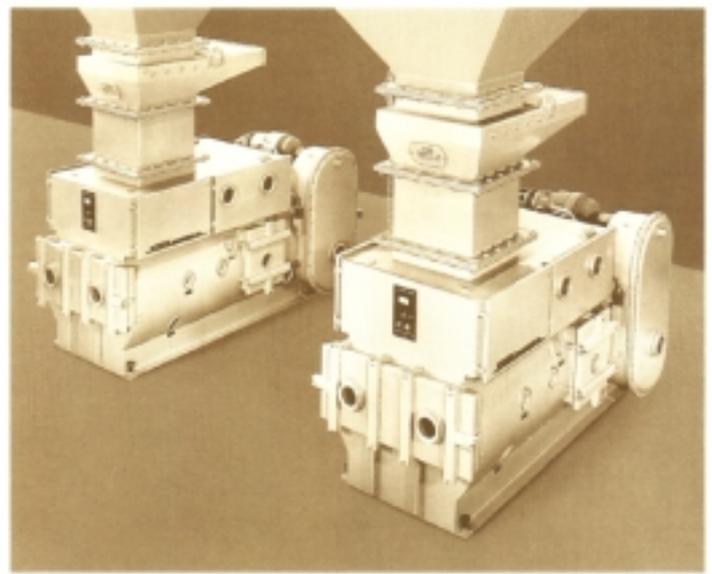
During the 1950s, Arthur Stock successfully combined the weighing and control of material flow into a single device, now known as a gravimetric feeder. Simple, rugged construction, combined with experience gained manufacturing power plant equipment during the 1930s and 1940s, ensured technical and commercial success of the new device. The first installation was placed in continuous operation at Niagara Mohawk Power Corporation's Dunkirk Station in 1957.



Ralph Hardgrove

In 1961, Stock Equipment Company hired Ralph Hardgrove, who had recently retired from Babcock & Wilcox (at 70 years of age) and who was the holder of 96 patents and the developer of the Hardgrove Grindability Index. Hardgrove's career had begun as assistant to E. G. Bailey (Bailey Meter Company) and included

decades at Babcock & Wilcox in boiler development. Hardgrove's leadership in the refinement and development of the gravimetric feeder led to general industry acceptance and by the mid-1960s most large, coal-fired boilers included gravimetric feed systems in their design

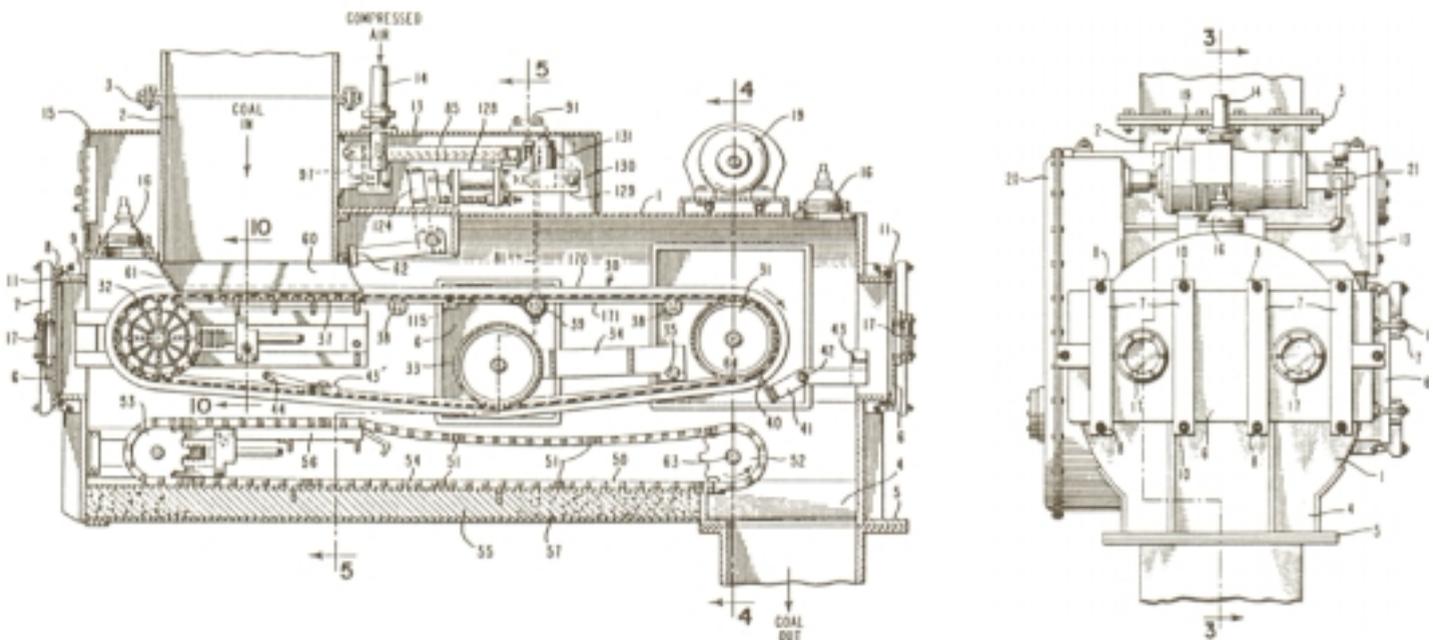


Two of twelve feed systems manufactured for Niagara Mohawk

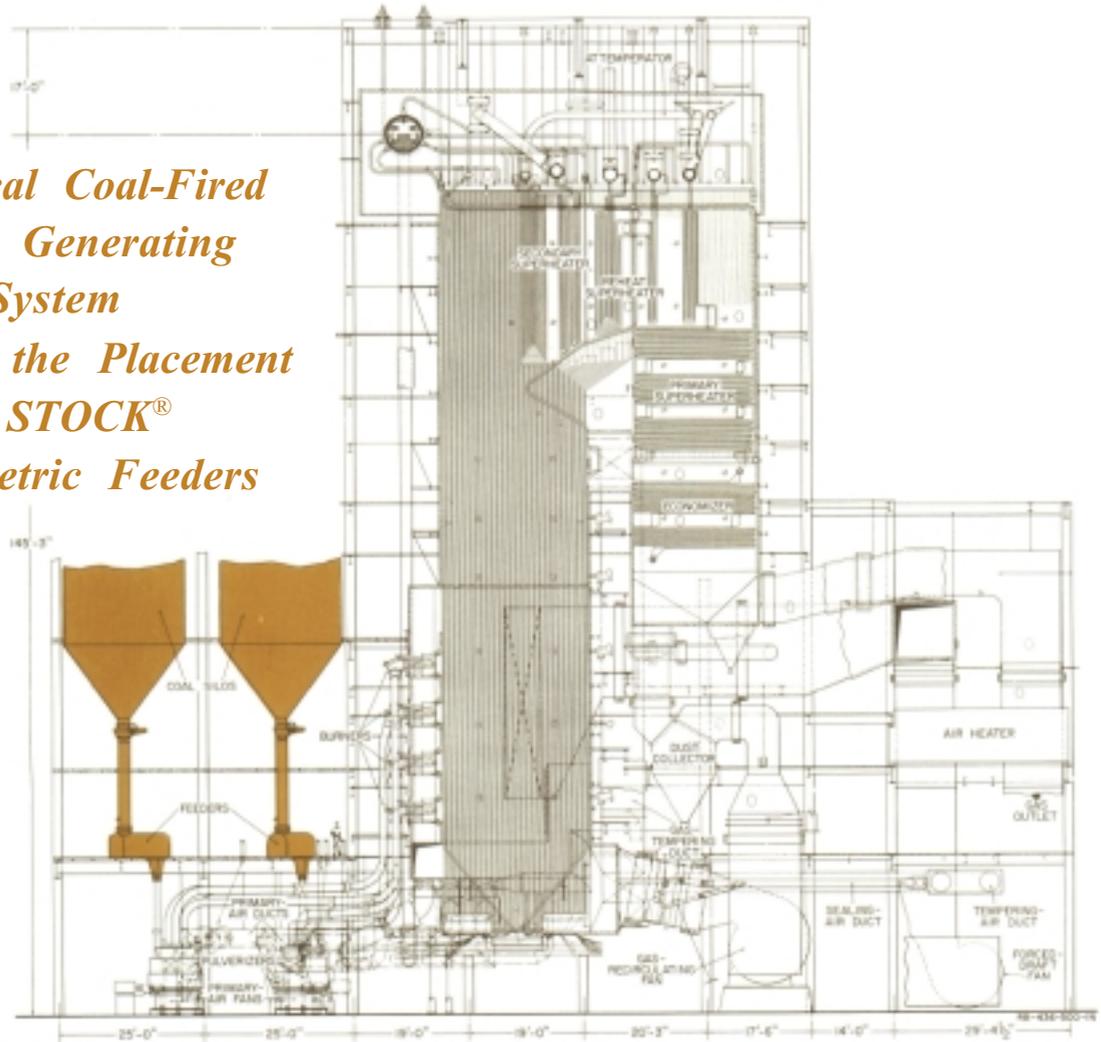
- A cylindrical steel feeder housing, fabricated to the explosion pressure requirements of NFPA Code (1)
- A belt conveyor system including drive and tail pulleys, inlet support pan, and a tension roll to maintain consistent belt tension (31, 32, 37, and 33)
- A balance-beam weighing system to measure the gravimetric loading on the belt (85)
- A motor-driven adjustable leveling bar to modulate the loading of material on the belt (62)
- A drag-chain cleanout conveyor to eliminate coal accumulation in the bottom of the feeder housing (53)
- A variable-speed-belt drive and control system (19)

Gravimetric Feeder Description

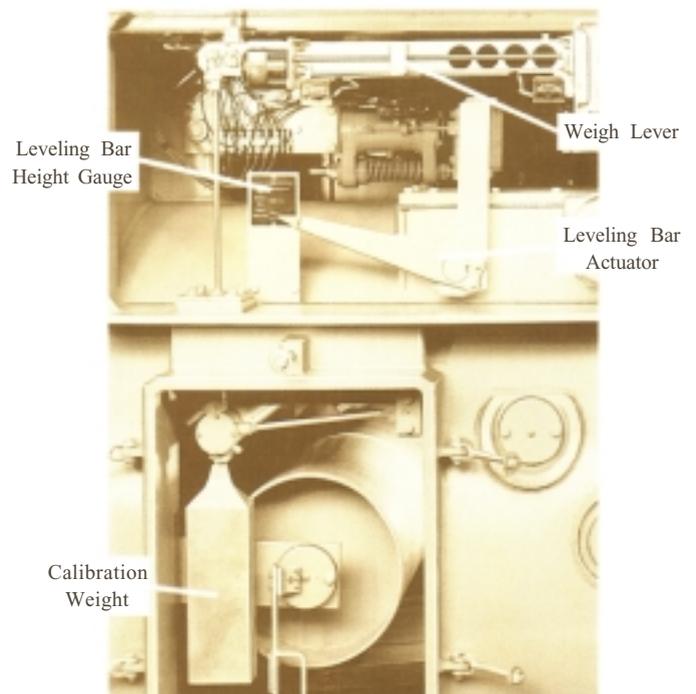
The first gravimetric feeders consisted of six major elements, as follows:



*A Typical Coal-Fired
Steam Generating
System
Showing the Placement
of STOCK®
Gravimetric Feeders*



The feeder was typically located immediately beneath the coal bunker and immediately over one of the pulverizers. Coal would pass down into the feeder and onto the horizontal transfer belt within the feeder body. As the coal proceeded from the inlet and toward the discharge, it passed over a weighing system comprised of two fixed and one moveable roller. As the coal density varied, the moveable roller would either rise or fall and thereby open or close switches controlling a material leveling bar actuator motor. The leveling bar was located just beyond the coal inlet and, by either raising or lowering it, exactly 100 pounds of coal could be maintained on the three-roller span which was equal in length to the head pulley circumference. The feeder, therefore, discharged exactly 100 pounds of coal for each turn of the head pulley. The head pulley speed was proportional to the rate of coal fed that could be expressed as pounds of coal per minute or pounds of coal per hour, as desired. Total turns of the feeder head pulley times 100 equaled the pounds of coal fed during any given period.



By commanding a change in the motor speed, and thus the head pulley speed, the combustion control system could command instantaneous fuel delivery rate changes.

The simplicity of the system allowed reliable operation in the hostile environment presented by the coal dust, heat, and pressures common to coal firing systems. Further refinements were provided to simplify maintenance and to minimize the possibility of equipment failure. These included:

- Internal parts regreaseable from outside the pressure shell
- Belt and chain tension adjustments accessible from outside the feeder body
- Weigh system and controls housed in a separate pressurized “piggyback” compartment, allowing access while the feeder was in operation

The result was an accurate weighing device that could be operated continuously, 24 hours a day, with only one or two shutdowns each year for calibration.

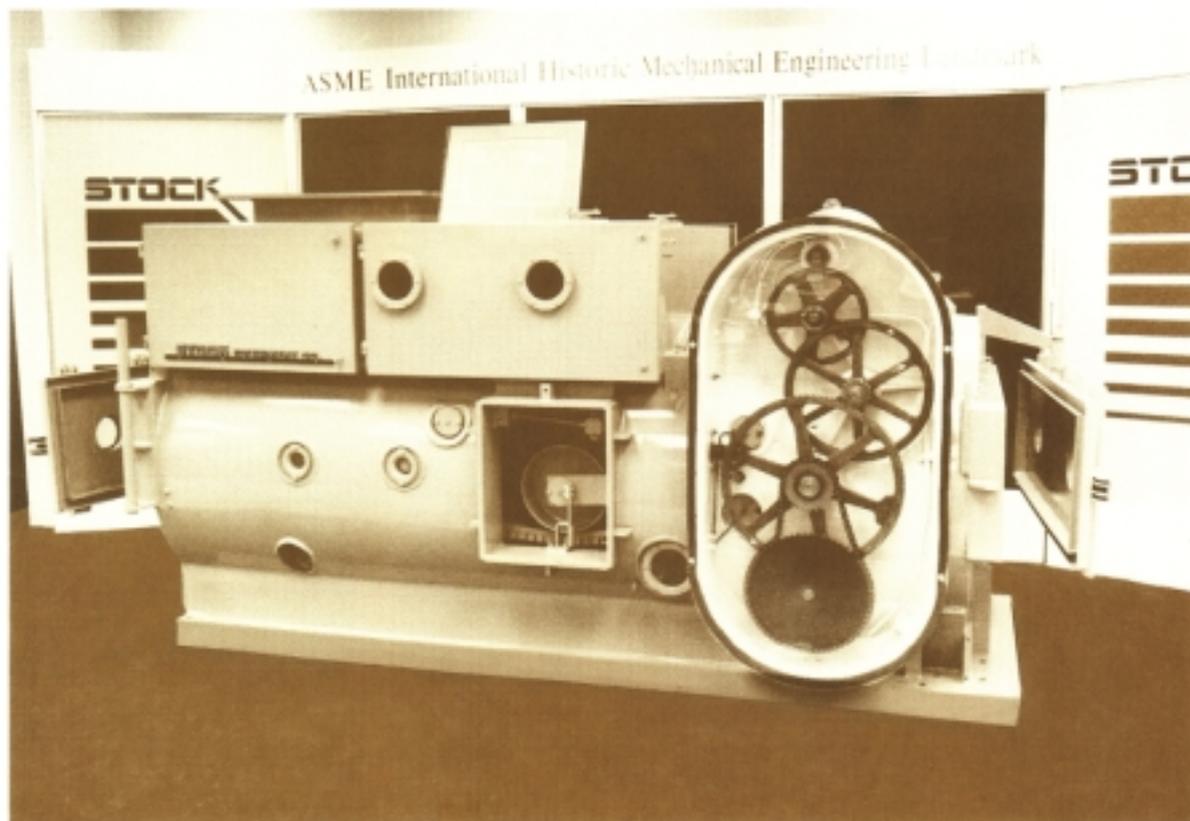
The First Gravimetric Feeder

The first gravimetric feeder was manufactured as part of an order for twelve feed systems to be installed at Niagara Mohawk Power Corporation’s Dunkirk Station, Units 3 and 4, in 1957. One feeder was completed early to allow for detailed accuracy testing, and was still operating successfully and feeding within the original accuracy tolerances when taken out of service in mid-1992. The original twelve feeders were replaced by Stock Equipment Company’s current gravimetric microprocessor-controlled design. The first feeder

was donated to Stock Equipment Company by Niagara Mohawk Power Corporation for restoration and public display. It has been renovated in honor of its inventor, Arthur Stock, and is now located at Stock Equipment Company’s Chagrin Falls, Ohio, headquarters.

From the First Gravimetric Feeder Until Now

Over 7,000 STOCK® gravimetric feeders have been installed worldwide since the initial Niagara Mohawk project. STOCK® gravimetric feeders are now manufactured in the United States, Europe, and Asia. They continue to be the accepted standard for the metering of a solid fuel to a combustion process.



Recently refitted and refurbished, the first STOCK® gravimetric feeder



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Stock Equipment Company, Chagrin Falls, Ohio

The cover photograph shows a group of 1943 Stock shop employees: Paul Phouts, Paul Gardiner, Perc Sheldon, Fred Stoneman, Horace Shippey, and Len Eames.

The illustrations that appear on the cover and on page three are from Arthur Stock's original patent application for the STOCK gravimetric feeder.

The coal-fired steam generating system illustration on page four is the courtesy of Babcock & Wilcox.