FROM ARCHIMEDES TO AUTOMATION

The History of The Screw Machine

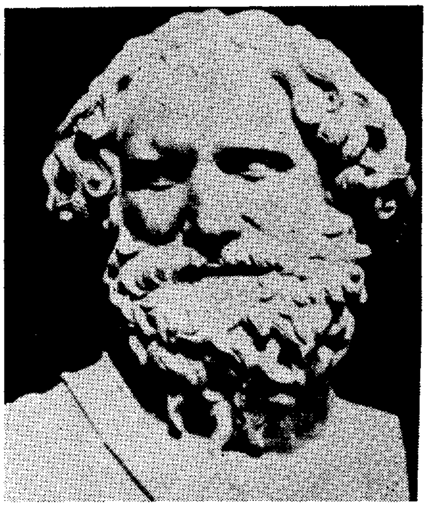
by

DONALD E. WOOD

100 YEARS OF AUTOMATION · SCREW MACHINE PRODUCTS

1873

1973



Archimedes (287-212 B.C.), the Greek mathematician, discovered the principle of the screw thread. History of the screw machine is closely related to the development of the screw itself.

Derivations of Archimedes' invention of the water snail are still in use today. The principle of the water snail, or 'Archimedes Screw', was to lift the water from the sump to the reservoir by means of tubing wrapped around the diagonal shaft. Although the screw, lever, pulley, wedge, wheel and inclined plane are the six basic mechanical powers, the screw was not used to any extent until centuries later.

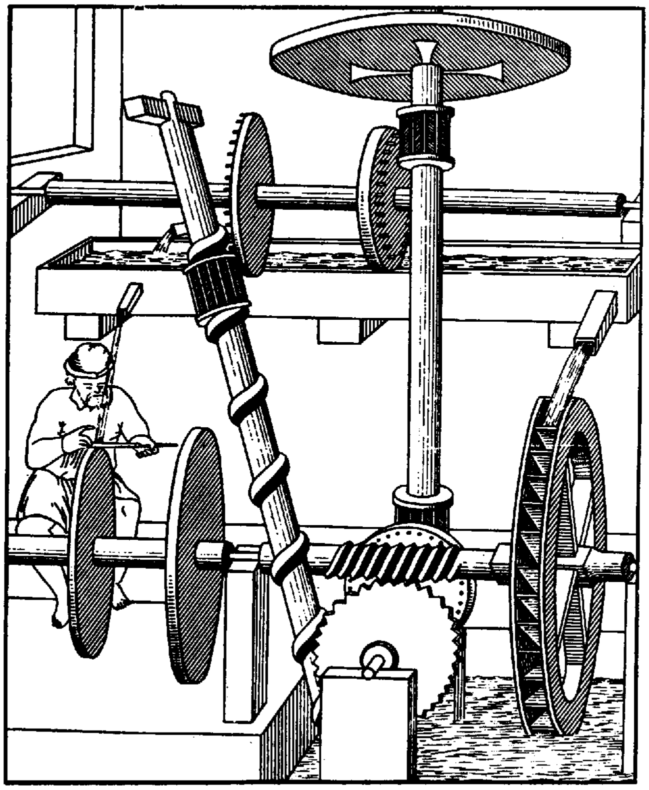
from ARCHIMEDES

PART 1: the history

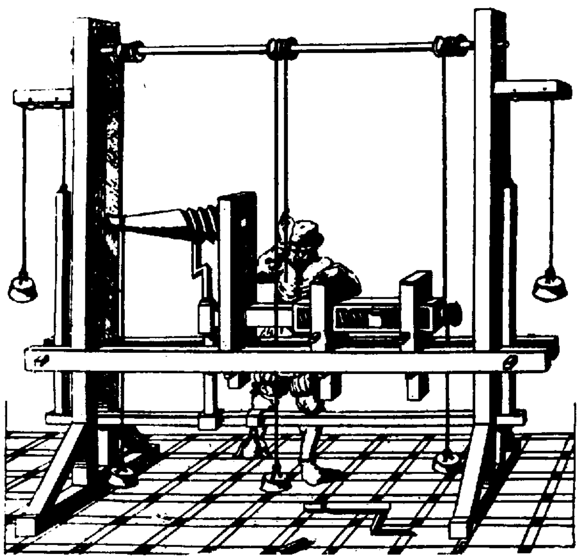
"Jim yawned as the radio-alarm clock began to hum. Switching off the electric blanket he made his way to the bathroom, splashed hot water on his face and buzzed his electric razor while his wife plugged in the coffee maker and turned up the oil heater's thermostat. Within minutes he had climbed into his hunting togs, placed his new automatic shotgun in the station wagon. "Have Fun, Jim," his wife called as he turned off the yard light. "Don't hurry back. I can phone for groceries, and if we need anything badly Jimmie can go after it on his bike."

JUST AN ORDINARY Saturday's hunting trip in the life of Jim and Martha Citizen, Anywhere, USA. A day any of us duplicate. A day which all of the money in the coffers of the richest man on earth would not have bought less than a century ago.

We accept as our birthright the appliances and conveniences which mass production has brought. We may forget at times that within the past 100 years our way of life has advanced more than in all preceding history. Our standard of living is high. It will go higher. We are privileged to live in the era of

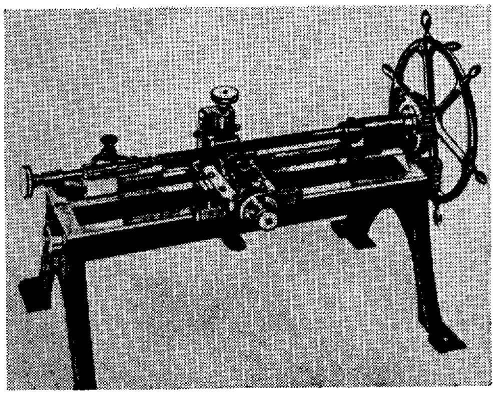


Invented by Besson in 1569, this screw lathe could cut threads of any pitch by interchanging pulleys of different diameters. The machine was operated by foot treadle, and the cutting tool was controlled by a pulley-driven master screw.



to AUTOMATION

of the screw machine



Maudslay built the first all-metal screw cutting machine in 1800, and developed the first true master screw, an important step forward in standardization.

enlightened mass production.

Not one of the items which Jim and Martha Citizen enjoyed on that Saturday morning was available until a means had been found to make metal parts automatically. The automatic screw machine was a prime factor in providing that means. The rise in our standard of living is, in fact, the result of the screw machine. In this and the articles that follow we will trace the history of the automatic from its first concept down to the present day.

Many Contributed

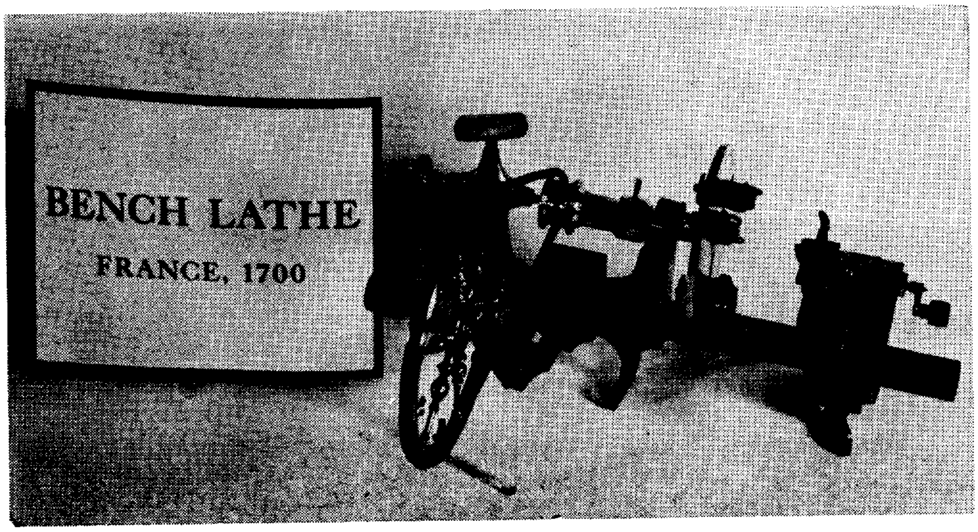
No one man can be pinpointed as the originator of the screw machine. In its ancestry are those who invented the wheel, those who discovered the art of smelting iron, those who laid the groundwork for the artisans of Europe, the medieval guildsmen. In no small way the Swiss watchmaker, and the feudal ironmaster, added their knowledge. In later years the Yankee mechanic was a prime factor. Along the route are strewn the whitened bones of bankrupt companies whose inventions failed or were superseded. For the fortunate few, the development of the screw machine became a real-life success tale of the Horatio Alger type.

The bar automatics we use today make such a variety of parts that the term "screw machine" is no longer descriptive. All but a few firms have dropped the term from their catalogs. Still, within the trade, the words "Automatic," and "Screw Machine" are used interchangeably.

"Screw Machine" has a historic connotation; it was the need for inexpensive, mass-produced threaded fasteners which brought the screw machine into being. The need evoked the machine. The machine, in turn, expanded its use far beyond the original intentions of its makers. Today's versatile, high capacity bar automatic can be adapted to almost any job. Ironically, screws are no longer a major product of the screw machine; other production methods have made inroads into this original source of work.

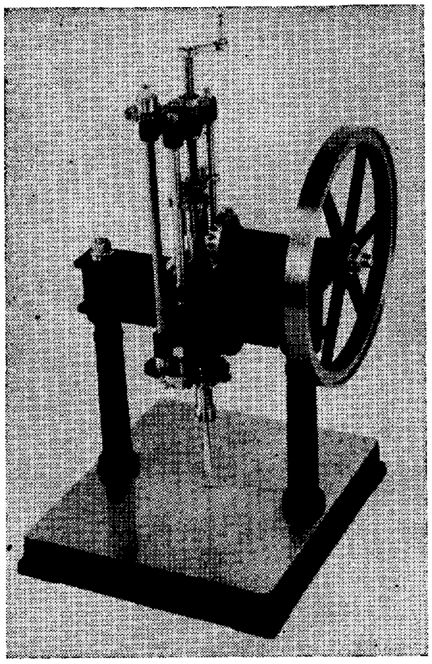
The Screw Thread

If we consider that a century ago the inch was rarely divided into more than 16 parts, and then only for very close work, the four decimal accuracy of today's machine tools stands out as a guidepost on our technological progress. We concern ourselves that a standard inch



Many will recognize this bench lathe, built in France in 1700, as the forerunner of today's engine and production lathes. (Photo courtesy DoAll Co.)

Donald E. Wood
Editor



Power-feed drill press was invented in 1840 by James Nasmyth of England. This was the first mechanically powered machine designed for drilling accurate holes. (Photo courtesy DoAll Co.)

block made in one part of the country may be unlike one made elsewhere by as much as a millionth. Our forefathers had a much more basic problem, and no means of communicating their measurements in precise terms.

Here again, the mass production of consumer goods, and its parallel problem, precise interchangeability of goods components, came only after machine tools had been devised which could make products alike in a rapid manner, and standardization of measurement had been established.

Along this ever-widening mechanical road, the standardization of the screw thread was an important milestone.

With the exception of relatively recent nuclear forces, all machine design rests upon six basic mechanisms: the wheel, wedge, inclined plane, pulley, lever, and the screw. One school still maintains that the screw is not a basic, that it is a combination of an inclined plane wrapped about a pulley. In either case, the screw was the last-born of the six.

There appears to be no sure reason why this should be. The helical design for the thread was as evident in nature as was the form of the pulley or wedge. Vines, hillside paths, and the serpent all were there for early man to see and copy. Still, not until the third century B. C. is there an historic record of the screw being used other than as an ornament. In that era, Archimedes, of our schoolday recollections, devised a "water snail" by wrapping a strip of material about a cylinder and using his assembly as a means of lifting river water for irrigation. His basic design is still to be seen in the augur-type industrial conveyor, and the ship's propeller.

Explorers find undeveloped peoples who still solder a wire about a shaft to produce a thread. This basic concept is also to be seen in some modern fastening devices, where helices are placed in a straight hole for special applications.

The Romans were a hard-headed lot. By the first century B. C., they were putting the thread to practical use for actuating wine presses, and in some forms of surgical instruments. Remnants of these have been preserved, and some types of helical forms were found in the ruins of Pompeii.

Rome loved luxury more than was wont, and its technological advance withered and died under a crippling tax structure and apathetic leadership. The Fall of the Roman Empire took with it the development of the screw thread. Threads were virtually unknown to the general public from this date until the middle 1400's, A.D., when Leonardo da Vinci, an engineer-designer far ahead of his day, drew plans for a screw cutting lathe.

Leonardo was content to invent; it is doubtful if his lathe ever reached prototype. Basically, it consisted of a square wooden bed over which a workpiece was guided past a stationary tool by means of pulleys and a master screw.

Throughout the Medieval Period of Europe, such threads as have been preserved were hand hacked from iron or wooden bars in what we could term the first truly "captive" shops, the primitive iron smitheries of feudal estates. Labor was cheap. The autocratic landowners had little need for interchangeability of parts, since the screws seldom were used outside of their own domain. In this age, the screw was a specialty item, used to hold together the armor of knights, the ornate jewelry of their ladies.

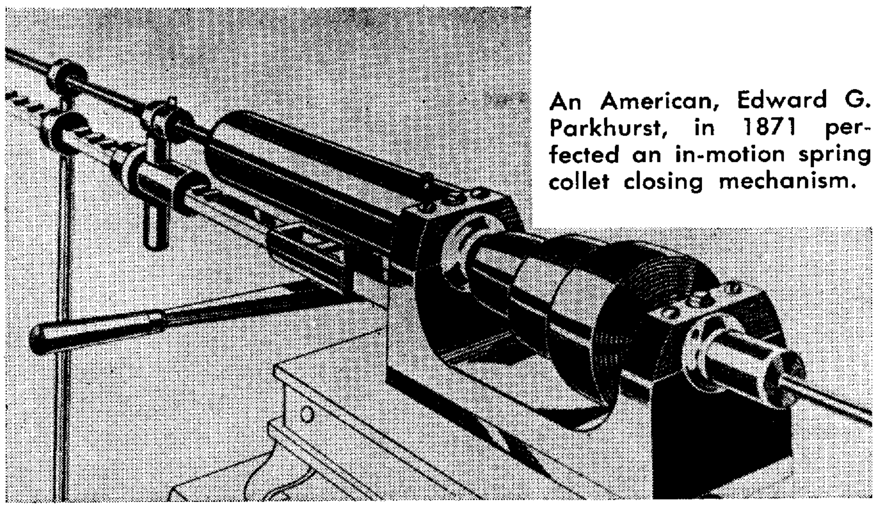
So long as labor was not a major

By 1850 the screw making lathe was in use, both in America and in Europe. Screw threads were cut with a hand chaser, a very tedious task performed only by highly skilled craftsmen.

cost factor, and muscle power was supreme, metal machining made few advances. The first signs of quickening industrial activity came with the advent of water power, animal treadmills, and later, the steam engine. This more potent source of energy brought with it the need for machine tools capable of withstanding work stresses in excess of human brawn, and eventually gave rise to the necessity of bolting together the machine parts.

A French mechanic, Besson, is credited with building the first working model of a screw cutting lathe. In contrast to da Vinci's concept, this machine was a wooden, foot-powered affair with a lead screw. It employed the principle of a movable tool, carried along the work. The year was 1569. Communications being what they were, it is doubtful if Besson even knew that more than 100 years before da Vinci had drawn plans for a machine to be used for the same purpose.

Besson was able to vary the pitch on his lathe, although it is doubtful if he could accurately check his results, or duplicate them on a volume production basis. Ropes and pulleys were used to move a guide screw *(controlling the cutting tool)* and the workpiece, simultaneously.



An American, Edward G. Parkhurst, in 1871 perfected an in-motion spring collet closing mechanism.

The Industrial Age

Two hundred and fifty years passed before the machine age was ready to be born *(about 1800)*. In the years to follow, men of vision would devote their lives to making progress in the working of metals . . . . . progress which, today, we would consider almost insignificant. Both in Europe and in the newly formed United States of America, some men would succeed in founding machine tool firms and manufacturing establishments. Some were to be perpetuated in the corporate names of industrial empires. Others, while working equally hard, were to be quickly forgotten.

Among those who received less honor than was their due, was Henry Maudslay. This English master mechanic spent 10 years making by hand a lead screw seven feet in length. Working with knives set in a comb-like holder, he scratched his thread form progressively deeper until he had achieved a helical thread accurate to within 1/16-inch on its total length. With this lead screw, Maudslay is credited with building the first all-metal screw cutting lathe in existence in the year 1800.

If a present day purchaser found that two screws of like size and pitch designation could not be easily interchanged in a female thread, he would be justifiably furious. We must recall that Maudslay and his contemporaries had neither a standard thread dimension, nor a means of checking one had it existed. It is little wonder, then, that when others copied his lathe they designed lead screws with different pitch.

It would, indeed, have been a marvel if, at this stage in our mechanical development, two lead screws of identical size, shape, and pitch could have been built.

And so, for many years, every screw cutting shop had its own thread designation dictated by the lead screws of its lathes, none of which was interchangeable with the others. The result was a hodgepodge of thread forms which plagued England until 1841, when a student of Maudslay's, Sir Joseph Whitworth, promoted and sponsored a compromise thread from which was finally accepted as the English standard, and given his name. It may be noteworthy here that not all screw producers considered a standard thread system to be a blessing. Until the Whitworth thread came along, each shop had enjoyed a captive market for replacement items of any threaded parts originated in their own shop.

Maudslay's all-metal lathe was an exception. Up to and through our own Civil War period, it was commonplace to use some wooden components on metalworking machine tools. If we consider that our colonial forefathers nicked the edges of swords and knives and used these tools as hacksaw blades, the Maudslay contribution to our industry stands out the more.

In this era, the intentionally-tapered thread had not been mastered. Screws were blunt-ended items intended to be driven or forced into wood or iron, cutting their own mating grooves as they progressed. The tap was still to come. Its use would have been limited by the various thread designs even if it had been available. Once a screw had been fitted, it was tied to its mating part; its loss could render the entire mechanism useless.

Thread production was a tedious task. Some followed Maudslay's example, but others were content to produce threads by hand, chasing

them in what today we would consider wood turning lathes, by holding a comb-like tool on a steady rest and moving it along the work repeatedly. This method successfully competed with machine-cut threading for a number of years.

One of the first screw products shops of record was at Tatenhill England, where bolts were scratched into shape, then hand finished to some degree of similarity. Here we have a record of the slotting of bolt heads, a major advancement of the industry, and an indication that henceforth screw drivers would be an item in the machinist's chest.

Heat Treatment

Hardening of metals to this stage had been confined to the sword and armor-making field. It is probable that cutting tools were scarcely harder than the material being cut. Still, by 1800, crude screw making factories were being established here and abroad. The lathe, once conceived, was being constantly refined. Bronze was being used for bearings, replacing the iron-on-iron contact in the spindle, and allowing faster rotation. The metalworking shops were a brand-new market for the farmer; a chunk of pork rind, held in contact with the spindle, was found to be an acceptable lubricant, and lard oil could improve tool life when used as a coolant. The rancid odor of lard became the olfactory trademark of the machinist.

The custom had been to make a male thread, and then from an assortment of female components to sort out parts which would go together . . . . . selective assembly in its most basic form. This situation continued until visionary men saw the potential of complete standardization.

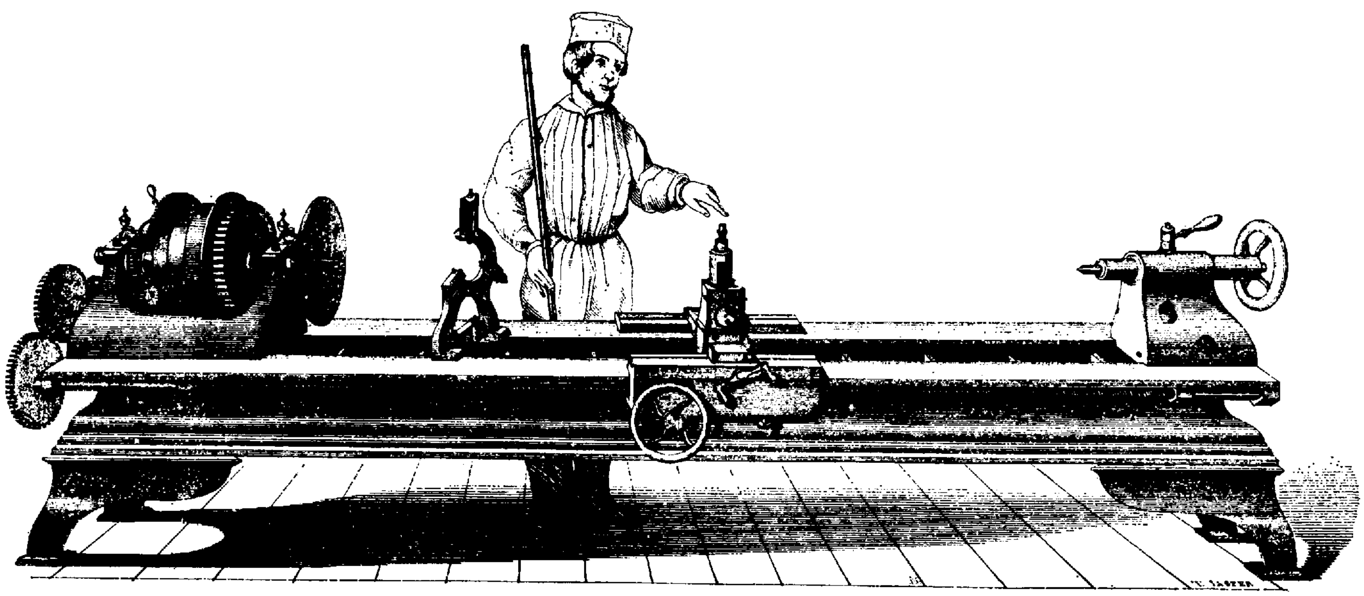
In every stage of our world's progress, wars have speeded the development of machines. As we credit the First World War with bringing the airplane its adulthood, and the Second World War with fostering the Missile Age, the War between the States brought America the need for the automatic screw machine. Among those who made this machine tool evolution possible was Edward G. Parkhurst whose August 29, 1871, patent for a simplified work loading idea, now refined into our in-motion collet closing mechanism, allowed bar stock to be end-fed through the spindle without shutting down the lathe. Without this basic device, our present day automatics would have only chucking machine capacity.——Ω

When this advertisement appeared in 1840, Francis A. Pratt (of Pratt & Whitney) was superintendent of Phoenix Iron Works, now Taylor & Fenn. (Illustration courtesy Pratt & Whitney, Inc.)

PHOENIX IRON WORKS

Geo. S. Lincoln & Co.

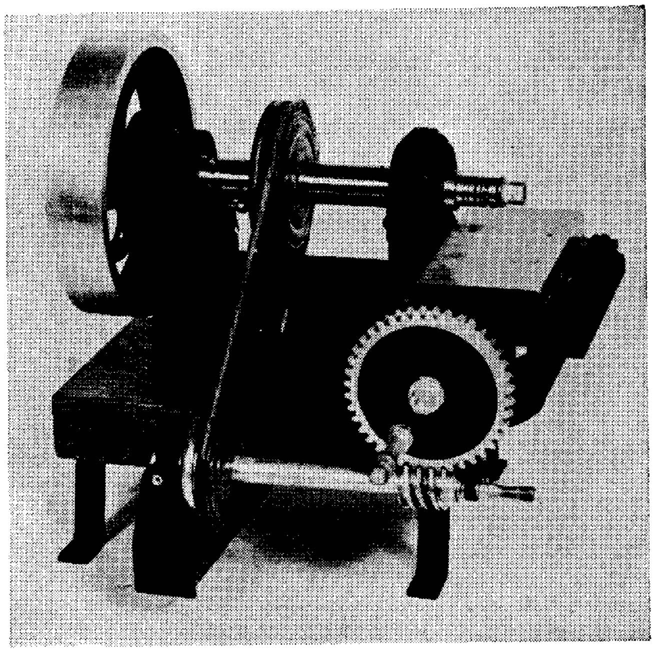
HARTFORD, CONNECTICUT.



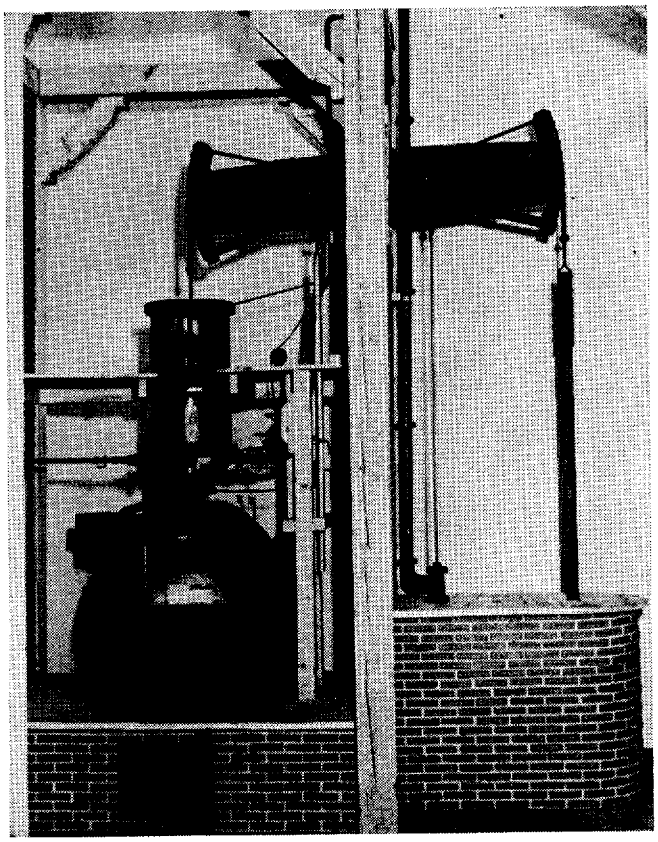
Screw Cutting Engine with Patent Rest.

With improved Cast Iron Bed, Cast Steel Spindle, feed motion carried by a screw, with a toothed rack for moving tool rest by hand, gib'd rest, with stationary and travelling back rest, back geared and change gears for cutting screws. Overhead pullies, &c. complete.

PART 2: the history of the screw machine



MILLING machine invented in 1818 by Eli Whitney proved his concept of interchangeable parts, a basic requirement for mass production. (Photo courtesy The DoAll Company.)



ABOUT 100 of these Newcomen "atmospheric" engines were built from 1712 on, until James Watt's more practical steam engine made them obsolete in 1769. (Photo courtesy The DoAll Company.)

from ARCHIMEDES to AUTOMATION

PART 1 in our history of the automatic screw machine traced the evolution of the screw thread from its first recorded date, three generations B.C., to its spurt of popularity which began in Europe and the United States of America at about 1800.

We must remember that such pioneers as Besson, Maudslay, and Whitworth gave us the concepts upon which the mass production of threaded parts, taps, and die heads depends, and more pertinently, brought into use the bar-fed lathe. Indeed, the principle of camming, upon which most screw machines are based, is but another branch of the helical thread form family.

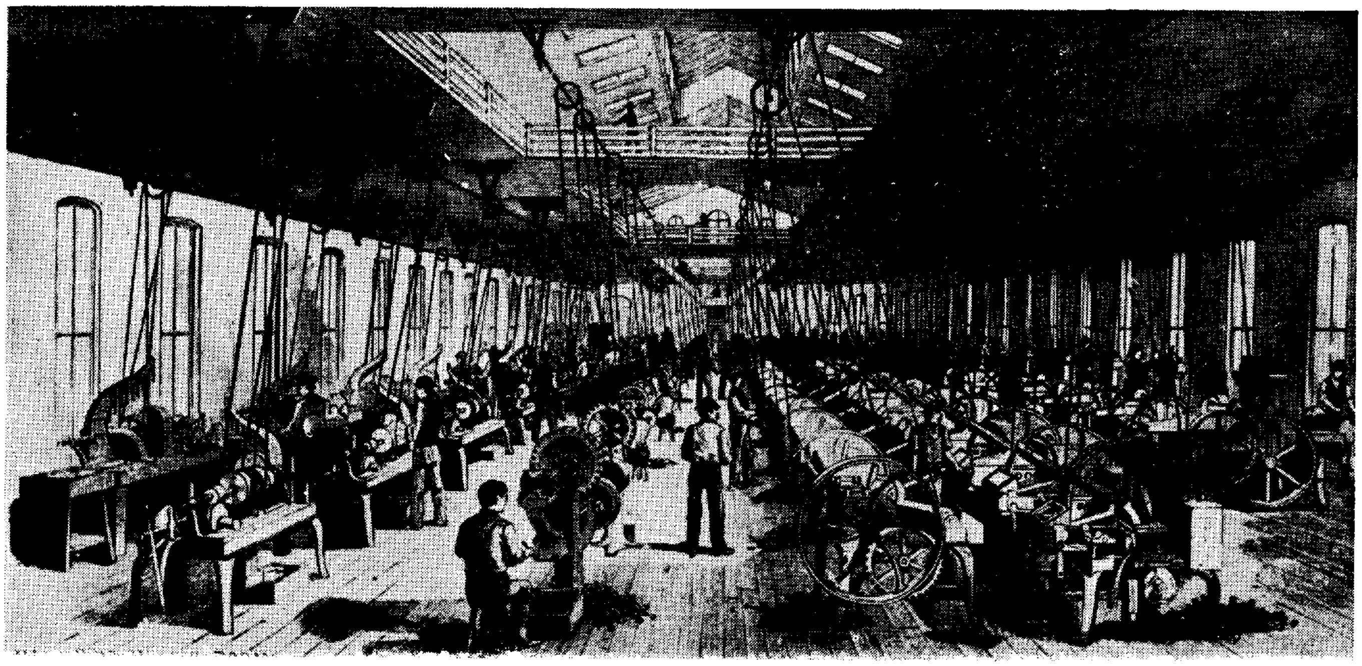
Our national standard of living did not leave the square wheel stage until inexpensive fastening methods had been made available generally. As evidence of this, consider what would happen to the items we use and enjoy each day if, by some magical means, every threaded component were removed. Such a condition was predominant until threads could be made by mass production means.

As the Westward movement came to America, the need for guns, traps, and trappings of the settling migrants created a vast market for interchangeable screws, bolts, and threaded parts. In such an era, it was only logical that Yankee ingenuity should see the need and make rapid strides to fill it.

In 1818, Micah Rugg established what is believed to be one of the first screw products shops in the New World. His bull-powered, crudely roofed factory at Marion, Connecticut, contained a few simple lathes, little better than those which Besson had built more than 250 years before. Rugg forged bolt heads by hand, and chased a simple thread on his standard item, a 5/16 by three-inch carriage bolt.

His product, at 16 cents each *(about 70 cents at today's monetary values)*, was the cheapest and best available to the settlers. Rugg made an attempt at hand fashioning his bolts to a degree of similarity. In short order, he had competition from other firms who saw the golden opportunity his product presented.

Competition, then as now, brought about improved methods and lower costs. Rugg's seven bolt



IN 1881, this was a "modern" bolt making department. Although these machines appear crude today, they were a far cry from those used by Micah Rugg in 1818, which were powered by a bull on a treadmill.

per hour production capacity was increased, and he, and the others who joined in this bolt making endeavor, were soon selling the same product for three cents, colonial value. This is an indication that, this early in our mechanical development, a firm spirit of keen cost consciousness was forcing the machining trade to improve methods, or be surpassed.

By 1850, semi-automatic lathes were cutting threads, and soon after the Parkhurst method, mentioned in Part 1, was allowing machinists to work from a bar of metal placed through the spindle. The laborious chore of hand chucking *(often with set screws)* had been relegated to the woodshed. Parkhurst also had a hand in developing the multiple-tool tailstock which, with the inclusion of a rotating device in which several tools could be placed, ultimately became our turret lathe, or "hand screw machine."

Our founding fathers had little more concern about standardization of thread forms than had existed in England prior to Whitworth's valiant efforts to regulate the many thread pitches there. As a consequence, the United States fell prey to as wild an assortment of thread styles as could be imagined by a creative machinist today. Threaded devices were coming into popular use, but the person who purchased a product in one area had little assurance that it could be repaired, threadwise, in another locality. With the Westward migration, this brought about situations as serious as the tale of the battle lost for want of a horseshoe nail.

Further complicating the situation, the railroads were beginning to come into use, and by 1860, with a hint of civil strife in the air, a committee named by the Franklin Institute finally settled on a standard thread form proposed by William Sellers, of Philadelphia.

This solved a great many of the problems, but still did not reconcile the Sellers' thread with the English Whitworth. The day was still distant when England and America, speaking the same language, could agree on an international thread design.

Birth of Machine Tools

For some almost illogical reason the bleak and beautiful, rough and remote area within a two-day horseback ride of Windsor, Vermont, became the birthplace of many of our machine tools. This area had basic assets; the Connecticut River, and its tributaries, gave water power at cheap rates. Coal and iron ore, although relatively low in quality and quantity, were nearby. River transportation of a sort was possible. None of these should have set this area apart as an ideal site for the large number of machine tool building firms which it incubated.

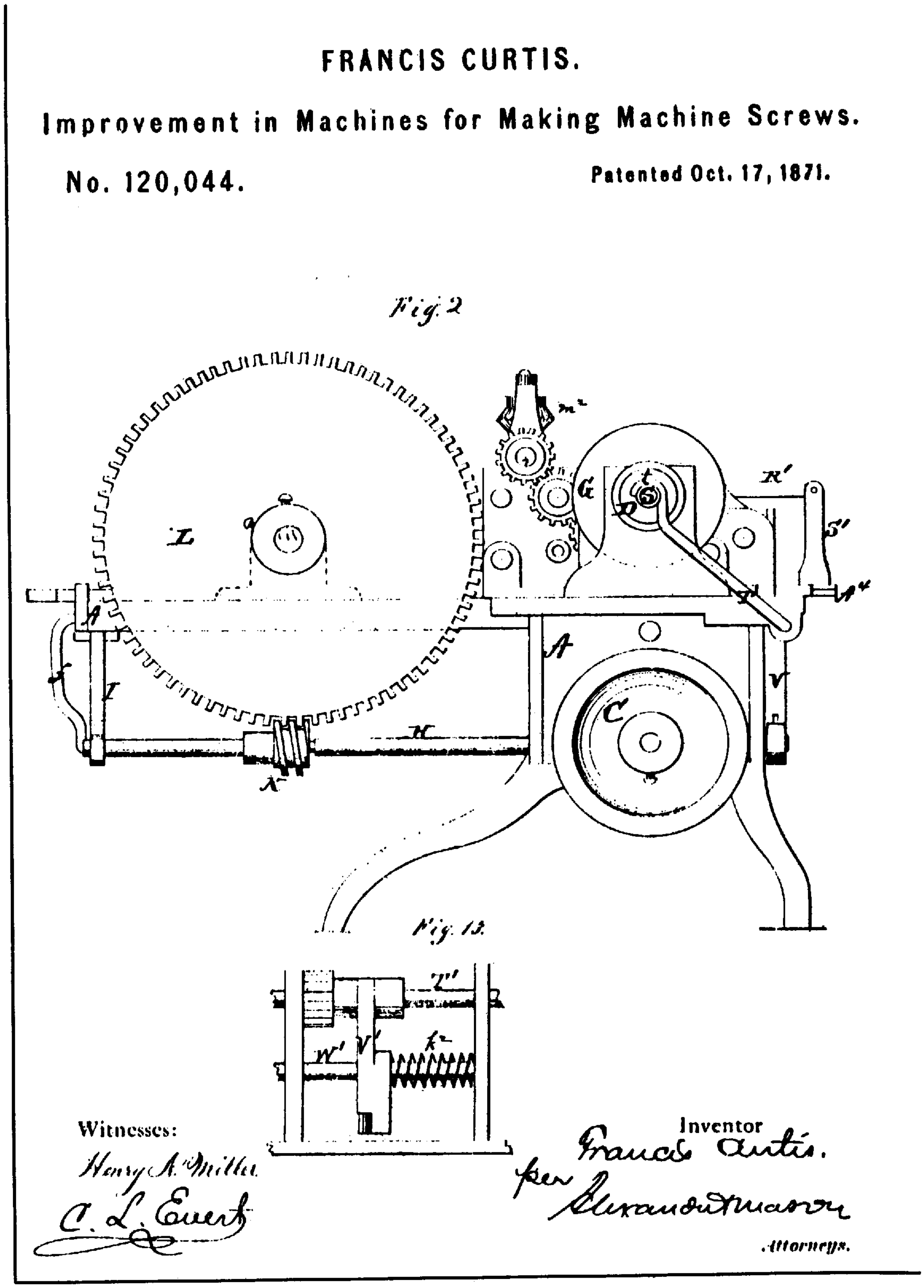
Another more important element was at work; the rugged individuals who chose to live in the long shadow of Vermont's Mount Ascutney had a collective creativeness equalled only in the mountains of Switzerland. Coupled with this were the high standards of ability which even yet are the trademark of the Yankee mechanic.

Into this environment, in only a few short years, were born such men as Francis A. Pratt *(Pratt & Whitney)*; Richard Lawrence *(Robbins & Lawrence, forerunner of Jones & Lamson and a phenomenal name in machine tool building in its day)*; James Hartness *(sparkplug of Jones & Lamson Machine Co.'s development)* and a host of others.

Finally, it was in this area that we find two men, Charles Billings and Christopher Miner Spencer, working in borrowed rooms to build the first truly automatic screw machine.

We must understand the way of life which existed in this New Eng-

ALTHOUGH Christopher Miner Spencer is generally credited with designing and building the first automatic screw machine in 1873, other less heralded—but no less talented—men also contributed immeasurably in its development. Two years before Spencer built his first automatic, Francis Curtis of Brattleborough, Vermont, another "Yankee mechanic," obtained this patent for a design improvement in a "machine for making machine screws." In his patent application, Curtis describes his invention as a "screw machine" and refers to its operation as "automatic." The top illustration in the patent reproduced here is a side view of the Curtis machine. The lower sketch is a view of the "mechanism for opening the header." Francis Curtis, incidentally, is a forebear of one of the founders of Curtis Screw Company, Buffalo, N.Y.



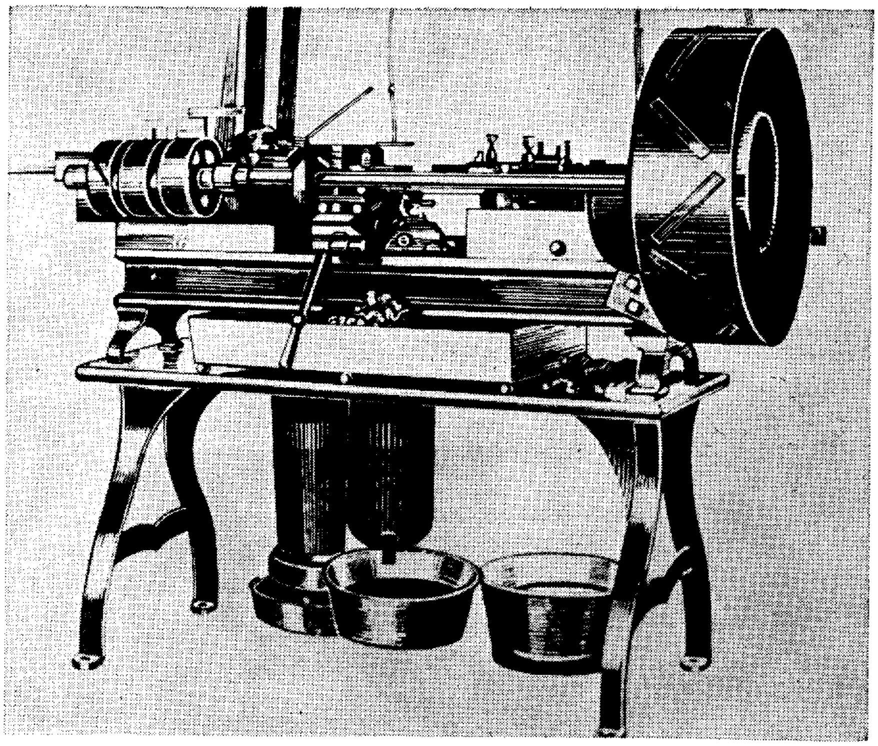
land community. Workers learned their trade by strict apprenticeship, often at pauper's wages. This was followed by a stint as journeymen, frequently in a different plant. Finally, the worker acquired the master machine rating and was on his own.

The accepted manner of gaining experience was to move from shop to shop. The worker who could produce precise work in several shops deserved the respect with which he was treated. Frequently, the more enterprising of these men worked their way up the ladder to management posts in some plant, or with the blessing of their employers set out to establish their own firms.

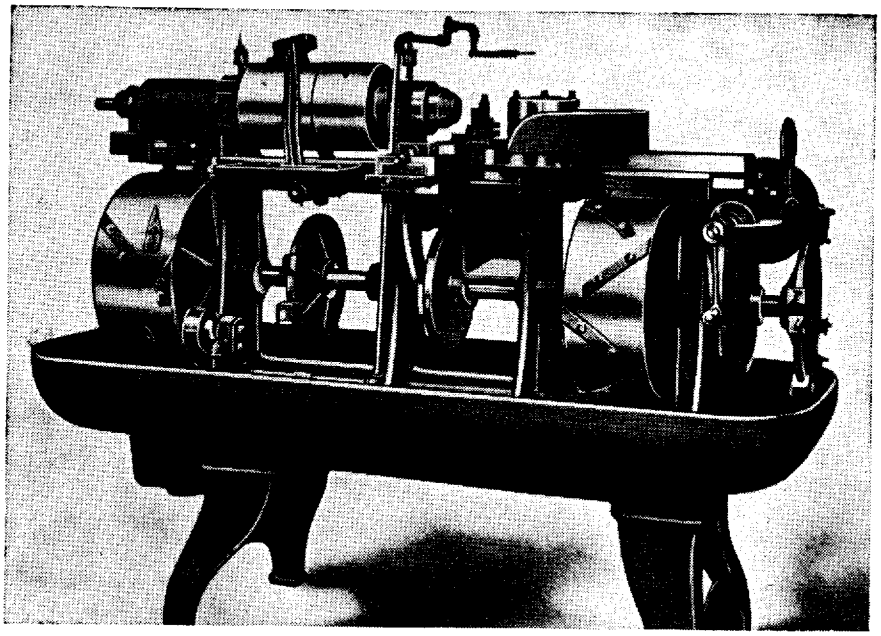
This interchange of men and ideas among machine tool firms still in creative infancy probably accounts for the title "Yankee Mechanic," and the esteem which this area still rates in the machine tool world.

As nearly as can be learned, the first fully automatic screw machine was built secretly by Christopher Spencer. Labeled the *Hartford Automatic Screw Machine,* it stands as the prototype for all single-spindle machines in use today.

Spencer was born in Man-



SPENCER's first single-spindle automatic screw machine (left) was built and patented in 1873. A somewhat later model of the Hartford automatic (below) was probably built by Pratt & Whitney, since this firm built the Hartford under license by the inventor. Hartford Machine Screw Co. did not enter the machine tool building industry, but was content to use the machines for screw products work. The Hartford firm was formed in 1876 by Spencer, the inventor of the machine, and George Fairfield, then president of Weed Sewing Machine Co.



chester, Connecticut, in 1833. At age 13 he showed his precocity for mechanics by cutting down his grandfather's musket into a carbine, using a foot-powered lathe for his work. Two years later, he built a working model steam engine, gleaning his entire knowledge of its mechanisms from Comstock's Philosophy, the machinists' handbook of that day. By 1849, at age 16, he had completed his apprenticeship and was accredited a journeyman mechanic. After the traditional stints in several shops he came to Hartford, Connecticut, to work in the gun making shop of Samuel Colt. Here he met Charles Billings, later to be his partner in machine tool building.

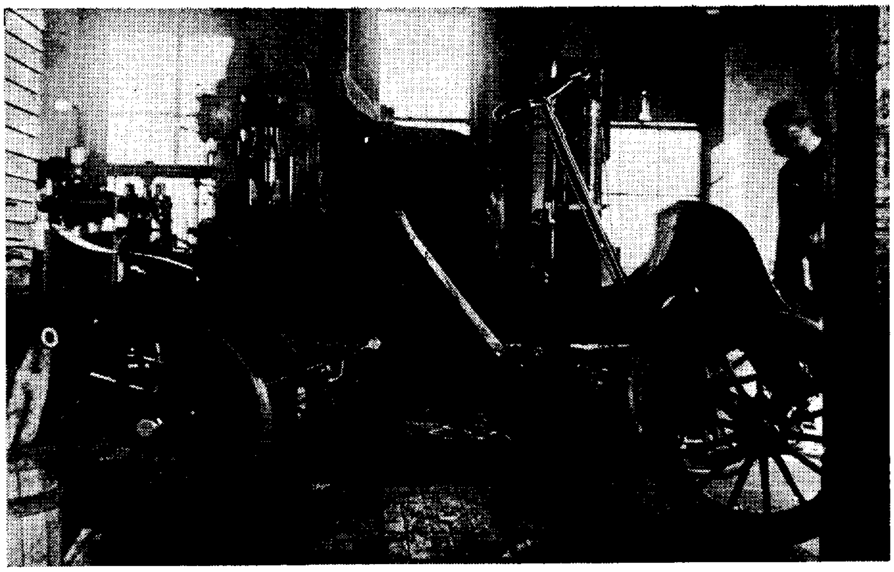
Billings had earned his mechanic's papers in the flourishing Robbins & Lawrence shops at Windsor, Vermont. Both Spencer and Billings then became acquainted with George A. Fairfield, another Colt employee.

Spencer was an improver at heart. Throughout his life he was constitutionally unable to see any piece of machinery without visualizing improvements for it. During his many moves, Christopher Miner Spencer invented a thread spooling machine which so impressed the Coats Thread Co. of Belfast that they moved their plant to the United States. In 1862, a year before the birth of Henry Ford, Spencer built a horseless, steam powered wagon *(the first in Connecticut)* which he drove around the streets of Hartford. The ratchet and pawl system he used to allow his wagon to turn corners was a forerunner of today's automotive differential.

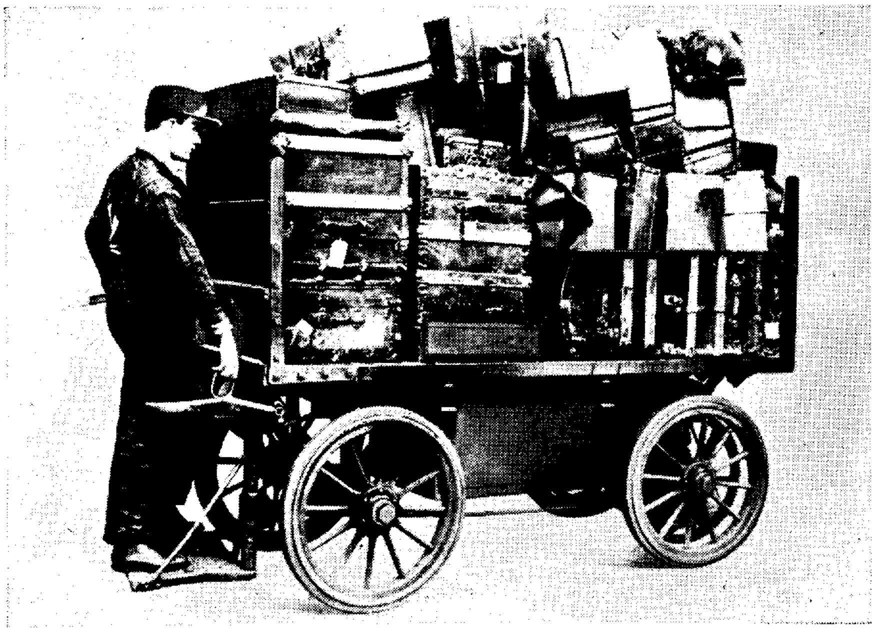
Firearms were a fascination for Spencer, probably due to the fact that many firms in his area were engaged in their manufacture. He is better known for the Spencer repeating rifle which he invented than for his Hartford screw machine. Spencer seven-shooters, 200,000 of them in the hands of men under Generals Custer, Sheridan and Sherman, so demoralized the gray-coated Confederate army, it is reported, that these guns have been termed a major factor in the victory of the North.

Typical of Yankee ingenuity and thrift, Spencer built the steam

THE AUTOMOTIVE industry, with its ever increasing demand for more and more interchangeable parts, played no small role in fostering the growth of the screw machine and screw products industries. The snappy sports job at right is the 1902 Model A Roadster, the first Cadillac ever built, and the "granddaddy" of today's luxury cars.



ONLY FOUR YEARS after the first Cadillac was built, the industrial truck industry produced its first powered industrial truck. The carrier shown below is on permanent display at Ford Museum, Detroit.



plant for his horseless carriage from rejected rifle barrels while home on leave from the front lines, where he acted as factory representative in training Union troops in the use of his rifle.

The automatic screw machine, which this ingenious pioneer built in 1873, was a direct result of his earlier work in the thread spooling field for Coats. At this date, the gasoline engine was only one year old. A Pratt & Whitney manually-operated turret lathe was obtained, and to it Spencer attached a cam shaft, strip cams, levers and segment gears for actuating the turret, collet, and cross slides. The machine was devised in rented rooms above the Cushman Chuck Co. plant from the basic lathe and parts procured in the scrap piles of nearby manufacturing plants.

Typically an inventor, Spencer did not grasp the potential of his automatic screw machine and, instead of entering into the manufacture of it, was content to place it in production of screws. To this end, George Fairfield, president of Weed Sewing Machine Co. in 1876, was brought in to help form the Hartford Machine Screw Co., now a division of Standard Screw.

This company is a healthy manufacturing concern in New England today, and can claim the title of being the oldest continuing screw products shop in the nation.

Spencer's patent coverage of the Hartford was spotty, and major factors being unpatented, other firms quickly made design changes and began to make automatics for sale to screw producers. The Hartford was finally placed on the market, built by Pratt & Whitney under license by the inventor.

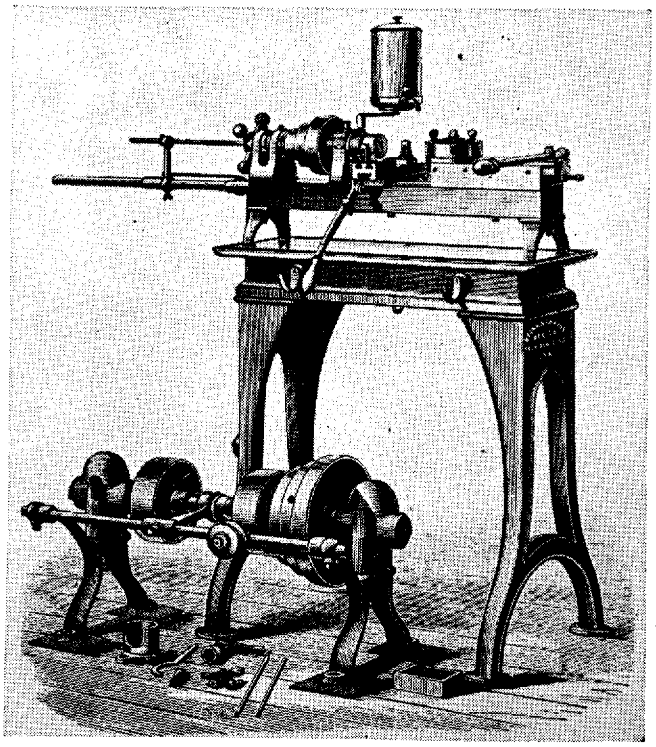
The Hartford would not be at all confusing to a modern-day setup man. Basically the camming, colleting and gearing were much like those we know. A simple shaft ran beneath the lathe bed. Strap cams bolted to cast cam drums actuated all mechanisms except the tool slide which was moved to and from the work point by a worm gear arrangement actuated from the camshaft.

Here, in oversimplification, were all of the elements of a fully automatic single-spindle screw machine.

In 1951, the Hartford Machine Screw Co. celebrated its 75th anniversary. Its extensive facilities along the Connecticut River at Hartford have grown through the years.

Spencer's inventions were many. At age 87, still as curious as ever, he took up aviation and made flights until his death in 1925.

The general public thinks of Christopher Miner Spencer as the inventor of a better rifle. To the machine tool world, his primary step towards automation has given his name added meaning. The thousands of automatically actuated spindles in use today are a fitting monument to this self-taught, inventive Connecticut Yankee. ——————— Ω



ORIGINAL Brown & Sharpe wire feed screw machine, the No. 4, was patented November 28, 1865. Stepped pulley jack shaft for spindle speed changes, and idler pulley for shutting off machine (foreground) were furnished.

from ARCHIMEDES t

PART 3: the history of the

THE TIME for industrial growth was at hand. The War Between the States had ended; the Union was preserved. Colonel Albert Pope of Boston was extremely nettled that bicycles, used extensively in the U.S. since 1800, were still being made abroad. No American firm had attempted to make them.

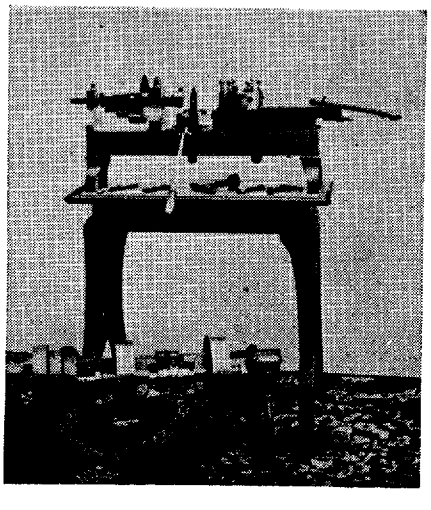
Within a few short years his irritation would lead to the domestic manufacture of them by the Weed Sewing Machine Co., Hartford, Conn., and by the turn of the century, more than 300 bicycle making firms would be in business. The two-wheeler, like the auto of our time, would allow more extensive travel, would widen the interests of the public, and lead to still more manufacturing.

In Part 2 of this series, it was pointed out that the New England area was the birthplace and proving ground for many of our oldest machine tool building firms. The Robbins & Lawrence plant at Windsor, Vermont, had been in the limelight as a gun making concern, and later in the manufacture of special machines, and now two other concerns were making their bid for public acceptance.

These firms, Pratt & Whitney Co., Hartford, Conn., and Brown & Sharpe Mfg. Co., Providence, R.I., were to become big names in the years just ahead. Both built their fame on close tolerance work; Brown & Sharpe is still synonymous with "precision" while Pratt & Whitney uses the word "accuracy" in describing its products.

Let us first trace the history of Pratt & Whitney. This firm, in the 1860-80 era here detailed, was the training ground for men who were to found machine tool building firms in their own right.

VERY EARLY Brown & Sharpe hand screw machine, exact date unknown, was elementary in design.



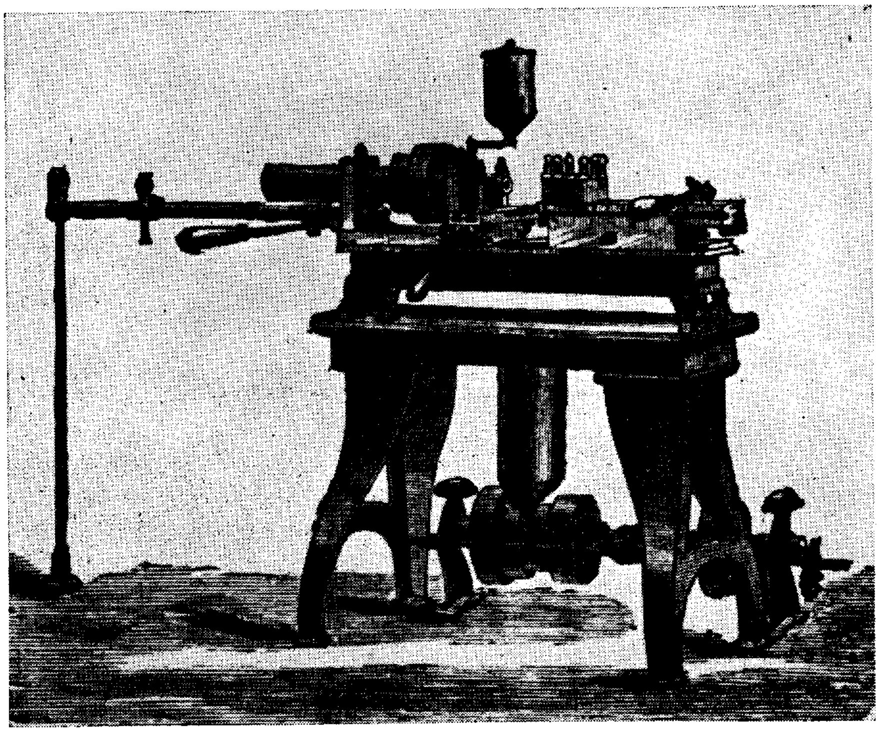
In a few short years, Pratt & Whitney apprenticeship training rosters carried such names as Worcester R. Warner, Ambrose Swasey, A. F. Foote, William Gleason, E. P. Bullard, E. C. Henn, R. Hakewessel, G. C. Bardons, J. N. LaPointe, F. N. Gardner, John Johnston, and many more whose signatures have been cast in the nameplates of American machine tools.

Francis A. Pratt, the Pratt in Pratt & Whitney, was born in 1827, attended grammar school, and apprenticed to a master mechanic. At age 25 he came to Hartford and began work in the Colt Armory. Colt's "pistol factory" in those days was considered to be the postgraduate course for young mechanics. Two years later he accepted an offer to become superintendent of the Phoenix Iron Works in Hartford, a company established in 1834, and now known as Taylor & Fenn Co.

In 1832, a son was born to Aaron and Rebecca Whitney in Biddeford, Maine. They named him Amos. The Whitney family had long been mechanically minded; Eli Whitney of cotton gin fame was an example. Aaron

AUTOMATION

screw machine



PRATT & WHITNEY's No. 1 screw machine, with Parkhurst Patent wire feed was one of the first capable of feeding stock without stopping spindle. Countershaft speed was 310 r.p.m.

Whitney was an expert locksmith and machinist.

The son, Amos Whitney, was apprenticed in the Essex Machine Co. of Lawrence, Mass., and in time he, too, came to the Colt factory in Hartford for this final training. In 1860, Pratt and Whitney confided their dreams to each other, discovered they both wanted the same things, and rented a small room on Hartford's Potter Street for part-time work. Both remained full-time employees at the Phoenix firm until their new venture was on its feet.

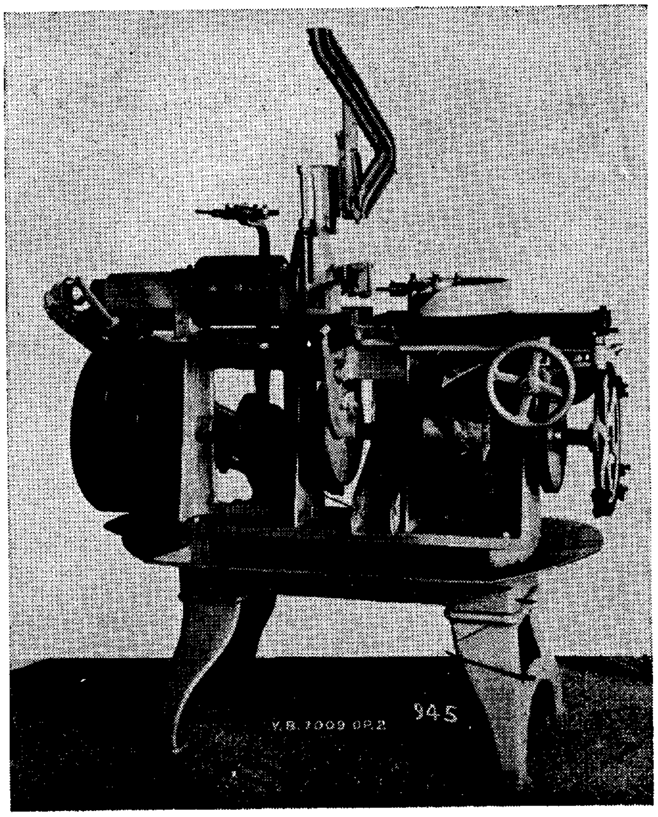
In 1865, the firm built new quarters on the present site of Pratt & Whitney property, and rented two of the three floors to the Weed Sewing Machine Co.

For many years, P&W built machine tools of almost every description. Foreign armament orders added to the firm's growth, and while the concept of complete interchangeability of parts has been credited to Eli Whitney and Samuel Colt, Pratt & Whitney Co. must be considered a real pioneer in this field.

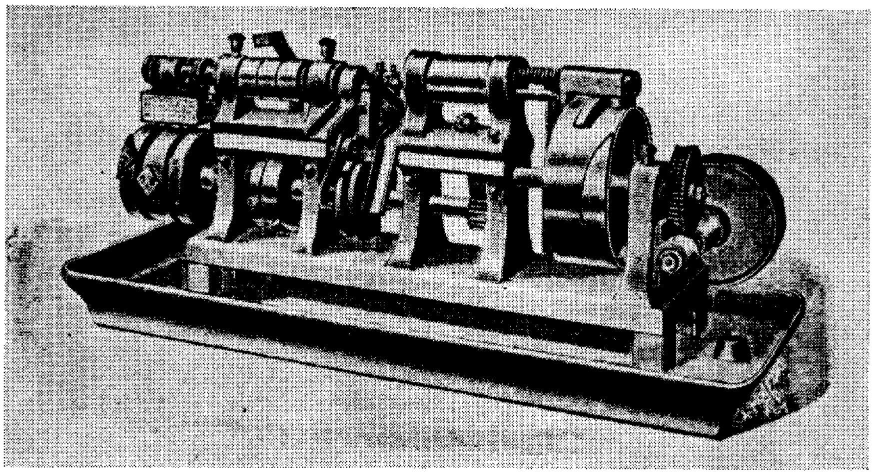
They ploughed back large portions of the company earnings into the establishment of permanent gage blocks, recognizing that parts could not be interchanged until extremely accurate means of measuring had been found. It is claimed in the archives of this firm that Pratt & Whitney established the first inch-standard in the U.S., a standard accurate to millionths.

Funds from this firm built the first comparator for measuring within a limit of one fifty-thousandth of an inch. Trips were made abroad to accurately measure and copy the British Standard Yard, the French Meter d'Archives. The American Standard, known as Bronze No. 11, was copied with the help of the U. S. Government. So, as every machinist knows, this firm established its reputation for accurate gages.

Among the machines built were



SPENCER Patent fully automatic screw machine, built by Pratt & Whitney under license by Christopher Miner Spencer, is shown equipped for second operation work. Parts chute, center, is made of wood. Wide spindle pulley included idler pulley and belt shifter device above it. Cam shafts were driven by second pulley at rear of machine behind hand wheel, extreme right.



AUTOMATIC watch screw machine, from 1888 Pratt & Whitney catalog, was intended for making "small screws and turned work of similar size." Spindle and bearings were of hardened, ground steel and protected from dust. Innovations included rapid traverse to point of work, and revolving tooling positions in the vertical turret.

turret lathes, and it is one of these, mentioned in Part 2 of this series, which Christopher Spencer modified into his Hartford automatic in 1873. The machine was later built by P&W, and is known in company records as the "Spencer Patent" screw machine. This item was a natural for the firm; the Parkhurst collet closing patent was in their name *(Parkhurst was a P&W engineer)*, and for a number of years, while this patent held, the firm had a corner on automated bar feeding.

It is notable that, when the Spencer automatic was introduced by Pratt & Whitney, the chief draftsmen at their plant was a former apprentice, John Johnston, later to become part of the Potter & Johnston Co.

Just how James C. Potter and John Johnston met is not known. Both had come to America from Scotland at an early age. Potter was a graduate of Mechanics Institute, Glasgow. Johnston trained at P&W. The pair founded Potter & Johnston on the second floor of a Pawtucket, Rhode Island, building in 1898.

The same year they began making the Automatic Chucking and Turning machine known as the "5½×10" automatic, forerunner of the Potter & Johnston line of chucking machines. In connection with this first automatic, P&J developed the Lever Chuck, patented to the firm in 1900. Elementary though this mechanism seems today, it was a "first" for the industry, allowing work to be chucked and unchucked without stopping the spindle, and without use of a collet.

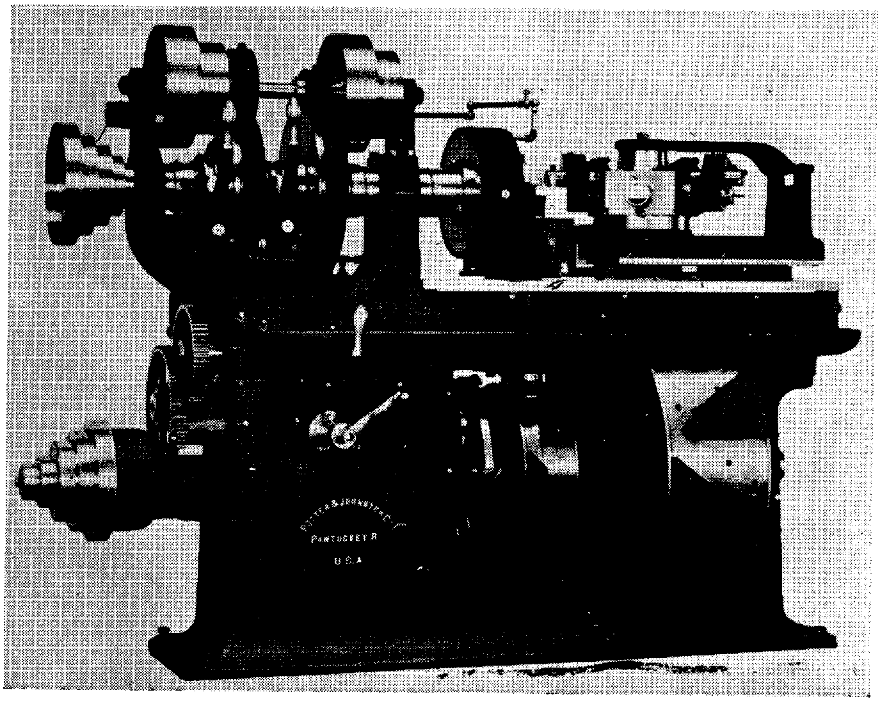
The firm prospered. By late 1899, they shipped their 100th machine, a lathe. The purchaser was Pratt & Whitney. Forty-nine years later Potter & Johnston Co. became a subsidiary of Pratt & Whitney, and is now a part of the parent firm.

While Pratt & Whitney carried forward their theme of "accuracy," another firm had been formed in Providence.

In 1833, a simple newspaper announcement there stated that David Brown, and his son, Joseph, had opened a tiny shop to "make and repair clocks and watches and to do other mechanical work of precision." Unwittingly, but with full intent to carry out their plan, this father and son team used in the little statement the word which has become the by-word of Brown & Sharpe Manufacturing Co.—precision.

David Brown, the father, was a

POTTER & JOHNSTON automatic turret lathe of 1901 vintage shows improvements in speed and feed variability sought this early in the development and the means used to achieve it.



Yankee pedlar (sic), running a store part time, and often taking to the road with his clocks, silverware and watches. He had settled in Pawtucket, where his son, Joseph R., learned machining in the shops of Walcott & Harris. In 1831, Joseph opened his own shop to make small lathes and machinists' tools.

Mutual interests soon put father and son in the same business, and together they opened the shop, mentioned before, in Providence. The shop was modest; it did not boast a forge or power of any sort. Both father and son were highly regarded for their mechanical ability. Clock towers throughout New England carry time pieces built in this company's early years. In the lobby of the Providence plant a grandfather's clock built by the original Brown ticks away the hours for every visitor to see.

Greater Precision

In 1833, the building of cotton industry machinery was predominant in the area, but the Browns chose to make items of greater precision. The firm had the usual "tough sledding" of most concerns; a fire gutted the shop in 1837.

Temporary quarters were obtained while the shop was rebuilt. Two years later, additional space was acquired. In spite of thriving business, David Brown decided to heed the lure of the West, and moved to Illinois. Joseph R. Brown remained as sole manager of the company.

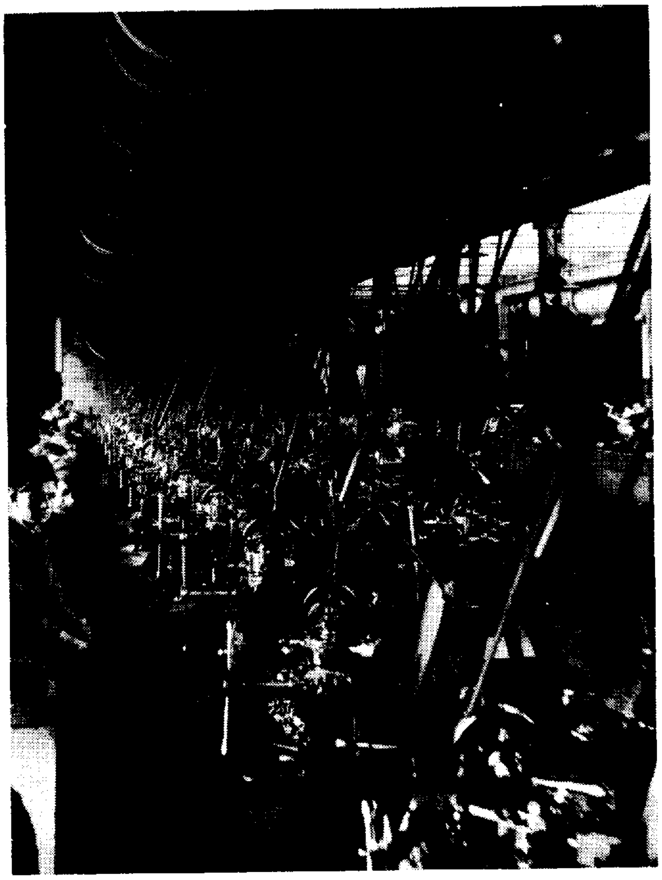
On September 12, 1848, the daybook of the firm carries this brief note: "Lucian Sharpe came to work for me this day as apprentice." It was an apprenticeship of the usual style; Sharpe's father received $50 yearly for his son's services, and Lucian was paid nothing except an allowance of $2.50 weekly for board when he was not staying in Brown's home.

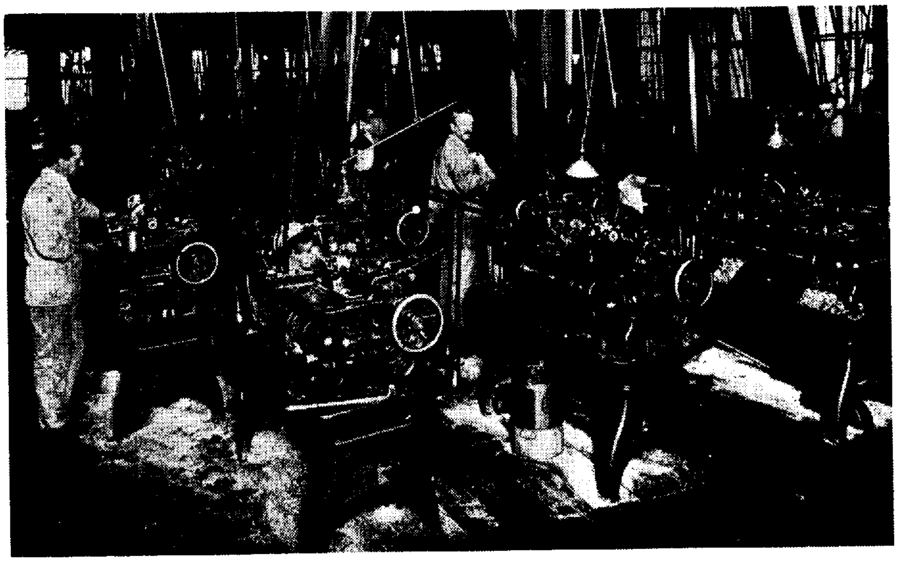
Lucian Sharpe, from the very first, showed the qualities which cause one employee to stand apart from the group. He was the first at the little shop in the morning, sweeping, arranging stock, opening the safe, sharpening pens. By reading he became a self-educated man, wrote much of the firm's correspondence, and translated at least two French technical books into English for shop use.

As part of the apprentice agreement, Lucian Sharpe was privileged to make for himself a set of machinists' tools of the type then used by watchmakers. A watchmaker's lathe he made during this period is still a treasured memento owned by Brown & Sharpe.

Sharpe advanced rapidly. In 1853, before his term of indenture was complete, he was made a full partner, and the firm assumed the name J. R. Brown & Sharpe.

OVERHEAD BELTS, gaslit work rooms, suspendered young operators (right) were typical of the daylight-to-dark 1910 era when this battery of Brown & Sharpe hand screw machines was photographed. Scant years later (below) fully automatic screw machines were a common shop sight, electricity had replaced the gas lamps, but overhead belts and handlebar mustaches prevailed.





The partnership proved beneficial to both; Brown was a shop man, interested in the mechanical improvement of his products. Like many such individuals, Brown thoroughly resented the paper work and business details which stole his shop time.

Sharpe was a master mechanic by now, but his first love was the business and management end of the venture. The two complemented each other and, in spite of their diversity of interests, enjoyed a mutually warm affection for each other. The business prospered.

Capital Short

In 1848, when Sharpe's name first appeared in the company title, the plant occupied a 60×30-foot room, employed 14 workmen. Capital was short; at one time a $600 shipment of tools and material from England almost broke the financial back of the little shop.

Brown set out to upgrade the standards of machine shop operations, in his own plant and in those of his customers. In 1850 he ventured into a new line, building an Automatic Linear Dividing Engine so precise that, today, after more than a century of service, it has not been superseded in design for accuracy.

The Vernier Caliper

With this background in precision, the firm began to make and market high grade steel, ivory and boxwood rules with special and standard graduations. Another item listed in early catalogs of J. R. Brown & Sharpe was the Pocket Vernier Caliper, of which it has been said "it is the first practical for exact measurement which could be sold in any country at a price within the reach of the ordinary machinist."

Quickly a line of micrometers, gages and gage blocks was added. For a number of years the firm concentrated on general machining, along with a line of textile machinery. In 1858, the firm began to concentrate on volume production of metalworking machine tools. This line soon overshadowed the manufacture of miscellaneous machinery and sewing machines which had been the mainstay until then.

During the period in which this Providence firm was gaining strength, Frederick W. Howe had become superintendent of the Providence Tool Co. Howe had prior experience with turret lathes and "turret screw machines" *(the terms were interchanged in early years, and even today a turret lathe is sometimes referred to as a hand screw machine)* at the Robbins & Lawrence plant in Windsor, Vermont.

Howe and Brown quickly became acquainted in Providence, and Brown had the Providence Tool Co. make castings for a hand screw machine of the Windsor type. Brown, like Spencer and the other inventive geniuses of his day, was not content simply to follow the design of other engineers.

Self-Revolving Turret

He altered the machine to include a self-revolving turret with a ratchet and pawl system actuated by the withdrawing motion of the turret slide. A feeding action was designed to allow the wire bar stock to be fed without stopping the spindle.

While devices of this type had been used earlier, Brown's patent of November 28, 1865, included improvements in stock feeding and also a releasing die holder of a type still used in principle today. A chasing tool, guided by a lead screw on the back of the machine, is an earmark of some of the first screw machines built by Brown & Sharpe.

From the time Spencer developed the Hartford automatic in 1873, until Samuel L. Worsley, a Brown & Sharpe engineer, was issued a patent in 1890, fully automatic bar machines had operated on the principle of "pick-up camming." Strap or bell cams were used with little regard to the exact throw of the tool. So long as the cam had sufficient rise it was considered adequate.

Special Cams

The Worsley innovation, patented in the U.S. and many foreign countries, featured the use of a fully automatic machine equipped with cams specially designed to suit the needs of the particular workpiece being made. The machine featured easy removal and replacement of these one-job cams which today are a major reason for the efficiency and productivity of the Brown & Sharpe automatic screw machines in use.

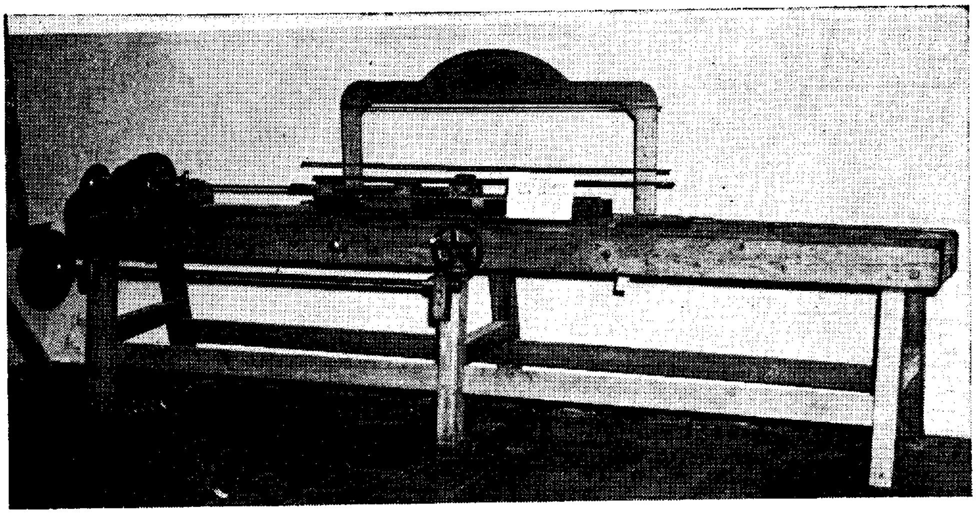
In quick succession, Brown & Sharpe gave their equipment a faster indexing of the turret, higher spindle speeds, and greater motor power.

The fact that Brown & Sharpe automatics today comprise in the neighborhood of half the total bar automatics used in America is evidence of the basic soundness of the machines built by this concern. Through the years, this firm has been granted many patents for improvements to its products.

Precision Center

Recently, in celebration of 125 years of service to the nation, Henry D. Sharpe, Jr., grandson of the original partner of J. R. Brown & Sharpe, established in the Providence plant a training area known as "Precision Center." Here, alongside the latest machines and tools of the firm are the treasured early products built by Joseph Brown and Lucian Sharpe.

The alumni of Brown & Sharpe's apprentice courses have gone into many fields: management, manufacturing, publishing and politics. Each has carried away the respect for precision which was made clear in that little newspaper ad five quarter centuries ago, and which has been the abiding policy of this firm through the years. ———Ω



WOOD-FRAMED gun lathe of 1780-1785 vintage using hand-forged tools and simple wooden bearing boxes is prized item in Jones & Lamson Machine Co. museum at Springfield, Vermont.

from ARCHIMEDES to AUTOMATION

PART 4: the history of the screw machine

THE INFANT screw products industry had its problems. Bar stock was almost entirely hot rolled; bars were hammered into some semblance of straightness so they could feed through fingers and collets. The roll scale and rust on the bars, mixing with lard oil coolants, gave men, machines, and parts a red appearance.

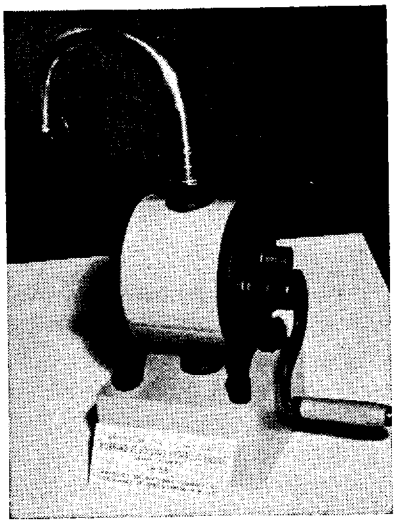
Tools were spectacularly lacking in uniformity; heat treating was still in the heat-quench-draw-hope stage. Bearings were either of bronze or cast iron, and required hand scraping for what precision they could give. Many machine parts were cast, and breakdowns were the rule, rather than the exception.

To complicate matters, screws, nuts and bolts were no longer the only parts being made. The bicycle industry, and the forerunners of today's gas-driven autos, were offering mass production turning orders to shops with automated equipment.

Christopher Spencer had not been idle. He devised a three-high spindled screw machine capable of revolving its tools and making parts from coiled wire. The wire straightening arrangement gave trouble, but Spencer incorporated into the machine a pick-off attachment; one part could now be slotted or burred on the rear end while another was machined in the spindle.

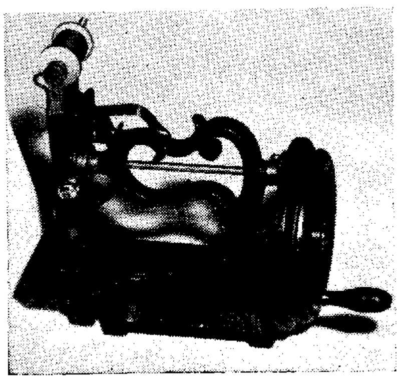
A number of these "over and under" wire machines were purchased by Reinhold Hakewessel, a Hartford resident who had apprenticed in Pratt & Whitney's shops and gained added experience in screw products work at the Hartford Machine Screw Co.

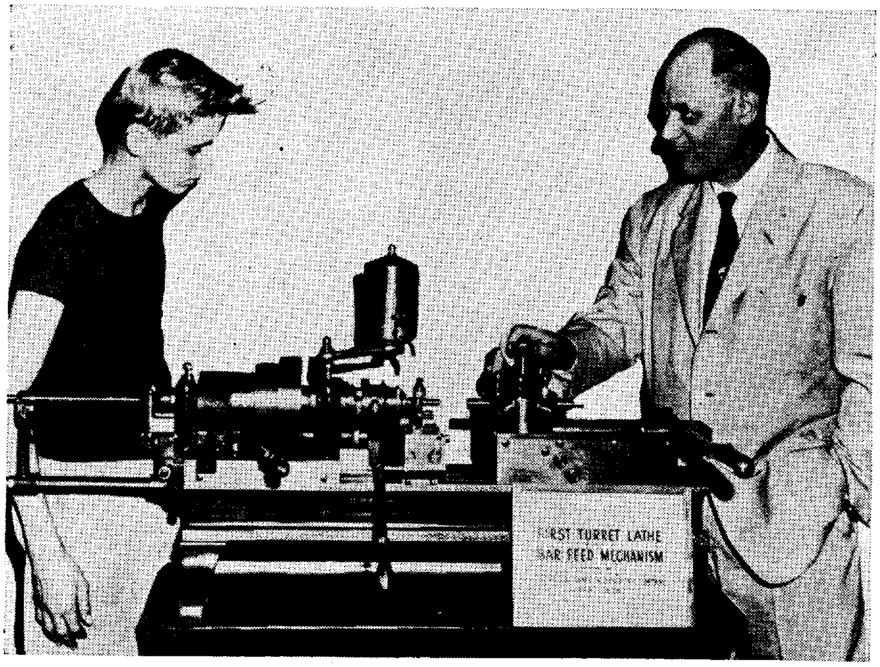
Hakewessel used the machines with some success. His then-novel idea of figuring the value of chips allowed him to compete for orders with Hartford Machine Screw Co. to that firm's irritation. Most importantly, the Spencer wire machines gave Hakewessel the cash



HUBBARD revolving hydraulic engine (above), a gear pump built about 1835 as product of National Hydraulic Co., forerunner of Jones & Lamson.

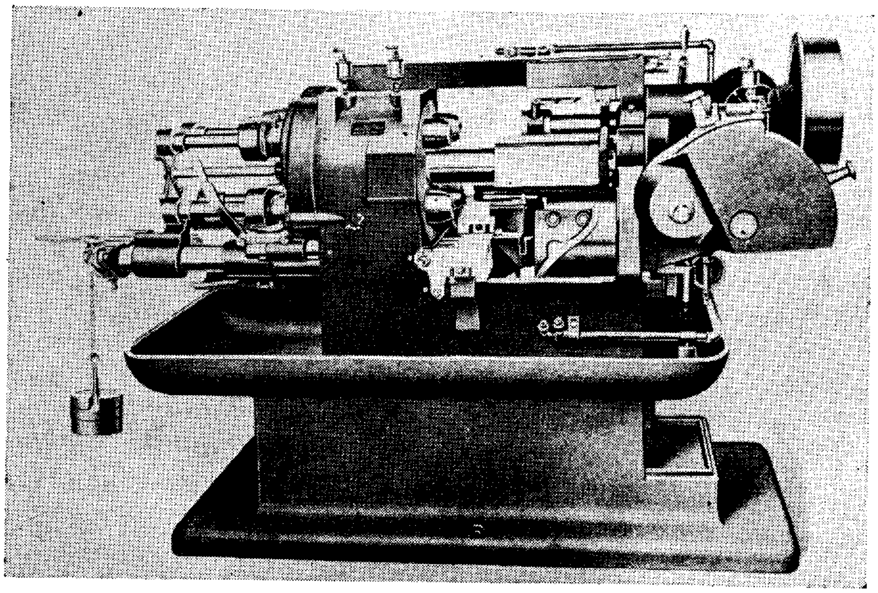
SEWING MACHINE (below) made by Vermont Arms Co. in 1856-58 era was product of this ancestor of Jones & Lamson in days when the firm made Windsor U.S. army rifles, Buffalo rifles, British Enfield rifles, gun making, textile, and metalworking machines.





JONES & LAMSON's first turret lathe with bar feed mechanism was built in 1868. Lathe pioneered automatic indexing turret, weighed about 400 pounds, had 5/8″ through-spindle capacity.

GRIDLEY multiple-spindle automatic of $1\frac{1}{4} \times 5\frac{1}{2}''$ capacity. This belt-driven model was probably one of the first built by Gridley at Windsor (Vermont) Machine Co. about 1907.



with which to develop a four-spindle bar automatic. He named it the Acme. Unknown even to himself, Hakewessel had founded an organization later to become the National Acme Co.

The machine tool industry, born and "fetched up" in New England, was about to move westward. Cleveland, Ohio, was virgin territory. Iron had been discovered there; coal was available by river from Pennsylvania. The Erie Canal, "Clinton's Ditch," had just been opened, linking the Great Lakes with the Atlantic by way of a man-made ditch from Buffalo to the Hudson River at Albany. But when the westward move came, it was not a mere desire to "Go West, young man, and grow up with the country." The move came for the one basic factor that influenced almost every decision made by the striving machine tool firms . . . . . money.

Hakewessel, while still operating his plant in Hartford, had induced two brothers, Albert E. and Edwin C. Henn to invest in his multiple-spindle bar machine. His finances were so low at one point that the master drawings for the Acme automatic were sketched directly onto the plastered walls of his office. When the weight of equipment in the plant threatened to bring the plaster down in a heap, the "blue prints" of this early machine were hastily transferred to paper.

In time, the Henns bought out Hakewessel and devoted their efforts to making and selling the multiple-spindle automatic. The first big order came from Cleveland.

In Cleveland, W. D. B. Alexander was the major stockholder in the National Screw & Tack Co. *(now the National Screw & Mfg. Co.)* His offer to the Henns was: He would buy 25 of their Acme machines, paying one-half the price in cash, the balance in National stock. In return, the Henns were to agree that Alexander had exclusive rights to use these machines in the Cleveland area! The Henns needed money. The deal was made.

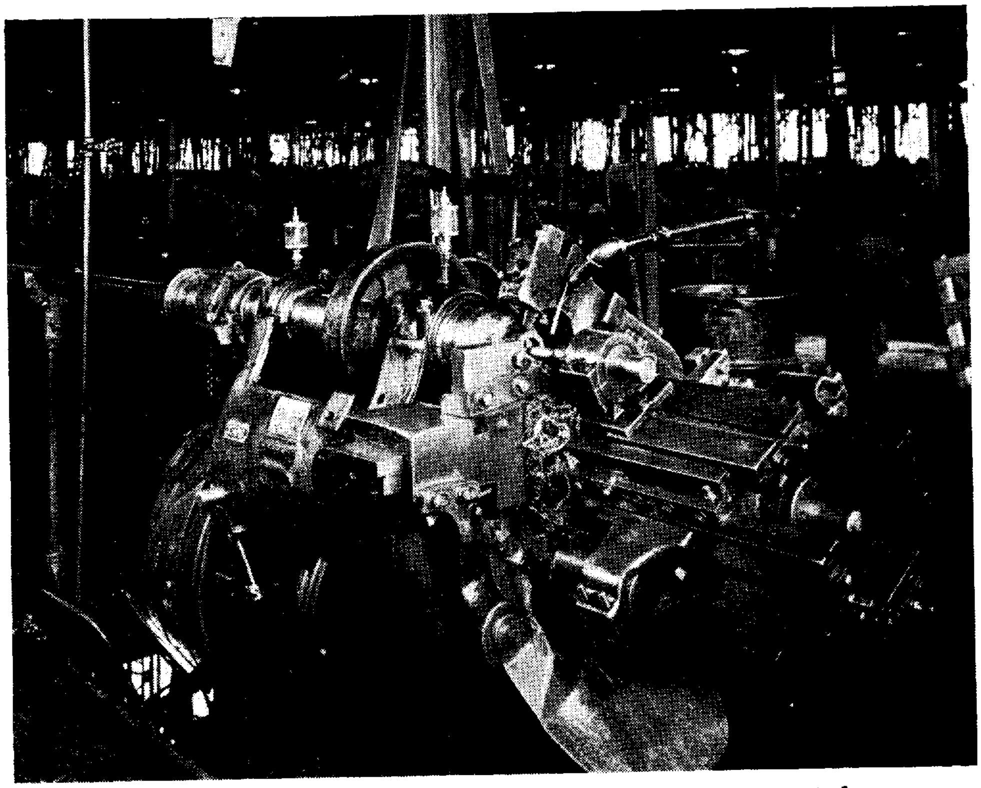
Not long after they moved their shop from Hartford to Cleveland. For the first time, the names "National" and "Acme" were linked by being in the same town, and having overlapping stock ownership.

To protect his interest in the Acme machine, Alexander placed his young accountant and office

manager in the Henn office. His name: Orrin Shriver Werntz, father of Orrin B. Werntz, now executive vice president of the National Screw Machine Products Association.

The young accountant found himself the conciliator between Edwin and Albert Henn in their frequent disagreements, and rapidly rose to prominence in the firm. Before his death in 1908, at age 32, Werntz had arranged for the building of a new plant for the firm, had set up foreign branches, and was earning $13,500 per year, an almost unprecedented salary for that day.

The Henn's move to Cleveland came in 1902, four years after Alexander had set up his screw and tack firm for "manufacturing, purchasing, dealing in articles special or staple, made from metals, such as screws, bolts, nuts, rivets, nails and kindred articles." The National firm had been capitalized at $100,000.



SINGLE-SPINDLE National Acme machine, built on Gridley patent. A few machines of this type are still in use as special purpose machine tools in some shops. Note forest of belting in background.

National and Acme

National had opened its doors in 1898. In its first year, the company made and sold 900,000 workpieces for a total of $2,700 and a net profit of $150. Two years later, with the Acme machines by now in use, there were 47 automatics on the line. Sales were in the $80,000 bracket, profits about $6,000, of which $5,000 was plowed back into more equipment.

The National Screw & Tack Co. soon merged with the Acme Machine Co. to form the National-Acme Screw Manufacturing Co. Though this represented only a merger of two firms with common interest, the names "National" and "Acme" were now separated only by a hyphen.

From the start, there was a conflict of interest. The Henns, naturally, wanted to build and sell machines. Alexander preferred to push the sale of screw products. All parties soon realized that they could not long continue to build machines and then compete for screw products work against the buyers of them.

The little firm tried to limit the sale of its machines and stay as a screw products shop. This was not altogether an unselfish approach; the Acme was highly productive, and with it the firm had an edge in its job work. But demand for the machine grew and National-Acme four-spindle automatics were placed on the open market. By 1914, this demand had made the firm a major factor in Cleveland's industrial growth.

The Windsor Machine

Meanwhile, up the Connecticut River, at Windsor, Vermont, creative New Englanders had not been sitting on their hands. The Windsor Machine Co. had also brought out a four-spindle automatic, designed by George Gridley, of whom we will hear more. This machine was announced in 1907. It was different from the Acme, yet similar enough to be competitive. It would, indeed, have been strange if the two machines differed greatly. Gridley, like Hakewessel, had learned his trade in the big New England shops. Their thinking must have been along parallel lines.

In 1915, the National-Acme Mfg. Co. of Cleveland bought out the Windsor machine, dropped the hyphen in its title and became The National Acme Co. Once in a while, in an older shop, machines can be found of the Acme type, an indication that such machines were made before that day in 1914 when National Acme settled into its present state of organization.

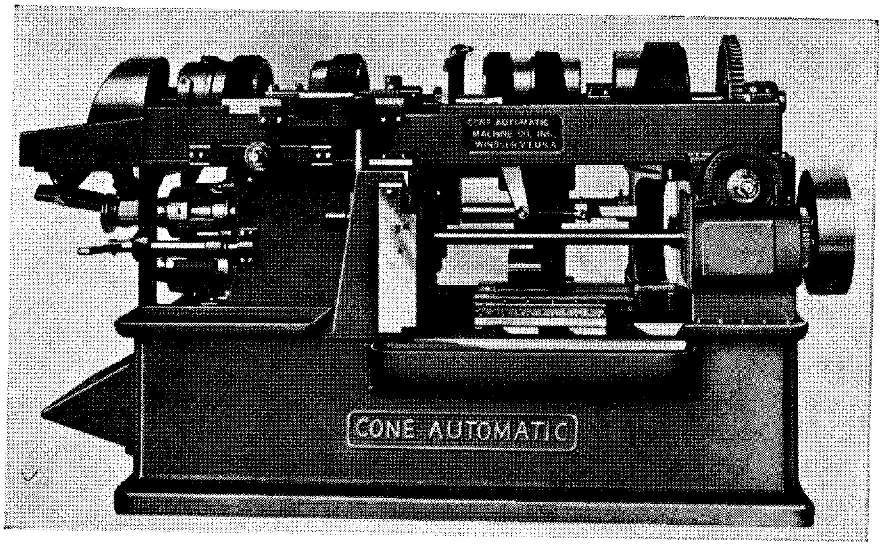
Thus, the Acme-Gridley machines of today are the product of a Connecticut four-spindle machine, the first of its kind ever made, combined with ideas of George O. Gridley, whose name today can be seen on at least two makes of automatics.

Gridley was born on a farm near Harwington, Connecticut, in 1869. Raised in the midst of the machine tool center of the nation, his natural bent for invention soon began

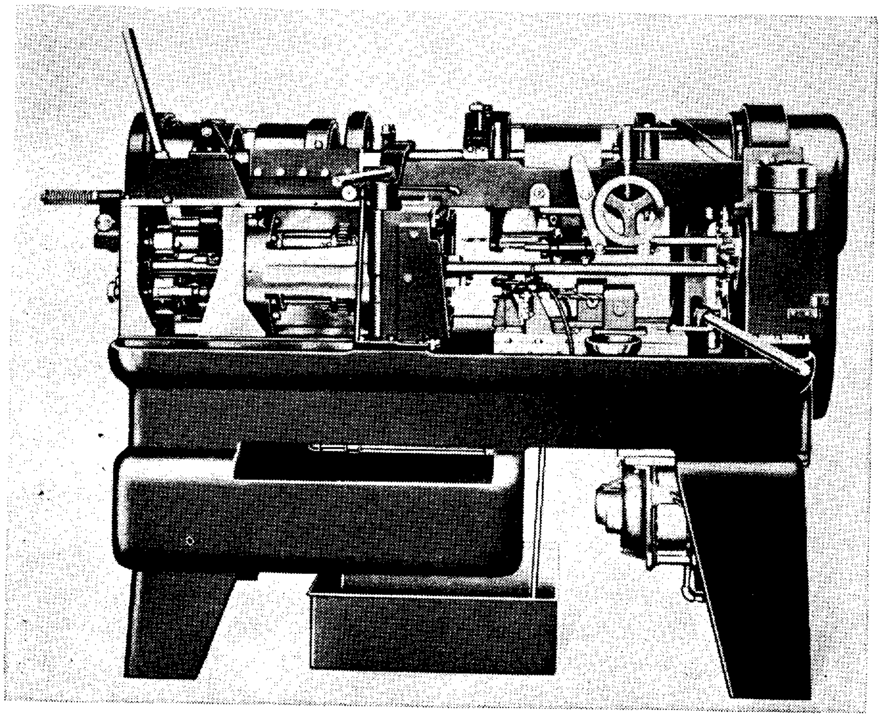
his lifelong love affair with machine design. At an early age, he chafed under the long hours of farm work, and at the first opportunity tried to escape from the farm.

Somehow, he became acquainted with James Hartness who was breathing life into the Jones & Lamson Machine Co. at Springfield, Vermont, but Hartness, despite his liking for the lad, could not place him as an apprentice at J&L. Gridley began his shop career in a button factory, turning pearl buttons to size at the piece-work rate of 3¼ cents per gross. A few months later, Hartness rescued Gridley and placed him at J&L as an apprentice at better wages *(seven cents per hour to start, with increases to nine cents per hour at the end of the three year term.)*

Windsor and Springfield, Vermont, are sister cities. Each occupies its own side of the hill, and hot rivalry existed in the days when the Robbins & Lawrence plant was at Windsor. Senator Ralph Flanders, career machine tool man of Springfield, has been quoted as describing his town as "an island of heavy industry entirely surrounded by cows." He did not add, as he might have, that the creamy white milk in the Springfield area comes from cows grazing on the Green Mountains and drinking from the Black River.



IN 1920, Cone Automatic Machine Co. brought out the heavier frame for its four-spindle machine. Note added mass of base, larger coolant reservoir and chip area, heavier top bed, than 1918 model below.



Vermont Inventors

Vermont has been inventive from the first. U. S. Patent No. 1 went to a Vermonter for a soapmaking invention in 1790. Thirty-seven years later, John Cooper was granted a patent for a rotary water pump, and wended his way toward Windsor, where available water transportation offered manufacturing possibilities.

Three miles from Windsor, he stopped at the workshop of Azabel Hubbard. In 1835, these two joined with other Windsor people to form the National Hydraulic Co., forerunner of Jones & Lamson Machine Co.

The company eventually became the Robbins & Lawrence plant, where military guns were made in quantity. At one point, around 1850, the firm was given an order for 25,000 rifles by the British government, and another order to equip a British factory for making more of the same weapons.

The Lamsons

In 1859, Russel Jones was operating a cotton mill at Colrain, Mass. Silas Lamson had a handle works at Shelburne Falls. When a flood wiped out both companies, the two moved to Windsor and joined Robbins & Lawrence Co. Here the Ball repeating rifle was built, along with the Winchester muzzle loader and the then-famous New Haven rifle. Christian Sharpe came to this firm with his Sharpe's Rifle plans . . . . . and the firm built this famous buffalo gun.

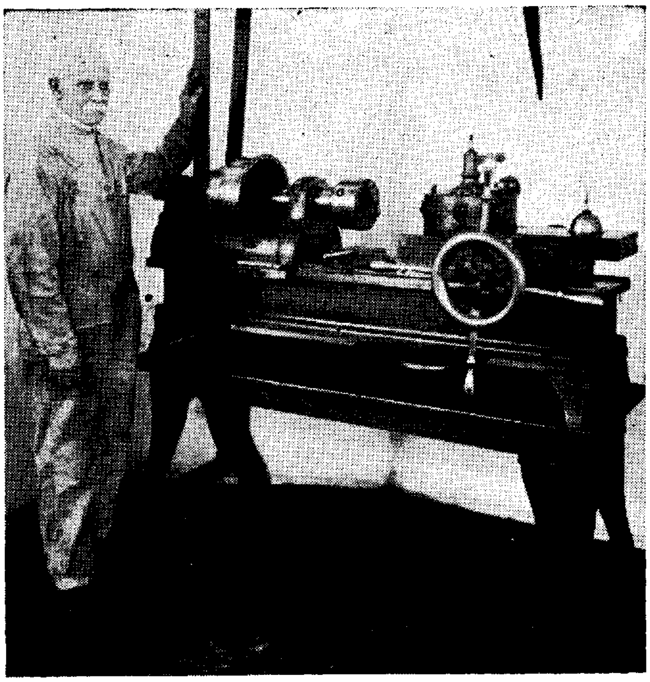
By 1861, four of Silas Lamson's sons were operating the Windsor

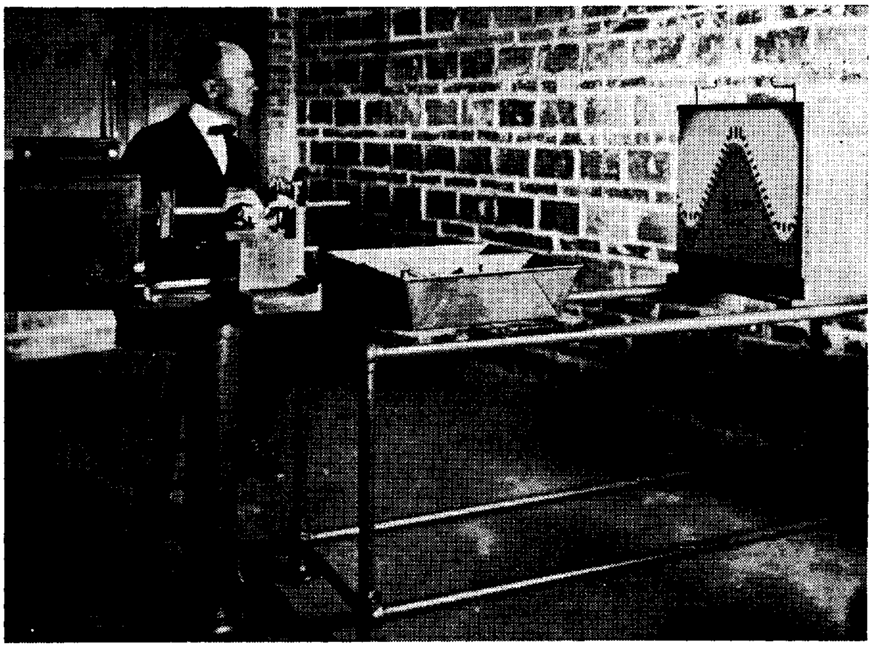
shop. Azabel Hubbard was foreman. Russel Jones, after a brief period away from the company, returned in 1876, and the company was renamed Jones & Lamson. In 1888, the firm moved down river and uphill to Springfield. At this time, Springfield was six miles from the nearest railway.

More will be said of Jones & Lamson's activities, but the point to be gleaned here is that Windsor, in 1888 a busy industrial town, suddenly discovered its shops had moved to Springfield. The city fathers scrambled to replace this lost source of employment for the citizens.

Gridley, meanwhile, had established himself as a valuable man at J&L. As James Hartness' secretary he had gained basic machine training.

RAM-TYPE turret lathe (right) built by Jones & Lamson about 1920. J&L employee (below) is shown operating a 1920-era screw thread comparator developed and built by J&L as a result of James Hartness' work on screw thread standards commission in World War I.





Gridley at Windsor

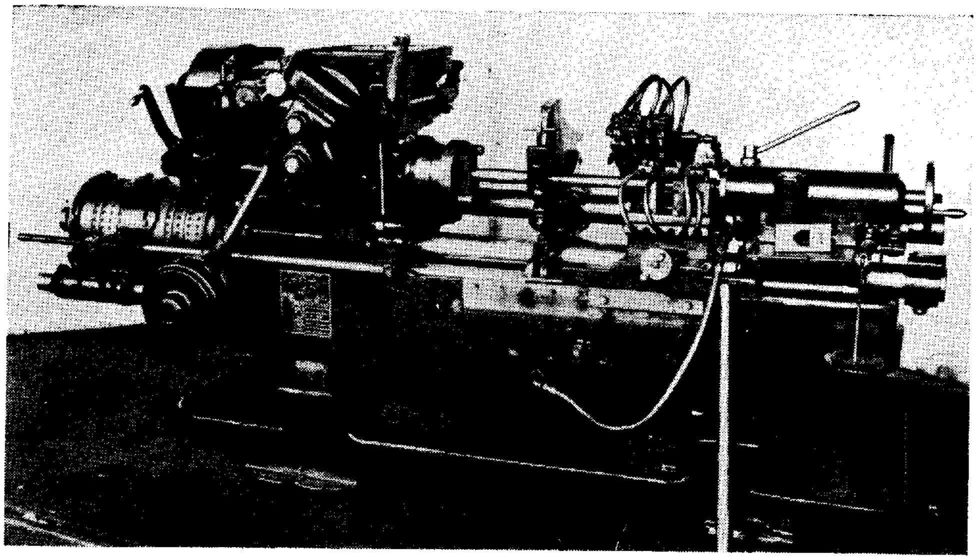
Gridley stayed with J&L until 1899. In that year, the Windsor Machine Co., the tiny firm set up at Windsor to replace the loss of employment, called him to be the plant manager. In an interview with *Automatic Machining* magazine before his death, Gridley recalled, *"There was only one decent machine in the whole shop. A Cincinnati milling machine had somehow had friendly treatment and was capable of holding size and doing good work."*

For several years, he built turret lathes at Windsor, plowing back earnings into better machines toward the day when he could make the screw machine he had designed. In 1903, the firm announced a single-spindle bar automatic. In 1906, a four-spindle multiple was built.

This manufacture continued until 1914, when as mentioned earlier, The National Acme Co. purchased the interests. The transaction involved several million dollars . . . . . a major financial deal of its day. The Gridley machine's value came from its earnings report of the previous year which showed it to be gaining in popularity.

Gridley principles are to be seen in the Acme-Gridley machine today. The idea of a central tool slide integral with the spindle carriage was born in this little shop far up in Vermont's hills. The rugged cross slides and rigid camming of the Acme-Gridley line were, at least in part, the influence of James Hartness as reflected on a young farm boy he befriended, George O. Gridley.

One reliable rumor has it that Gridley offered to stay out of the screw machine design field for life if National Acme would agree to a sizable annuity for him. When this was refused, he moved to the Hartford, Connecticut, area and began to build another type of multiple-spindle automatic under his own name. In this endeavor, Gridley licensed the manufacture of his machines by National Acme and the New Britain Machine Co. In time, his patents were purchased by



FAY automatic lathe of Flanders type, 1920 vintage. Machine had spindle speeds 16-181 rpm, back arm feeds .001-.027 ipr, carriage feeds (with change gears) .004—.050 ipr. Photo courtesy Jones & Lamson Machine Co.

New Britain. Gridley went to this company as a chief engineer for some years. The New Britain-Gridley automatic is the result.

While the single and multiple-spindle machines were being designed and built at the Windsor Machine Co., Gridley acquired a skilled foreman, Frank L. Cone. When Gridley left the company, Cone stayed on as manager of the National Acme Windsor Division until 1917, when he left to form the Cone Automatic Machine Co.

Cone Automatic

Cone, like his fellow Yankee mechanics, was a hard working man. In a few months after leaving The National Acme Co. he had perfected his own version of a four-spindle automatic.

With the camshaft above the work and tool axis, supported in a full machine-length topbed, the Cone machine made use of shorter and more widely spaced upright frame supports, for a longer tooling area. With no camshaft in the base, a table type end-slide provided end tool positions for work spindles in the two lower positions of the carrier. The two upper end positions were serviced by opposed end spindles supported by the top bed, with actuating levers also supported by the top bed. The positioning of cams on the outer areas of the machine frame provided more room for larger diameter cams, cam rolls, transmissions shafts, bearings and gears.

Unlike many companies which went through a series of financial troubles, stock trades, and mergers before arriving at final corporate form, the Cone Automatic Machine Co. sprang full grown from Frank Cone's basic invention. This highly precise, versatile, mass production machine has, of course, been refined, changed, improved, and made available in many models, but the machine frame, the concept of camming, and simplicity of tooling, all of which Cone envisioned, have remained.

Fay Automatic

James Hartness has been given credit for initiating many plants to the concept of producing parts directly from the bar, or from a casting or billet held in a chuck. As he traveled about the country selling his flat bed turret lathe, Hartness found that mechanics would use the lathe for drilling, boring and reaming, and then would place the part between centers on an engine lathe for the O.D. work. About the same time, he discovered that a Pennsylvanian named Fay had devised a lathe using cams and drums to actuate all tools, and Hartness bought the patents. Thus it was that Jones & Lamson began to manufacture the Fay automatic.

Optical Comparator

During the first World War, Hartness was on a commission for the standardization of screw threads. His work in this field led to the introduction of the Jones & Lamson optical comparator in 1919. In this work, the firm had to develop and manufacture lenses to its own specifications.

Other Developments

During these years, many types of machines came into being. The Gridley "Supermatic" multiple drilling machine was developed. Many specialized gun making machines and thread grinding devices were originated in this Springfield-Windsor area.

Jones & Lamson can take credit for establishing at least three firms. William L. Bryant of nearby Ludlow, Vermont, was a draftsman. He conceived the multiple-spindle grinder, and was encouraged by Hartness of J&L to form the Bryant Chucking Grinder Co.

In like manner, E. R. Fellows, a clerk in a store at Torrington, Connecticut, came to Springfield as a J&L draftsman and invented the gear shaper. Again with Hartness' blessing, he formed the Fellows Gear Shaper Co. at Springfield. Still another J&L employee, F. P. Lovejoy, gave his name to the Lovejoy Tool Co. in this same town.

With such an inspirational atmosphere prevailing in a time when there was a growing demand for automated machine tools, it is little wonder that men with little formal training were able to found their own companies.

The economy of the nation was ripe. The population was growing by leaps and bounds. In a sense it

was a time typical of the period we experienced following World War II. New families were springing up, housing was short, and the public, with money to spend, was clamoring for goods. Industry, striving to fill the demands of the people, was as thirsty for automation as the populace was for the goods automation could produce.

Hartness Chucker

Hartness went on to other activities. He invented the Hartness automatic chucking lathe, a unique item tilted at an angle to allow easy insertion of the workpiece. He became governor of his state, and remained a revered citizen of Springfield. His home, on a pine-shaded bluff high above the Black River, is now the Hartness House, a plush hotel maintained by the Jones & Lamson Machine Co., the Fellows Gear Shaper Co., and the Bryant Chucking Grinder Co. Primarily intended for the use of these companies' customers and representatives, the Hartness House is one of the finest public hotels in a small town.

Astronomical Telescope

Evidence of Hartness' creativity is to be seen by guests at this hostelry. Deep beneath its first floor is a narrow tunnel leading for many feet under the lawn to a small circular room which houses an astronomical telescope. Rumor has it that Hartness retired here to be alone, study the stars, and consider the future of his many enterprises, and the mechanical problems at hand.

With characteristic New England frugality, Hartness built his telescope from lenses made in the J&L optical shop, and powered its actuating mechanisms with change gears from a J&L lathe. This long-range instrument is considered of such quality that the U. S. Government still borrows its facilities at times for weather studies. ———Ω

A Note on The Screw Machine Products Industry

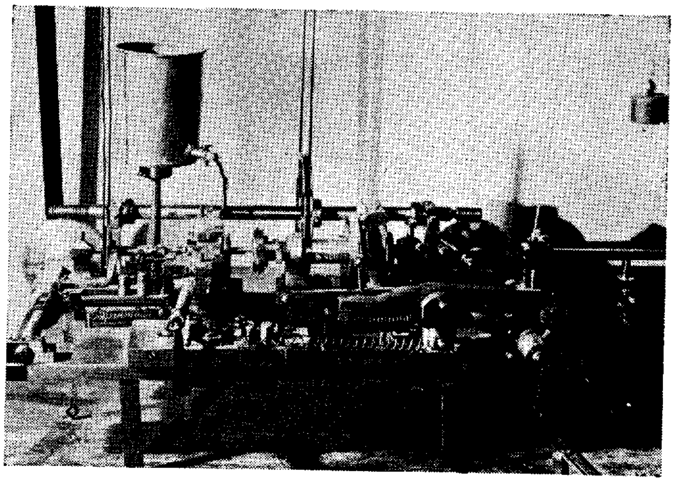
The industry is composed of more than 1800 manufacturing companies. These annually produce in excess of 1 ¼ billion dollars sales of special component parts. These components become a part of machines, appliances, automobiles and similar durable goods and products for individual, industrial, military and scientific use.

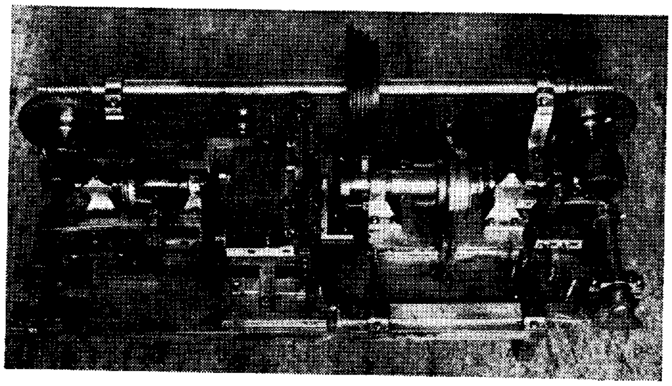
Because these parts are manufactured strictly to customers' specifications, and are of precise dimensions, demanding close individual control during production, the manufacturing units of the industry tend to remain small in size.

In this day of mergers, acquisitions, and "Bigness", the screw machine industry is truly representative of a rapidly diminishing breed — the highly skilled craftsman, the entreprenuer.

Without the automatic screw machine — all of the metal turning lathes in the country, working 24 hours a day, year 'round, could not satisfy the appetite of American industry for component parts. The industry has often been referred to as the "Pioneer of Automation" with the invention of the automatic screw machine dating back to 1873.

SWISS AUTOMATICS, regardless of make, have—from their inception to present date—been distinguished chiefly by the sliding headstock and ability to hold close tolerances. Here are two very early models, the Tschopp (right) and the Schweizer (below), both with sliding headstocks.





PART 5: the history of the screw machine

from ARCHIMEDES

WHY A HILLY, beautifully bleak environment promotes the development of men with unusual mechanical genius is a question others must answer. Perhaps it is the long winters, when there is time to contemplate problems and find the answers. Perhaps it is the very ruggedness of the life which brings a stimulating influence to bear on mind as well as body. Perhaps, again, it is an urge to rise above the rural environment by any means at hand.

Just as the hills of New England gave to America the single and multiple-spindle automatic screw machine, the valleys of Switzerland gave to the world a completely different screw machine intended for much the same type of production.

The Swiss automatic, conceived as a means of producing tiny watch parts at rates faster than manual means, has found wide use in metal working industry the world over.

There was a different approach to the problem in Switzerland, however. The Swiss had been making very fine watches by hand for generations. Their need was for a machine which could simulate hand results faster. In contrast, the American style automatic was intended as a means of *increasing* precision. Here, the products being made by manual means were relatively crude. The automatic brought precision.

Paradoxically, both Switzerland and America developed their automatics at about the same year without collaboration. Automatic machining of watch screws began at the tiny Swiss mountain village of Moutier about 1873.

Since the dawn of civilization this area had been agricultural. The arrival of the Swiss automatic gave it a new and vital industry.

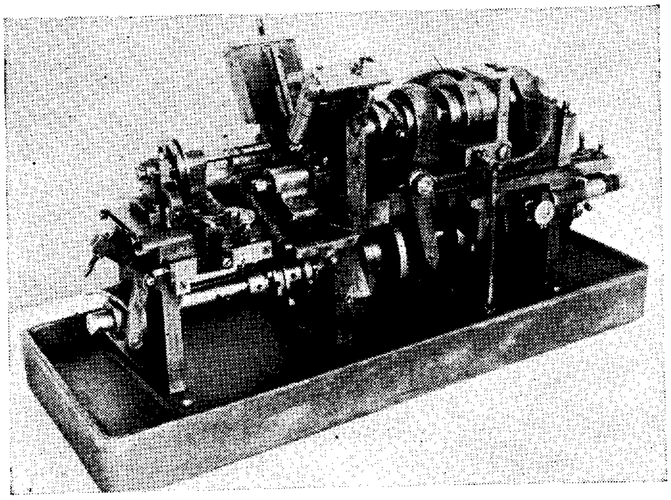
Watchmaking depends upon the manufacture of many tiny parts, each to close specifications. The quality of the final product is the result of the precision built into its components. The Swiss, like our New England forebears, dictated the quality of their workmanship by insisting upon long-term, low pay apprenticeships before a workman was allowed to produce work for export.

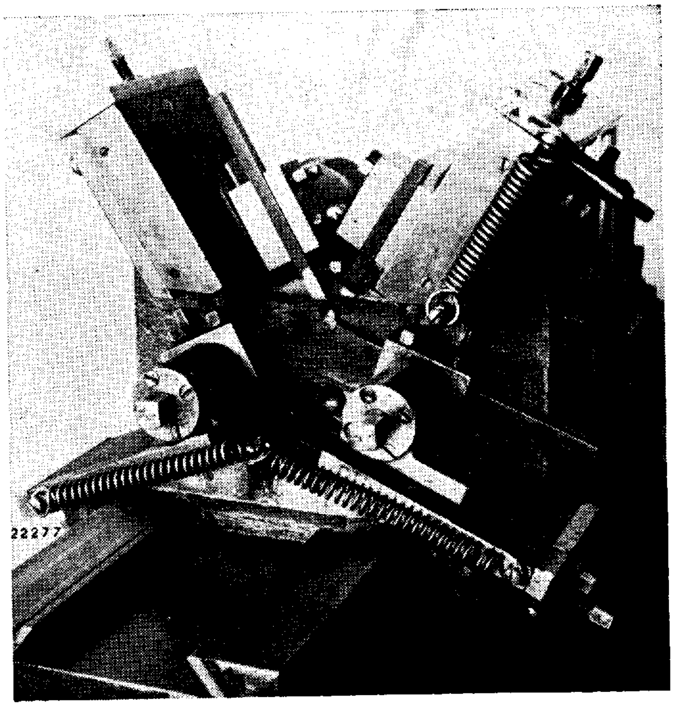
The Swiss and American automatics did not borrow from each other. Each arrived at its mass production solution from opposite ends of the problem. Universally, American automatic screw machines employed the principle of moving the tools along a revolving, but longitudinally stationary bar of metal. The Swiss, mainly because of their entirely different need, devised the mechanism we know as the sliding headstock, a distinguishing feature of Swiss screw machines to this day.

The sliding headstock idea, simply stated, means that the work is colleted in a spindle which can be advanced and retracted axially while in rotation, and that the tools have transverse motion but are axially stationary.

From 1873 until 1904, rudimentary Swiss automatics were in use for making watch parts. A few such machines still exist. During this period, Switzerland experienced an industrial revolution somewhat comparable to that which occurred

ANOTHER early model Swiss automatic was the Laubscher (below), with its old design toolholder (right) which employed four cutting tools instead of the present design which features an additional, vertical cutting tool.





to AUTOMATION

in America. The time was ripe for progress. Since the 17th century, watchmakers in Geneva had "farmed out" hand work to families in the Jura mountain locality, and this work had become a family enterprise in the long, snowy winter months. Patient hand work was required, and the temperament of these rural folks seemed to thrive upon it.

Switzerland exists by virtue of its exports. It must bring into the country the raw materials it needs for manufacture. It has no iron, coal, oil, wool, silk, or sufficient wood or paper. These imported products must be transformed into a finished product of sufficiently high value to overcome the cost of shipping in the raw materials, and still leave a margin upon which the national economy can survive. Such a situation dictates that *only* a high-value export item can be allowed. Shoddy workmanship would quickly lower the prestige of the country's product and cause economic disaster.

The Swiss will frankly tell you that *technique* is their most important product. The land is heavily populated. Great emphasis is placed on education and culture. The need in the late 1880's was a means to produce a greater volume of product without loss of quality. The sliding headstock screw machine was an answer.

The Swiss are reluctant to give any one man total credit for designing this principle. Rumor has it that such machines were used at Bienne in 1872. Progress was slow, however, until 1904 when Andre Bechler, a visionary young engineer refined the existing crude models into their present state of efficiency. Bechler was only 21 when he founded the machine tool firm which bears his name.

At this tender age, he had shown himself to be a creative genius. He had designed machines, and achieved a brilliant record in the tough technical university where he had undergone the traditional Swiss educational process. His company built a variety of general machine tools until 1914 when "A. Bechler & Co." became "Bechler, Moutier, Switzerland" as the trade knows it today.

Bechler has had many patents to his credit. His contribution to the screw machine industry cannot be ignored. In 1905, he patented a threading and tapping attachment featuring differential speed, and the principle of mounting cams on external camshaft bearings. In 1908, a patent was issued to this company for a single-unit guide bush holder, a basic device in a sliding headstock machine where support of long workpieces is a controlling factor in size and concentricity.

In the Swiss automatic, the concept of micrometer adjusting screws first came into being. This, however, came only after set screws had been found to be time consuming and less effective for adjusting.

Because of their differing needs, the Swiss concentrated first on precision, then on speed, while the American automatic came into being because of a need for faster production, and picked up additional precision as it was refined.

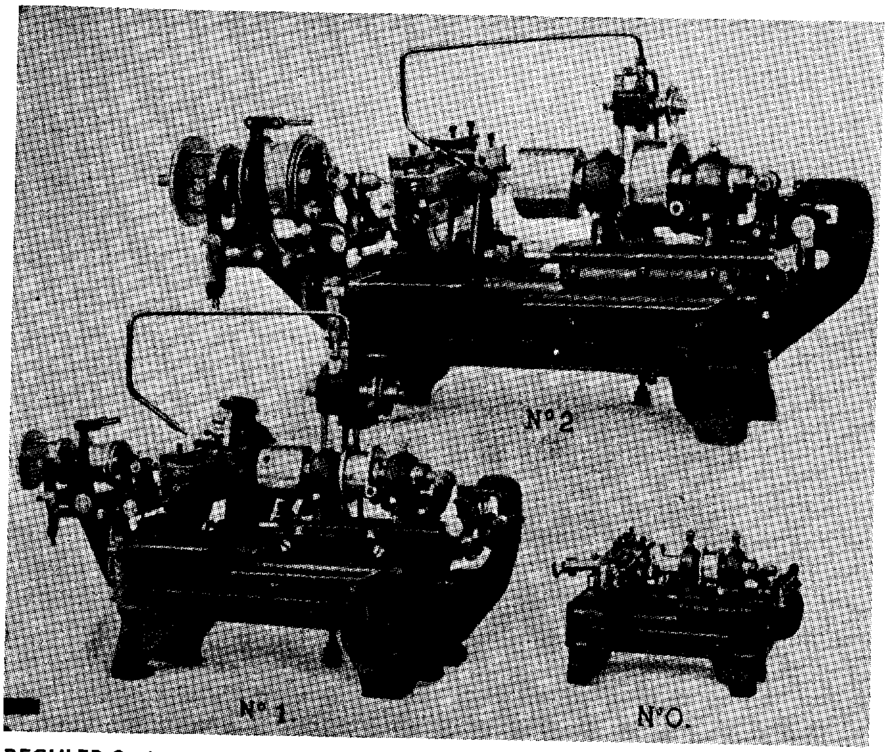
For many years there remained a marked dissimilarity between work produced on Swiss and American automatics. Today, this line of demarkation has become blurred, and "Swiss jobs" are frequently run on fixed-headstock screw machines and vice versa.

The natural expansion of Swiss automatic use, once it had proved effective in tiny screw and nut production, was to the manufacture of miniature pinions, shafts, and stepped parts. The shortage of new Swiss automatics during World War II forced some of our machine tool builders to manufacture sliding headstock screw machines temporarily, an evidence of the effectiveness of these machines for small shaft and pinion work.

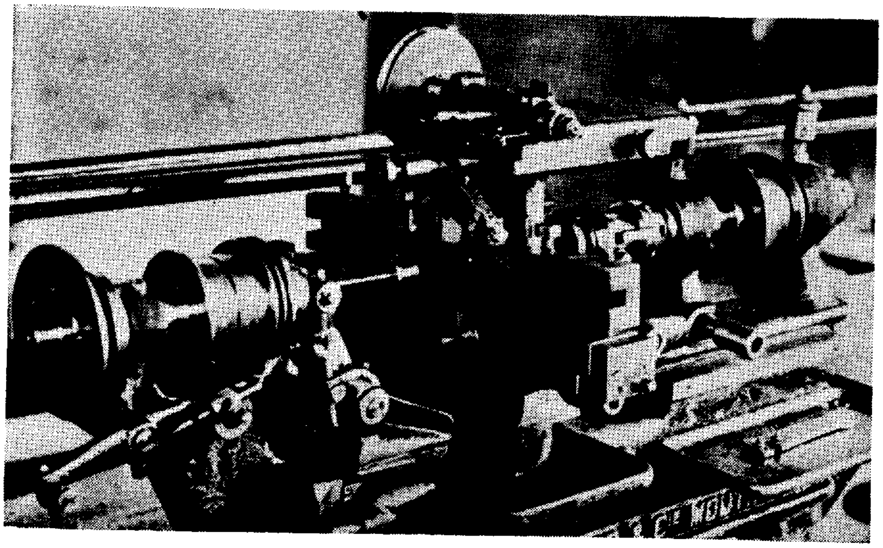
The support of the workpiece in a close fitting bushing within scant thousandths of the tool point has been the earmark of such screw machines from the first. When working with very small rod stock, such a means of support is, of course, the ideal condition, often far superior to the conventional work supports used on fixed headstock automatics.

The story is told, true or not, of the American wire company which produced an extremely accurate wire of such a small diameter that it was considered a fine evidence of the American technological ability. This wire was sent abroad as part of an exhibition of U. S. wares. According to the legend, a Swiss machinist obtained a piece of this very fine wire, drilled a hole in it lengthwise, and sent it back to the manufacturer as an example of Swiss workmanship.

This tale, probably exaggerated in its repeated telling, points up the fact that while Swiss automatics are being used widely in almost every section of industry today, their original purpose was to fill a need for fast machining of tiny parts to close limits.



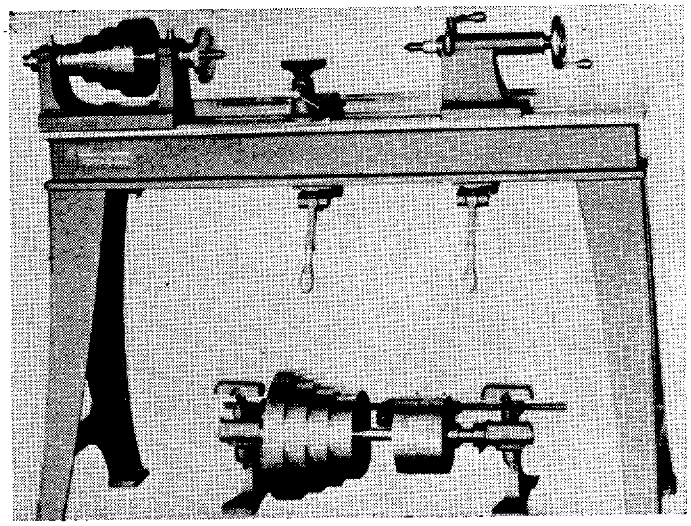
BECHLER Swiss automatic at the turn of the century (below) employed two cross tools, a threading attachment which operated on the overlapping principle, and a screw thread device. Above are three Bechler models, also of the early 1900's, with the old-style guide bush holder.



Common Denominator

Bechler was not alone. His history is cited here as an example of what has been done in lands other than our own. There are many highly respected makes of Swiss automatics today. To name them all would require much space, and a partial list would surely bring a complaint from those unmentioned. While the builders of such machines operate as separate entities, the Swiss automatic can always be distinguished by the sliding headstock feature to which all the makers have held.

It is doubtful if anything will come along to supersede the Swiss automatic within its specialized field of work for a long while. Wherever long, slim, precise parts must be mass produced to microscopic tolerances, the Swiss screw machine finds a welcome spot in the hearts of production men everywhere.——————Ω



LATHE shown at right is one of the original 10 machines Ambrose Swasey and Worcester Reed Warner sold for $60 each. From this humble beginning, the firm of Warner & Swasey prospered and grew to become one of the major U.S. machine tool builders.

from ARCHIMEDES to AUTOMATION

PART 6: the history of the screw machine

IN PRECEDING CHAPTERS we have pointed out that the need for a rapid means of producing similar threaded parts brought into mass use the automatic screw machine.

The automatic, in turn, can look to the turret lathe as its direct ancester. In fact, as mentioned earlier, the Hartford automatic, first of a long line of makes and models, was devised by adding cams to a Pratt & Whitney turret lathe.

Few turret lathes existed in the U. S. before 1850. A few had been built as "specials" for individual shop use by adding a multi-tool holding device as a replacement of a tailstock on an engine lathe. There were none available as a manufactured item until men saw the possibilities they offered for faster machining.

Probably some traveler first brought this turret principle to America after seeing a British "Capstan Lathe" *(English nomenclature still uses the word "capstan" in describing turret lathes.)*

The first record available of turret lathe use in America is at the Silver & Gay shops in North Chelmsford, Massachusetts. Frederick Howe noticed these machines, recognized their extra value over engine lathe types, and prevailed upon the Robbins & Lawrence plant at Windsor, Vermont, to make and sell them to the machining industry.

There were few secrets in New England in those days. The friendship of plant owners, the financial intermingling that had come with the years, and the apprentice-journeyman system of training that caused shop-to-shop travel among employees, made it difficult to keep any competitor entirely unaware of another plant's activity.

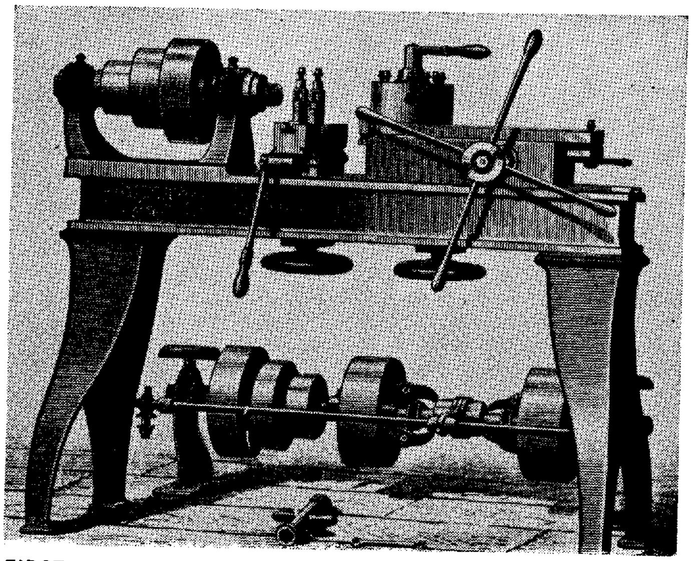
Actually, little attempt was made to keep new equipment secret. The market for better machine tools was so vast, and the production facilities so inadequate, that anyone who could produce a good product could sell it. Patents by the score were entered during the 1850-1870 years. Many, applying to machine tools, were almost identical except for some one facet. All incorporated the New England traditional concept of ruggedness, precision of a sort, and unpicturesque design.

Along the way there had been an attempt to bring a little beauty to the machine tool field. Early sketches show drill presses with Grecian columns supporting the drill spindle, and ornate scroll work cast into the frames and guards of other machines. In general, however, the manufacturer was far too busy to consider the esthetics of design, and simple rudimental construction was the most important feature until the day arrived when machine tools acquired the present sleek, powerful, streamlined appearance.

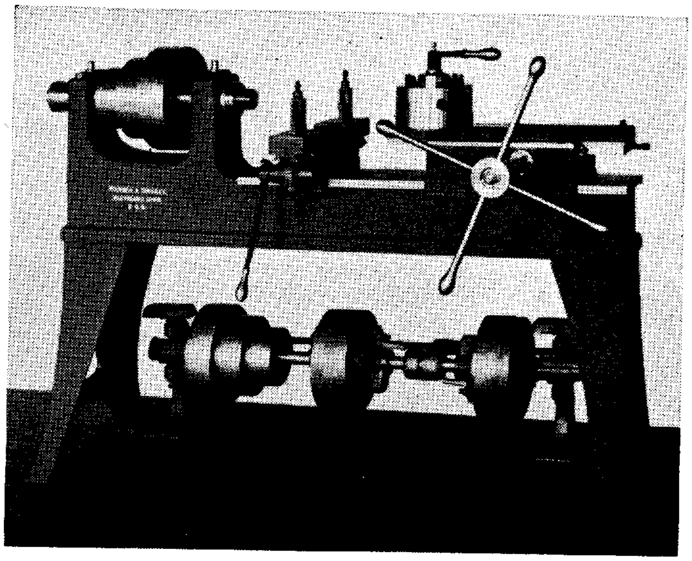
When Robbins & Lawrence began their production of a turret lathe, other firms were quick to follow their lead. We noted earlier that Pratt & Whitney was among this group, and that P&W for years enjoyed an advantage through its patent on a collet chucking device.

Thus, in an era when the automatic screw machine was a-borning, we also note strides in the development of the turret lathe, whose history we will attempt to trace.

The first to be considered will be the Warner & Swasey.



FIRST Warner & Swasey turret lathe (above) was a 16-inch Monitor lathe. At right is another early model W&S. Both featured round turrets. Overhead drive shafting (shown below machines) was furnished.



Mention Warner & Swasey to a shop man and he will think of turret lathes, automatics, or chucking machines, depending upon the type of equipment with which he is most closely associated.

Less known to the machine tool community is the fact that The Warner & Swasey Co., Cleveland, builds textile equipment, road grading machines, and has a high rating as the manufacturer of large, delicate astronomical telescopes.

Ambrose Swasey, descendant of forebears who came to Salem, Massachusetts, from England in 1630, was born in 1846 at Exeter, New Hampshire, well within the magical compass circle we have described earlier as the incubator of machine tool firms. His first employment was at the local Exeter Machine Works, where he apprenticed.

Worcester Reed Warner started life on his family's fourth-generation farm near Cummington, in Western Massachusetts, also in 1846. Warner attended local schools and spent a year at a drafting and design institute in Boston before a whim of fate brought him to Exeter to work for the firm where his future partner was employed.

It seemed destined the two should be friends. They shared an interest in astronomy, both had ambitions of owning a machine shop, and both were more than usually creative. They worked, studied, dreamed, and planned. In 1870, they left Exeter to get additional on-the-job training at the Pratt & Whitney plant in Hartford, Connecticut.

Their talents blossomed under the enthusiastic supervision of creative management. Swasey designed and perfected a milling machine for generating spur gears, and another miller for machining epicycloidal gear cutters. Warner, though equally creative and industrious, leaned toward managerial interests and was soon in charge of a Pratt & Whitney department. He was named manager of the firm's display at the Centennial Exposition in Philadelphia.

Warner, Swasey Join Forces

By 1880, their plans were laid. Their experience had been gained, and Messrs. Warner and Swasey were ready to launch out on their own.

Like others of their area, they chose to leave the confines of the New England hills, and opened shop first in Chicago, then moved to East Prospect Street in Cleveland.

Ohio was still 'way out West for the machine tool industry, but not so far as Chicago, where the partners had found a critical shortage of skilled labor. Little had been done even in Cleveland by anyone in the promotion of quality machining. It is stated that the Warner & Swasey shop, though tiny and primitive by today's standards, offered better facilities than could be obtained anywhere in the U. S. West of Philadelphia at the time it was opened.

First Machine Tool Order

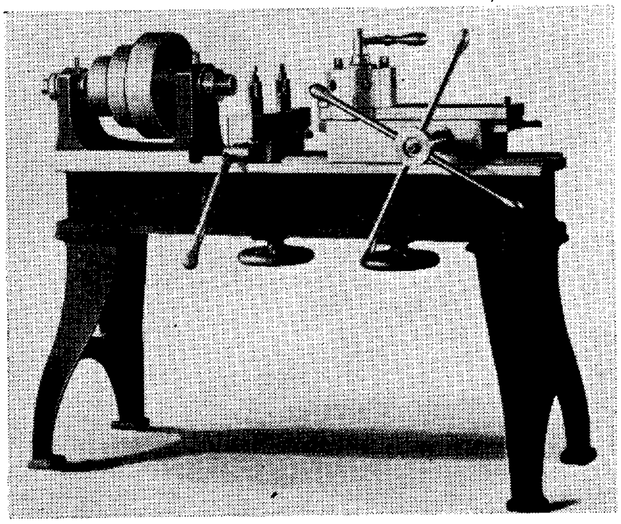
The firm began with an initial order for 10 small hand lathes, total sales price, $600 for the lot. Orders poured in, and they soon had to expand. When sewing machines came into popular use, these two men devised special milling machines needed in making sewing machine parts. The bicycle brought them business and when, in later years, the auto industry came to Detroit, their firm was ready and able to produce the specialized mass production machines needed.

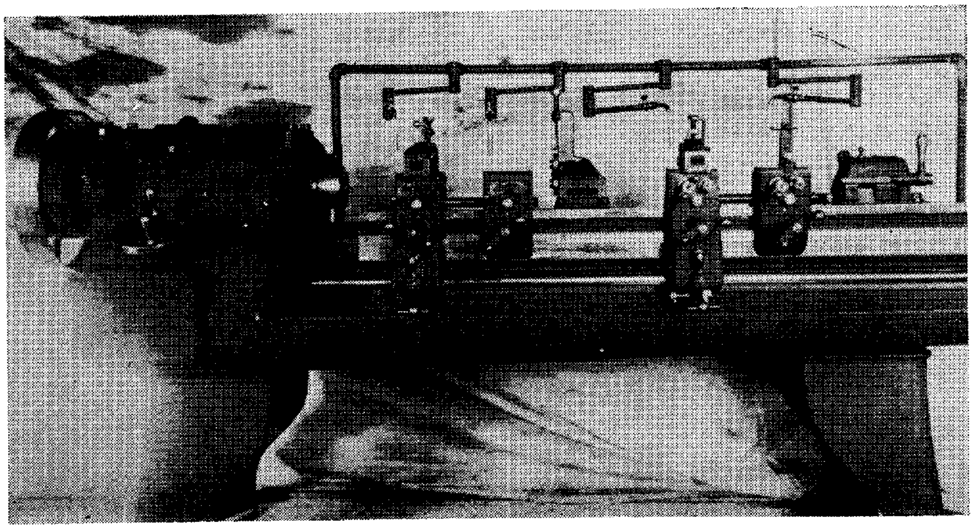
Most recently, Warner & Swasey has turned its attention to screw machines, building single and multiple-spindle automatics, and chuckers, for the industry.

Since the intent of this series is to trace the history of screw machines rather than to detail the features of each type machine, we

will not indulge in particulars here. Suffice it to say the Warner & Swasey automatics and chuckers depart from some of the conventional models to give the industry a cutting stroke flexibility without the traditional tool slide cam changing. The simplicity of design points out the company policy set by these two men who came from the New England area to form a machine tool firm in the midwest. The locale has changed, but the influence of the Yankee mechanic lingers on.

THIS old style turret lathe, built in 1881 by Warner & Swasey, is now on display at Ford Museum, in Dearborn, Michigan.





FIRST LoSWING lathe, built in 1905 by Seneca Falls Machine Co., was equipped with two power feed and two trailer turner carriages connected together by a right and left-hand lead screw. This arrangement facilitated setting tools the correct distance apart for cutting shoulders on the workpieces. A cylindrical tool holder provided side clearance for the cutting tool.

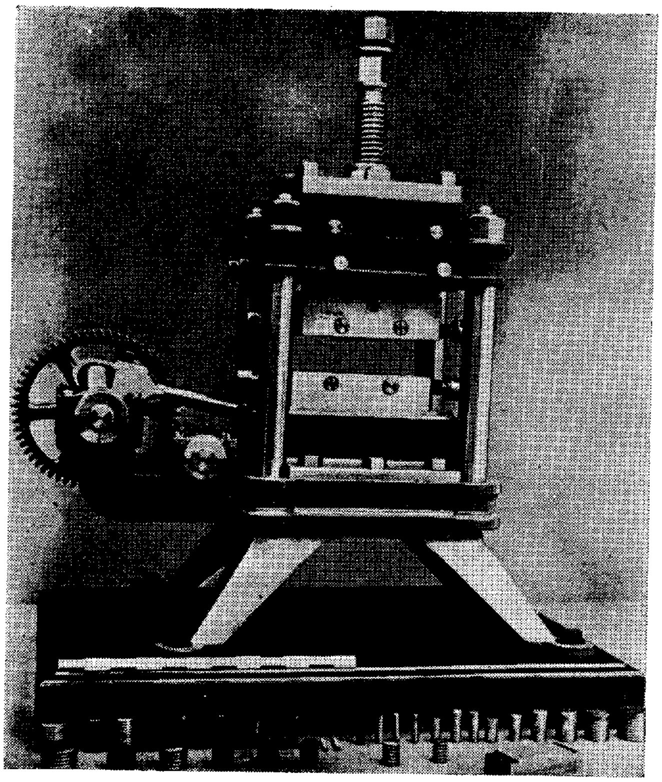
Seneca Falls Machine Co.

Though by the early 1900's machine tool firms were springing up throughout the midwest, many retained some ancestry in New England. Such a firm is Seneca Falls Machine Co., Seneca Falls, New York, manufacturer of the Lo-Swing lathe. Though not a true screw machine, this type of equipment has had vast influence on the automotive industry's metal turning techniques, and is a valuable accessory in many screw machine shops.

The firm began in 1864 as the Fitchburg Machine Works, Fitchburg, Mass. The first products were engine lathes, planers, radial drills and boring machines. In 1905, its engineers conceived the idea of the multiple tooling principle so familiar to users of Lo-Swing equipment. It found quick acceptance wherever jobs required that long shafts be turned.

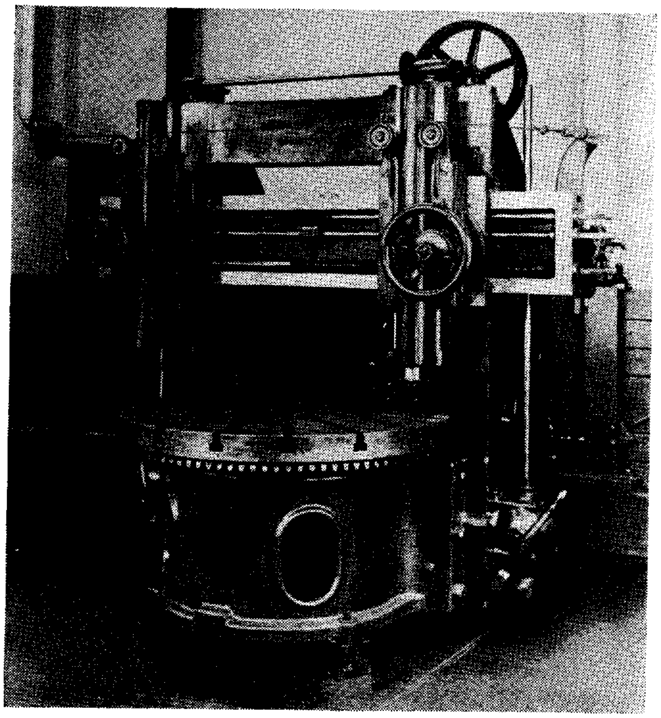
The efficiency made possible by using several tools cutting at the same time in a rigid setup under automatic conditions was a step in automation's progress. The engineers used rail-type mountings for the turning carriage, leaving the rear end open for work supports.

In 1924, Fitchburg bought out Seneca Falls Machine Co. and moved to the New York State site. This firm claims credit for being the first to offer hardened steel carriage ways on commercial lathes, and is believed to be a pioneer in producing a closed cycle automatic lathe equipped with anti-friction bearings and hardened cams running in oil. In 1927, automatic work loading devices were added, making it possible for one man to operate more than one machine. Ω



THREAD rolling machine, 1851, is now at the Science Museum, London.

Photo courtesy Reed Rolled Thread Die Co.



BULLARD boring mill, built in 1891 for The Bullard Co. by Bridgeport Machine Tool works, founded 1880.

from ARCHIMEDES

PART 7 (Conclusion): the

THREAD ROLLING, one of the fastest and most economical methods of producing threads on a work blank, has been known in principle for more than 100 years. It is believed to have been developed independently in Europe and the U. S. The first thread rolling patent was issued to Hazard Knowles, of Colchester, Connecticut, in April, 1831. His method provided for reciprocal flat die thread forming.

Many processes followed. By the 1870's, with screw machines coming into use, a few firms began to roll threads as a highly secret, and very crude, process.

The wrought iron and Bessemer steel available in these early days tended to fold and fracture easily. Roll threading fell into a disrepute which, even today, causes the layman to doubt the quality of a hardware item with rolled threads. "Rolled thread" was a term used to differentiate between a precise thread form, and those of inferior quality.

That, of course, is now in the past. To some extent, the screw machine trade can credit the rolling of threads on hot and cold extruded blanks with the loss of some screw machine jobs. This is overbalanced by the ease with which modern screw products can be roll threaded, however, and the ability of screw machines to produce threads close to the shoulders of work did not arrive until fast, accurate roll threading attachments had been developed at about the time of the first World War.

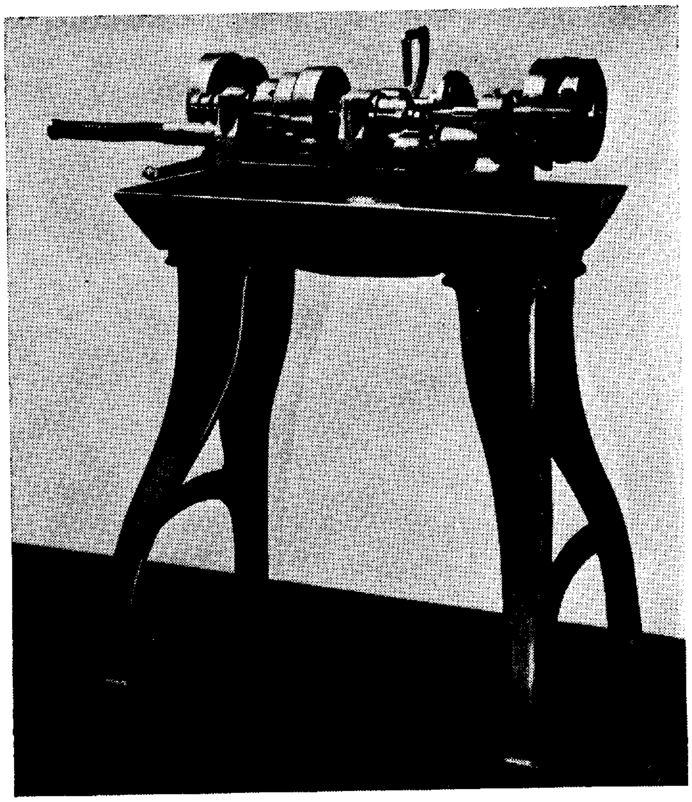
The Bullard Influence

Edward Payson Bullard, founder of the firm bearing his name, is a typical example of what can be achieved by an industrious man in spite of the worst possible circumstances. Born at Uxbridge, Massachusetts, Bullard lost his mother at age 3, his father at age 7. He was placed in the care of foster parents near Great Barrington, Massachusetts. After a farm boyhood, he was apprenticed at the Whitin Machine Works, Whitinsville, Massachusetts.

During a three year apprenticeship he was paid three shillings sixpence per day *(63 cents)* for the first year, and six shillings *(about one dollar)* in his graduation year. The Whitin system of quoting wages in shillings is a holdover

to AUTOMATION

history of the screw machine



FIRST automatic machine built by Cleveland Automatic Machine Co. in 1888. Featuring standard universal cams, this machine helped to revolutionize the American standards of production.

from colonial days, and was not dropped by this firm until 1907.

Bullard came to Whitin in 1858. Three years later he was faced with the choice of staying on *(his abilities assured him a job)*, or of looking elsewhere for work. With a letter from his Whitin foreman he took the two-day walk to Hartford, all of his earthly possessions on his back in a little bundle. The letter gained him a job at the Colt "pistol factory," where the Civil War was creating much work for the firm. Two years later Bullard moved to the Pratt & Whitney plant, by now making the top machinist's wage of the area, $2 per day.

In 1864 he married, and opened a general machine shop in Hartford, Bullard and Prest, in a former county jail building. Several new types of drill presses were built. The first of these is still to be seen at the Bullard plant in Bridgeport.

The depression following the Civil War, coupled with a Connecticut River flood which destroyed the new firm's tools and equipment, caused foreclosure. Bullard reorganized in Bristol, acquiring Gray's Foundry *(now the site of Session's Foundry Co.)* The business went broke in 1869.

He moved his family to Georgia, taking a job as plant superintendent, but hatred of the "damyankees" was still high. He moved to Cincinnati and set up as a used machinery dealer, handling war surplus equipment. This firm failed. In 1875, he formed the firm of Allis, Bullard and Co. in New York City, dealers in new and used machine tools. Allis soon withdrew, and Bullard assumed control.

His knowledge of machine tools gained him a reputation which drew machine tool company representation for the New York area. In one week during 1879 he sold $10,000 worth of equipment, a fabulous sales record for that era.

Some customers wanted machines he did not carry. He designed a new type 16-inch lathe, and had it built at Chicopee Falls, Massachusetts, and later at the Bridgeport Machine Tool Works when that company opened in 1880. He began to commute between Bridgeport and his other business in New York.

At his death at age 65, in 1906, four of his sons and a nephew held key positions in The Bullard Company. His New York business had been turned over to a trusted worker. His equipment was known around the globe.

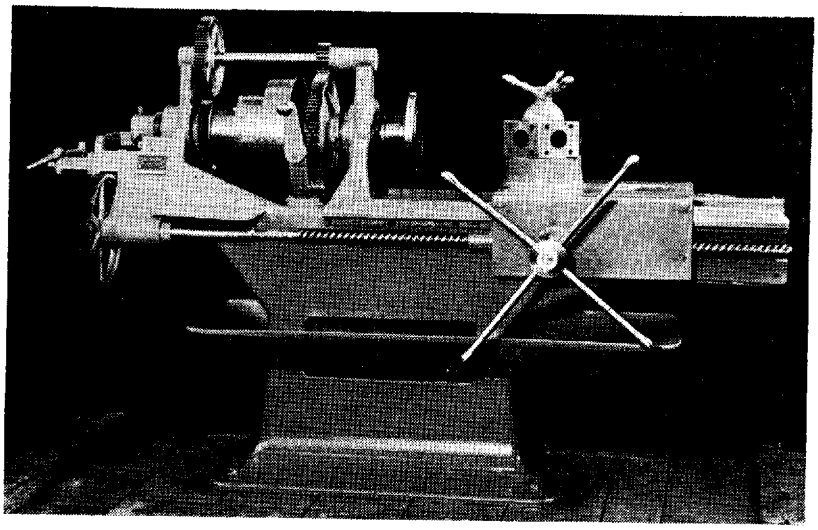
The big break for this firm came one day when Henry Ford was developing the techniques for making the "Tin Lizzy." Ford had managed to slash the time needed for making his car from one and one-half days to 93 minutes. His crying need was for a machine capable of mass producing certain parts to such close limits that interchangeability of components would be possible.

Sensitive to the needs of industry, the Bullard management team struggled with the problem night and day. Within a few months a new idea began to take shape—build a machine incorporating several individual machine tools in one; co-ordinate the operations automatically so that the one machine will perform all the jobs necessary to complete a given part.

Thus was born the multi-spindle tool known as the "Mult-Au-Matic!"

The principles of the new machine were outlined by E. P. Bullard, Jr., to his brother, Dudley Brewster, who collaborated in its development.

"On this machine—the longest operation should be done in the



1889 Model turret lathe skidded and ready for shipment to the new Hall of Tools at the United States National Division of the Smithsonian Institution as a donation from Gisholt Machine Co.

shortest time possible. All operations should be done simultaneously. Unloading, loading and chucking should be performed in the time of the longest operation. To do this, we require a multi-spindle machine wherein each spindle can be run at its own speed, and each tool slide should be fed at the exact feed desired. All spindles should be coordinated so that the overall operation is continuous, reducing time lost between cuts."

Finally the machine was built. Exhaustive tests were made, refinements introduced and bugs ironed out. The Mult-Au-Matic was ready for its debut!

Proceeding with his carefully planned approach, E. P. Bullard, Jr. headed for Detroit, where he arranged an appointment with Henry Ford. Would Ford consider a machine capable of machining a flywheel in two minutes? Ford, who had worked hard to get the time down to 18 minutes on the part, grinned and said, *"Cut my time in half and we'll do business."* Once installed in the Ford plant, the new Mult-Au-Matic produced a flywheel at intervals of just over 60 seconds.

The Mult-Au-Matic, although not a chucking machine in the usual sense, employs the principle of cams and gearing, work rotation and cross slide tooling associated with such machine tools. The machine offered the young auto industry a fast-cycle automatic machine for space and labor saving work. Its use throughout the world stands as the reminder that E. P. Bullard, a man with only a belief in himself and an idea as resources, can succeed.

LeBlond

In 1883, R. K. LeBlond, with only two employees, set up shop to make printing type molds, gages, and small accessories for the printing trade. In 1889, his brother, John A. LeBlond, joined him. The little company began to build lathes and lathe attachments in 1891. In this connection, Nicholas Chard, of the Lodge & Davis Co. joined the LeBlonds, but his interests were bought out when he became concerned with the finances of the business in the panic of 1893. From that date, the company concentrated on producing 14, 16 and 18-inch lathes and small single and multiple-spindle drill presses. In 1898, the firm moved from its downtown Cincinnati site to the suburban Linwood area, and in 1918, to its present Norwood plant. Subsidiaries of the firm now are: The Cleveland Automatic Machine Co., J. H. Day Co., and Fosdick Machine Tool Co.

Lodge & Shipley

William Lodge, founder of Lodge & Shipley Co., was born in Leeds, England, in 1848 and came to Cincinnati where he worked for John Steptoe and Co., a milling machine manufacturing concern. Lodge's first company was in partnership with William Barker. In 1886, Barker sold his interests to Charles Davis, and Lodge & Davis was formed. In 1892, Lodge left to found Ohio Machine Tool Works, which continued for a year until the name was changed to The Lodge & Shipley Machine Tool Co. In that same year, 1893, the firm developed its Five-Step Cone Lathe. A year later quick-change gearing was announced, and about 1900 the Three-Step Cone Double Back Geared Lathe came into being.

Gisholt

As a child, John Anders Johnson left Norway in 1844 and settled with his parents in Milwaukee. He worked as a farm helper, taught school, and took a job selling farm machinery. In 1862, he entered partnership with Morris E. Fuller in the farm implement business. Soon a third partner, Samuel Higham, joined the firm at the time the Madison Plow Co. was acquired.

C. N. Conradson, inventor of a power windmill, came to work at what was now known as Fuller & Johnson Co. In the production of windmill and farm implement parts, the plant had a need for

machine tools, leading to the development of a tool grinder for lathe and planer tools. In another project, the firm converted an old engine lathe into a turret lathe. The lathe was efficient. Larger models were built, and since a demand for them seemed to be present, a separate organization was set up as a machine tool division. The new organization took the name "Gisholt," the name of the Johnson family homestead in Norway. Gisholt was organized January 22, 1889.

As the business grew, Gisholt built a new shop, now known as The Main Works, in Madison, Wisconsin. From the $40,000 original incorporation the company has grown to a worth of more than $10 million. Buildings cover 14 acres of floor space. The firm's basic products remain the familiar ram and saddle-type turret lathes, three kinds of chuckers, automatic turret lathes, and special machine tools.

Greenlee

As will be seen from this section of the screw machine history, not all firms had their roots in New England. Some sprang up in the midwest, often from firms in other lines, but always as the result of a demand for a product capable of producing turned parts, faster, cheaper, better, or all three.

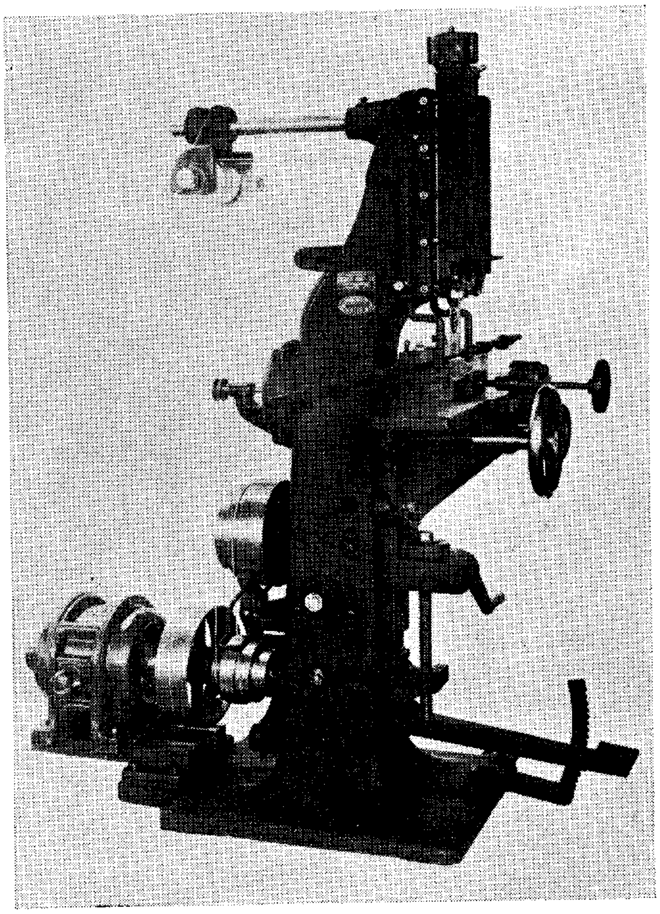
In 1866, identical twins, Ralph S. and Robert L. Greenlee, opened a machinery sales office in Chicago. The Chicago Fire wiped out the available used machine tools of the area, and the brothers set out to fill the gap by making a line of wood working machinery. In 1876, they developed a hollow chisel mortiser, popularly known as the "machine that bores a square hole." Efforts remained in the woodworking field up through the year 1904. Meanwhile, the company had moved to Rockford, Illinois.

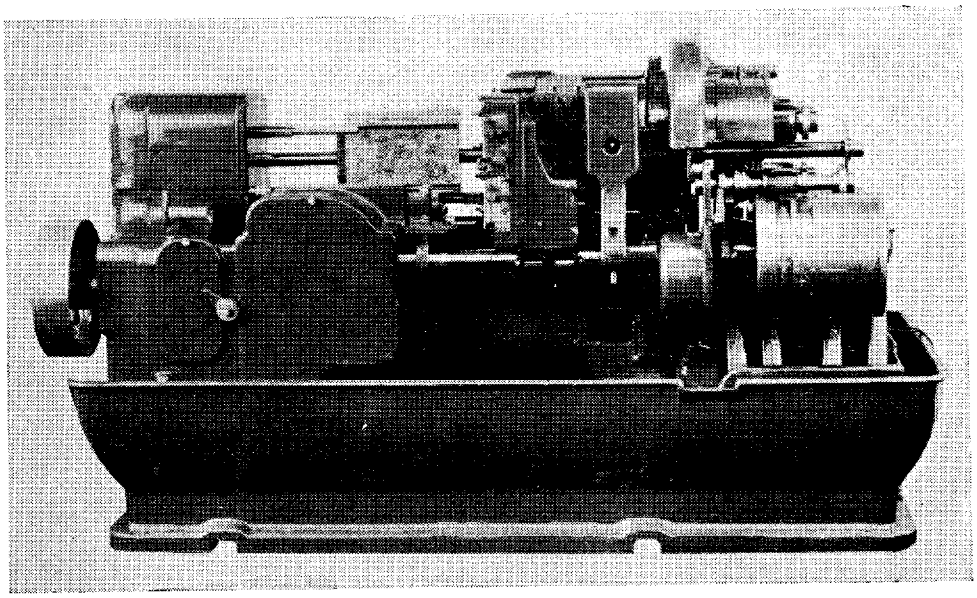
Automation is thought by many to be a product of the Detroit automobile industry's need for in-line production. Still, as early as 1908, Greenlee Bros. & Co. was building and marketing a transfer line machine for adzing, boring, and trimming wooden railroad ties. In 1915, this automation know-how was applied by the firm to a line of metalworking machine tools.

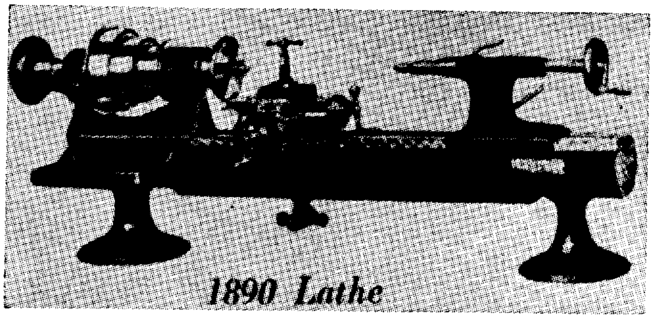
In the 1930's Greenlee brought out its first fully automatic transfer line for machining engine blocks. In 1927, a four-spindle bar automatic was introduced, soon followed by the six-spindle Greenlee bar automatic. Air feed screw machines were introduced not much later to meet a demand for even faster machining rates.

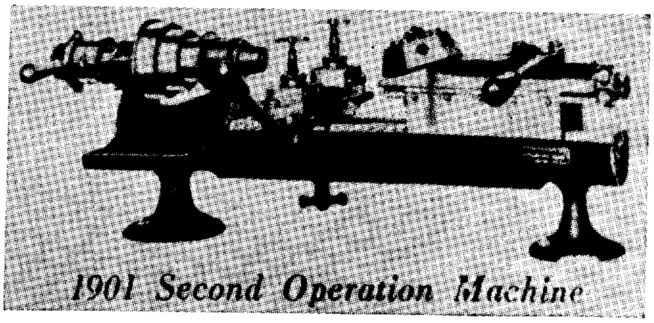
Though a small tools and woodworking division, and a foundry,

MODEL 227-B, first type of vertical powerfeed hollow chisel mortiser, (right) manufactured about 1920 by Greenlee Bros. & Co. Below is an early model 1¼ four-spindle Greenlee automatic.









FIRST Hardinge lathe (left) built in 1890; and a Hardinge second operation machine built in 1901 (right) when the firm was headquartered in Chicago. Other early Hardinge products were collets and feed fingers.

are still prominent parts of Greenlee Bros. & Co., the versatile, easily-tooled, fast and accurate Greenlee bar automatic is perhaps the best known to readers of *Automatic Machining*. In Rockford, Illinois, this firm is known as a good citizen; 17 percent of its employees are in the Greenlee Twenty-Year Club, and every effort is made to live up to the company motto, *"Greenlee Grows with Rockford."*

Hardinge

Enter almost any shop where precise work is performed and the name "Hardinge" will be found on some item. This equipment may be a Hardinge chucking machine, a bench lathe, or a secondary lathe. The equipment may also well be the collets and feed fingers in any of the makes of automatic screw machines.

On Labor Day, 1925, Morrison Machine Products, Inc., moved from Rochester, New York, to what had been the Westside carbarns on College Avenue in Elmira, New York. At this point, the firm became the first independent manufacturer of collets, feed fingers and pads for all makes of automatics, chuckers, and lathes. In 1931, Hardinge Brothers, of Chicago, builders of machinery and collets since 1890, moved its facilities to Elmira. In 1938 the companies were merged, thus putting the products of both firms under the same management. The firm has continued to be known as Hardinge Brothers since that date.

The Chucking Machine

It has been said that the history of the chucking machine can be traced to the potter's wheel, one of man's first mechanisms; paintings of such equipment have been found dating to 1800 B. C. in Eurasion tombs. The potter placed his blob of material upon a revolving wheel, fashioned it internally and externally by hand much as today's high speed and carbide tools produce a finished product from a chucked work blank.

As will be readily recognized, the automatic chucking machine is a direct outgrowth of pioneer work in the lathe and multiple-spindle fields. It is, after all, an automatic screw machine used for castings, forgings, or work blanks, rather than for end-to-end production from bar stock.

Originally, both chucking and bar machines were designed to produce only one piece at a time. The advent of the multiple-spindle principle ended that. One of the first multiple-spindle chucking machines of record was built in 1891 by George C. Prentice & Co., Inc., New Haven, Connecticut. It employed rotating tools, chucked but stationary workpieces, to produce brass and steel parts for the plumbing and bicycle trade.

In 1911, New Britain Machine Co. bought out the Prentice firm and Robert S. Brown, well known machine tool designer and inventor, was assigned to work on this pioneer chucker. In 1912, New Britain brought out its line of single and double-ended chuckers for working on parts requiring one-end work, work on both ends, and for secondary work on partially completed blanks.

The tools were made to reciprocate; the chucks had moved endwise before. Air and hydraulic chuck actuators were added. Antifriction bearings were used, and a Geneva indexing system allowed fast, precise positioning of the spindles for progressive operations on each piece. This line of machines was carried by the company with few changes through 1924. During World War I, the company had built many special-purpose machines for the war effort.

The first line of work-rotating chuckers made by this firm was

announced in 1924. It was an adaptation of the New Britain Model No. 206 multiple-spindle screw machine. Equipped with eight-inch chucks, it had four spindles, although mounted in a six-spindle screw machine frame. It was developed for the production of ball bearings. The machine, because of its conversion from a screw machine, was of the closed-end type.

Meanwhile, George O. Gridley, mentioned in detail earlier in this series, had come to Hartford and was building a line of Gridley-type machines featuring swinging cross slides. In 1929, Gridley merged with the New Britain Machine Co. and, working with New Britain engineers, developed the line of open-ended chucking machines. In 1935, the company introduced its Model 675 open-end chucker.

Since then, the basic machine has been improved into the current line of four, six and eight-spindle models ranging up to 12-inch chuck capacity. All are equipped with hydraulic chucks, carrier lifting mechanism *(a New Britain feature which causes the spindle carrier to rise from its bearings during indexing to reduce spindle carrier bearing wear)*, rotating and locking mechanisms and the Gridley turret. Depending upon the type of work to be done, the cross slides may be the swinging type, or flat.

Summary

Time and space do not permit the mention of the long list of machine tools in the screw machine industry whose history would be equally as interesting as those covered in detail. The editor has endeavored to select those facts which seem to be milestones in the development of the industry from its primitive beginnings to its present state of automation.

We have come far since Maudslay hand-hacked the first lead screw, or Besson built the first all-metal lathe.

Yet, even greater things lie ahead.

It can be predicted with certainty that cams, as we know them today, will be superseded by simpler actuating mechanisms. The advance of tape controls in other lines assures that tape-controlled bar automatics will be with us . . . . . perhaps sooner than we suspect.

The building block concept of machine tool design already announced by one maker of screw machines, will change our thinking; the screw machine in the near future may become simply one item in transfer line production in the advanced shop.

Quick changing and pre-setting of harder, and still harder, tools will change the concepts we now hold.

Just as Spencer could not foresee the day when spindle stopping and cross tapping, drilling, milling would be commonplace, the innovations of the future are hidden from the present day shop man.

There are those who predict the screw machine will be as dead as the carbon steel tool bit in the near future. With this we cannot agree.

Changes will come, just as they have in the past 99 years since the first automatic was built; the screw machine industry *must* change, or be trodden under foot in the rush for better automation. It *will* change, improve, shift and roll with the trends.

But above all, a history of the screw machine industry points up one factor: For every advance in technology there has been a man who came face to face with an idea, often an idea which contradicted recognized practice. History shows that men will stubbornly pursue such ideas in the face of almost overwhelming hardship and discouragement.

A man and an idea. There lies the future of our trade. ——Ω