

Hughes Two-Cone Drill Bit

Designated a Historic Mechanical Engineering Landmark
by The American Society of Mechanical Engineers

August 10, 2009

The Woodlands, Texas



HISTORIC MECHANICAL ENGINEERING LANDMARK

HUGHES TWO-CONE DRILL BIT

1909

AFTER SEVERAL YEARS OF EXPERIMENTS, HOWARD HUGHES, SR. AND WALTER SHARP INTRODUCED A NOVEL DRILL BIT IN 1909 FOR OIL DRILLERS, SUITED TO DEEP BORING THROUGH MEDIUM AND HARD ROCK. UNTIL THEN, THE RUDIMENTARY "FISHTAIL" BIT LIMITED DRILLERS TO RESERVOIRS NEAR THE SURFACE. THE "TWO-CONE" DRILL BIT, REPRESENTED HERE BY THIS EARLY PRODUCTION MODEL, BECAME THE CRUCIAL TOOL FOR TAPPING VAST, DEEP OIL FIELDS, FIRST IN THE U.S. GULF COAST AND THEN AROUND THE WORLD. TODAY, ROLLER-CONE DRILL BITS IN USE WORLDWIDE STILL RELY ON DESIGN PRINCIPLES INTRODUCED BY THE HUGHES TWO-CONE DRILL BIT.



THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS 2009



Howard Hughes, Sr., preparing to run the first Two-Cone Bit.

Hughes Two-Cone Bit



Early Industry Days

In the early days of the Texas and Louisiana oil industry, just after 1900, the rotary drilling system enjoyed wide acceptance. At the time, the rotary rig used only one type of bit for all formations: the fishtail. This system worked exceptionally well when drilling loose formations and those prone to caving, but suffered from one persistent weakness: The rotary system could not drill efficiently in medium- and hard-rock formations. This shortcoming limited oil drillers to petroleum reservoirs located just beneath the surface.

When rotated in medium- and hard-rock formations beneath a heavy string of pipe, the fishtail bit scraped a borehole slowly. Even a fishtail bit of the hardest steel would wear down rapidly to blunt stubs and lose gauge without achieving any appreciable penetration. The hole would have to be reamed to full size before drilling progress could resume.

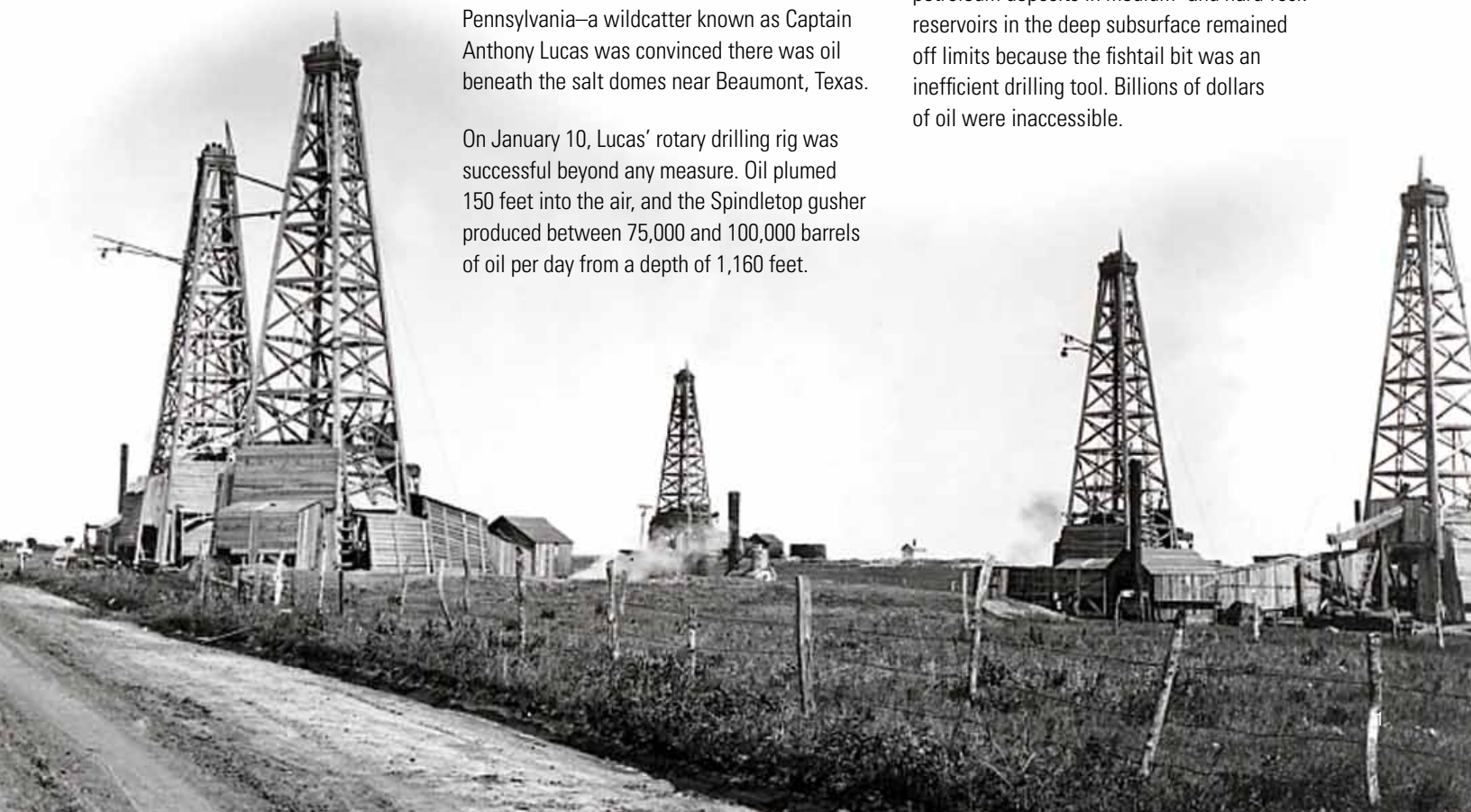
Drillers recognized this inefficiency in time and money, but a satisfactory solution remained elusive.

In January 1901—forty-two years after the first US oil well was drilled in Titusville, Pennsylvania—a wildcatter known as Captain Anthony Lucas was convinced there was oil beneath the salt domes near Beaumont, Texas.

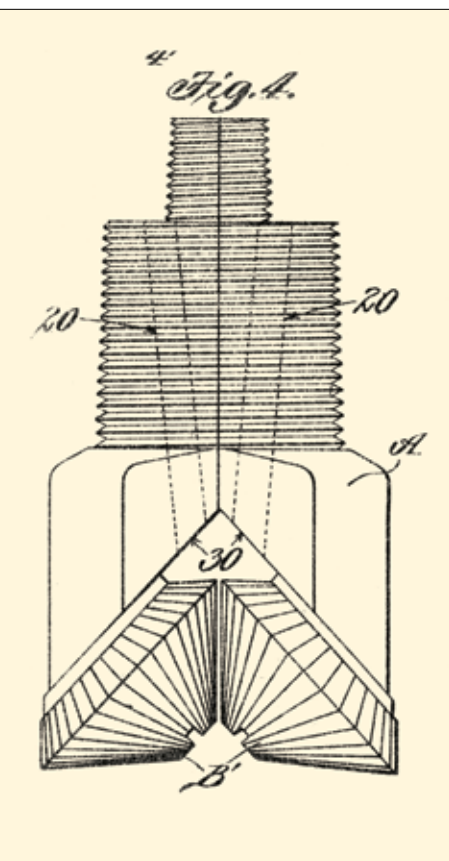
On January 10, Lucas' rotary drilling rig was successful beyond any measure. Oil plumed 150 feet into the air, and the Spindletop gusher produced between 75,000 and 100,000 barrels of oil per day from a depth of 1,160 feet.

The oil industry spread rapidly along the Texas and Louisiana coasts and moved north into the Mid-Continent region of Oklahoma. In 1905, another huge strike occurred in Glen Pool, near Tulsa, Oklahoma. Oil was discovered in formations other than salt domes in California and the Rocky Mountains.

Drillers were on the move, and petroleum was becoming an essential ingredient to lubricate and power the wheels of American progress. In the oil fields, steel structures soon replaced wooden derricks, drilling mud technology evolved, and blowout preventers were developed and refined. But the big prize of petroleum deposits in medium- and hard-rock reservoirs in the deep subsurface remained off limits because the fishtail bit was an inefficient drilling tool. Billions of dollars of oil were inaccessible.



Howard Hughes' Revolutionary Invention



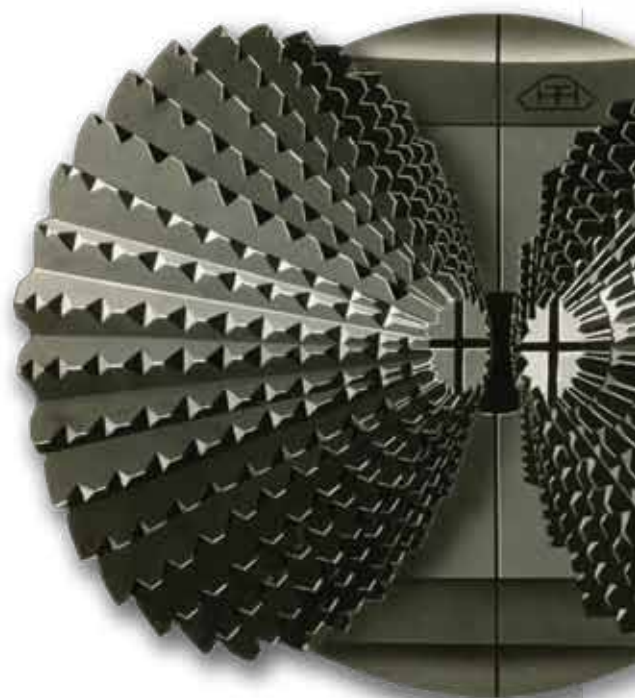
News of the Spindletop gusher, a seminal moment in U.S. energy history, was exciting stuff to thirty-one year old Howard Robard Hughes, Sr., of Lancaster, Missouri, who had quit practicing law to work in the lead- and zinc-mining business. As did many others, he traveled to Beaumont, hoping to strike it rich as had Captain Lucas. Although history records Mr. Hughes and his business partner, Walter Sharp, had experienced success in their early oil-drilling ventures, they were quickly frustrated by the slow rate of penetration in harder formations. The fishtail bit simply could not achieve sufficient drilling progress.

Around 1906, Mr. Hughes began to conduct experiments on a rock bit designed to replace the fishtailbit. In 1908, Mr. Hughes and Mr. Sharp built the first wooden model of a roller-type bit with two cone-shaped cutters.

They tested this experimental bit in Goose Creek, Texas; the pipe twisted off, but a second bit test proved successful. According to a Hughes Tool Company biography, Mr. Hughes "drilled fourteen feet of hard rock in eleven hours, brought in a well, and thus discovered the Goose Creek field, which became one of the greatest oil fields in the Gulf Coast region."

Instead of scraping the rock, as does the fishtail bit, the Hughes bit, with its two conical cutters, took a different engineering approach. By chipping, crushing, and powdering hard-rock formations, the Hughes Two-Cone Drill Bit could reach vast amounts of oil in reservoirs thousands of feet below the surface. This new drilling technology would revolutionize the industry.

Immediately following the successful drill bit tests, the partners founded the Sharp-Hughes Tool Company in 1909. The first shop to manufacture the bit occupied a 20-foot by 40-foot rented space. Later that year, on August 10, 1909, the US Patent Office affirmed and protected the intellectual property rights of the invention with a patent granted to Mr. Hughes.



Following the death of Mr. Sharp in 1912, Mr. Hughes purchased his half of the business. The company was incorporated in Texas in 1915 and became the Hughes Tool Company.

By that time, the Hughes Two-Cone Drill Bit, which unlocked the full potential of the rotary drilling system, had been used successfully in eleven US states and thirteen foreign countries. The bit and the rotary drilling system were pioneering inventions that paved the way for the development of technologies and processes still used in the oil field today.



H. R. HUGHES.

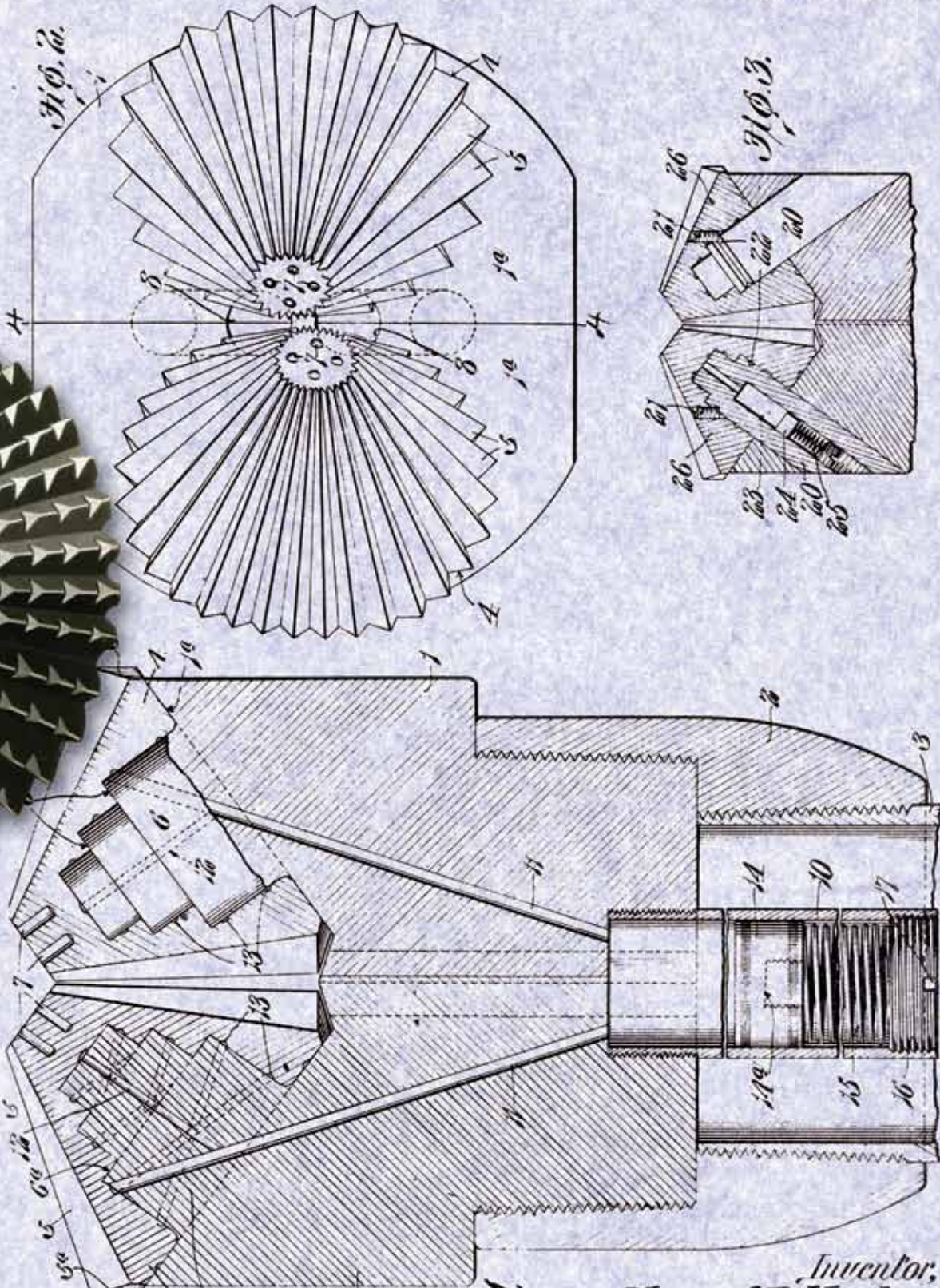
DRILL.

APPLICATION FILED NOV. 20, 1908.

930,759.

Patented Aug. 10, 1909.

2 SHEETS—SHEET 1.



Witnesses:
George E. Adams
Nels L. Church

Inventor,
Howard R. Hughes.
Fig. 1. by Baker & Cornwall Attys.

Industry Step Change



In the 19th century, the rig technology was simple to use, but slow to operate. Known as cable-tool drilling, a steel cable with a bit was dropped repeatedly on the hole bottom. After a few repetitions, drilling stopped so the rock cuttings could be hauled to the surface and drilling would resume. The start-and-stop operation didn't make much progress penetrating the subsurface: A crew could drill only about 25 feet a day.

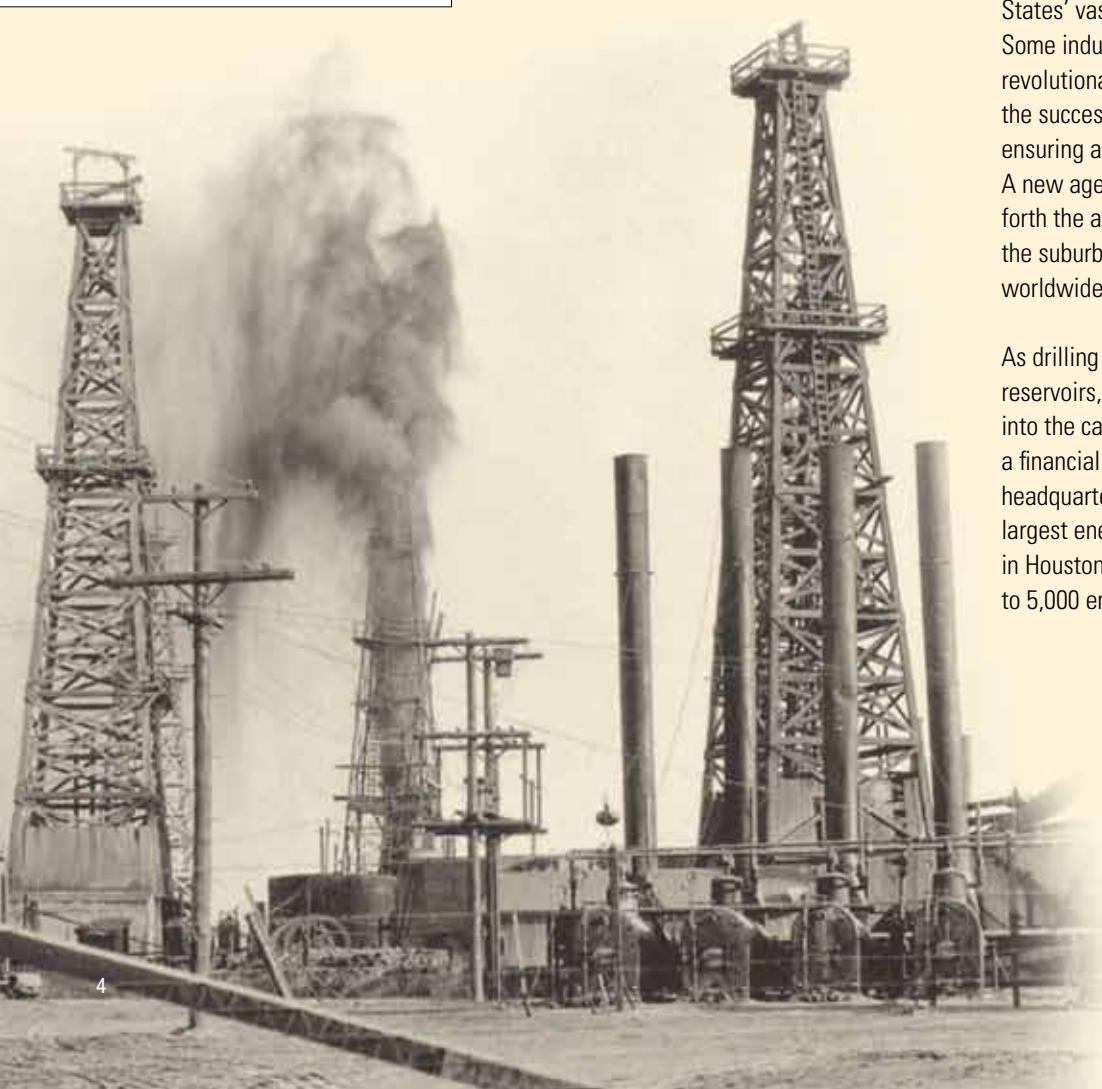
On August 27, 1859, cable-tool drilling launched the modern petroleum industry in Titusville, Pennsylvania. Edwin L. Drake, a former railroad conductor who was persuaded by a banker to buy stock in the Pennsylvania Rock Oil Company, drilled the first successful US oil well all the way to 69.5 feet. Oil floated up to within six feet of the surface.

Soon, there was a better system although the limitation of going deep remained.

Many historians look to the Spindletop gusher in east Texas and the switch from the cable tool rig to the rotary drilling rig as the beginning of the cheap-oil era. With the invention of the Hughes Two-Cone Drill Bit, the latent potential of the rotary drilling system was finally realized. This new method of drilling opened up huge supplies of oil in Texas, Louisiana, Arkansas, Oklahoma, and California.

The tools required for tapping the United States' vast oil resources were now at hand. Some industry experts believe Mr. Hughes' revolutionary drilling technology enabled the success of Henry Ford's new Model T by ensuring abundant supplies of cheap fuel. A new age of liquid fuel was born, bringing forth the automobile, a network of highways, the suburban way of life and, eventually, a worldwide network of commercial aviation.

As drilling expanded into deeper, larger reservoirs, Houston, Texas, quickly developed into the capital of the US oil industry and a financial power center. Eventually, the headquarters of eight of the world's ten largest energy companies would be located in Houston. In all, the city would become home to 5,000 energy-related businesses.



The Hughes Two-Cone Drill Bit comprised two detachable, cone-shaped cutters of hardened steel. (See drawing on the next page.) The cones, each with 166 cutting edges, revolved on bronze pin-bushing bearings shaped to provide a large surface with reduced friction. The bushings were lubricated by means of oil holes drilled through the head and run to an oil valve on the lubricator.

The detachable cutters could be removed for sharpening or replacement when dull. Unlike the fishtail bit, the Hughes Two-Cone Drill Bit rolled in a true circle, crushing and grinding the rock.

This rolling motion allowed the cutting edges to chip the rock, one edge after another. Significantly, the cutting edges were designed so they would avoid

falling into previous cuts, preventing what is known as tracking. This enabled each edge to continuously crush a new portion of the rock. The absence of pure scraping of the fishtail bit allowed the Hughes Two-Cone Drill Bit to drill faster and further before sharpening.

The bottom of the drill hole, as formed by the operation of the bit, was a perfect seat for a water-tight joint, preventing leakage after the casing had been set.

A new era of oil-well drilling had begun.

In 1933, twenty-four years after Mr. Hughes' invention and nine years after his sudden death, Hughes Tool Company engineers developed advancements to the original Two-Cone Bit concept. The company commercialized the Tricone™

three-cone bit, which quickly became the industry standard. During the Tricone bit's seventeen-year patent protection, the company's market share approached 100 percent.

Today's roller cone bits still utilize the same basic concepts introduced by Mr. Hughes in 1909. Over the years, extensive research and development has resulted in new seals and bearings, improved carbide cutters, and superior lubrication. But, in the end, it is the bit's ability to crush and powder rock with a simple rolling motion that makes the roller cone the preferred method for drilling many formations even today. This year, 2009, marks the 100th anniversary of Mr. Hughes' revolutionary invention.

Case Study: Fishtail versus Two Cone

The House No.1 well of the Producers' Oil Co., Humble, Texas, struck rock at a depth of 1,819 ft., after which the fishtail bit bored 38 ft. in 19 days, an average of 2 ft. per day. The cone bit was then substituted and bored 72 ft. in 6 days or 12 ft. per day, a six-fold increase in performance, resulting in a 75% reduction in cost-per-foot.



Standard Fishtail Bit

Day crew

4 Men, \$3 per day, 19 days	\$228.00
1 Driller, \$200 per month, 19 days	126.67

Night crew

4 men, \$3 per day, 19 days	228.00
1 night driller, \$5 per day, 19 days	95.00

Dressing 38, 9-in. fishtail bits at \$2.25	85.50
Steam and water, 19 days at \$10	190.00

Total cost for 38 ft. of 9-in. hole	\$953.17
Average cost-per-foot	<u>\$25.08</u>



Hughes Two-Cone Bit

Day crew

4 Men, \$3 per day, 6 days	\$72.00
1 Driller, \$200 per month, 6 days	40.00

Night crew

4 men, \$3 per day, 6 days	72.00
1 night driller, \$5 per day, 6 days	30.00

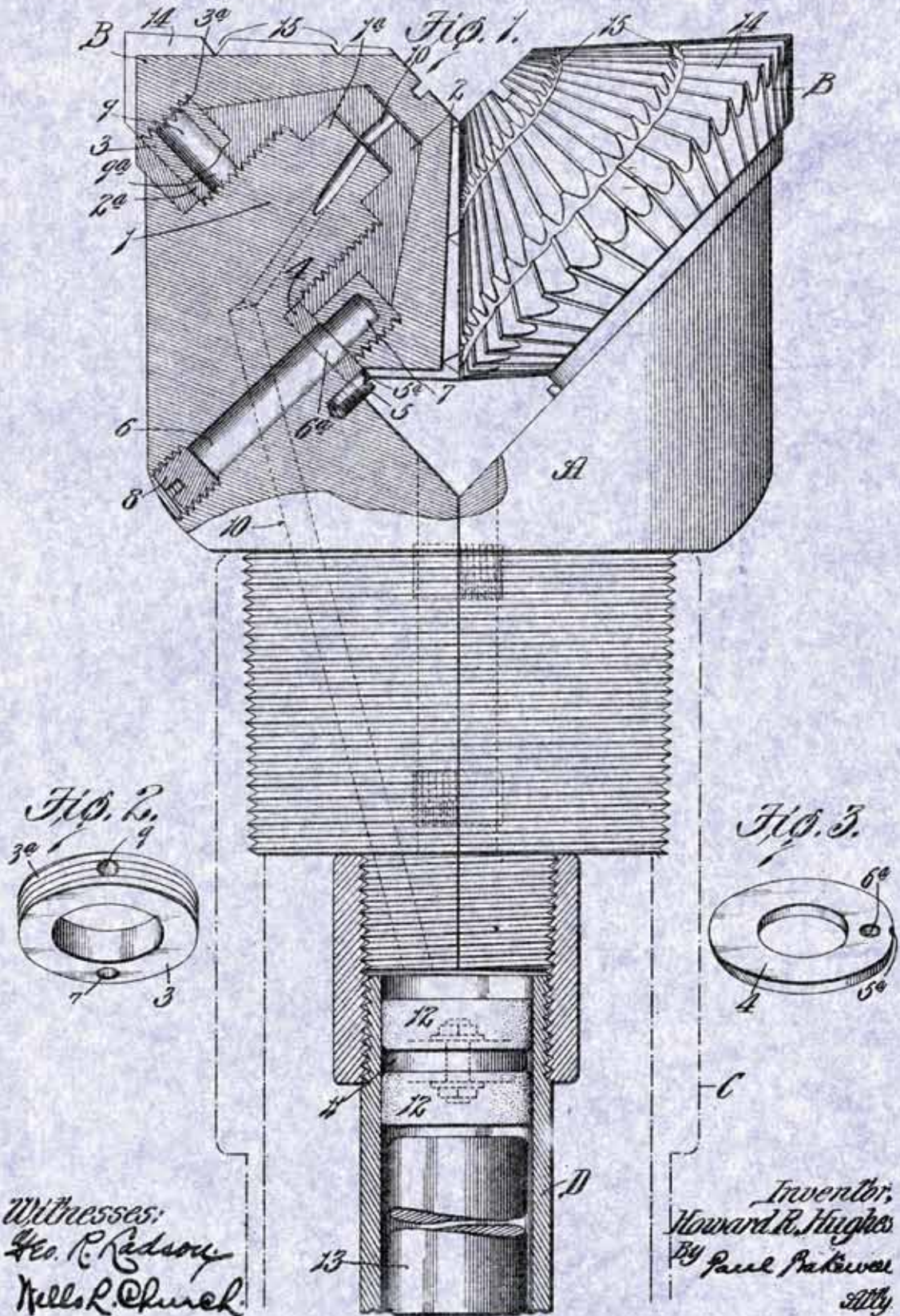
Steam and water, 6 days, at \$10	60.00
Rental of bit for 30 days	50.00
3 sets of cones at \$45	135.00

Total cost for 72 ft. of 9-in. hole	\$459.00
Average cost-per-foot	<u>\$6.38</u>

H. R. HUGHES.
 ROLLER BORING DRILL.
 APPLICATION FILED MAY 29, 1910.

979,496.

Patented Dec. 27, 1910.



Witnesses:
 Geo. P. Redson
 Nellie R. Church.

Inventor,
 Howard R. Hughes
 By Paul Parker
 Atty



Howard Robard Hughes, Sr.

September 9, 1869–January 14, 1924



"We purpose never to be satisfied but will continue, with the help of our experienced engineers, to anticipate the requirements of the drilling industry."



The son of a successful lawyer, Howard Robard Hughes, Sr., was born in Lancaster, Missouri, on September 9, 1869. He spent his childhood years in Keokuk, Iowa. Hughes followed in his father's professional footsteps for a while after studying law at Harvard University and the University of Iowa. But, he would soon leave the Keokuk law practice for the lure of the lead- and zinc-mining business near Joplin, Missouri.

Just months later, at age 31, news of the Spindletop gusher in Beaumont, Texas, captured his imagination. Hughes traveled to Texas shortly after the January 1901 seminal moment in US energy history. He and his friend and business partner, Walter Sharp, thrived as wildcatters.

But, during those early days of the oil industry, drillers could not reach the big prize of oil under medium-to hard-rock formations. The common fishtail bit would dull quickly with little rate of penetration.

Mr. Hughes had a better idea.

He designed a rock bit with two conical cutters to unlock the full potential of the rotary drilling rig, enabling a rapid penetration rate. About three years after he began working on this challenge to develop improved drilling technology, Mr. Hughes invented the Two-Cone Drill Bit with two detachable, cone-shaped cutters of hardened steel. The US Patent Office issued a patent on August 10, 1909. The Sharp-Hughes Tool Company was born.

The partners instinctively understood the necessity of research and development to keep the company at the forefront of technological innovation. "We purpose never to be satisfied but will continue, with the help of our experienced engineers, to anticipate the requirements of the drilling industry," Mr. Hughes said.

In 1910, a year after the company's founding, the partners opened the industry's first research laboratory to study rock

bit performance. To this day, a culture of continuous improvement in drill bit technology remains the company's hallmark.

Mr. Sharp died in 1912, and Mr. Hughes purchased Sharp's half of the business. In 1915, the Hughes Tool Company was incorporated in Texas.

During the remainder of the decade and into the early years of the 1920s, Mr. Hughes was granted a total of 73 patents for his inventions connected to rotary drilling.

One invention, unrelated to the petroleum industry, was a horizontal boring or tunneling machine designed for the U.S. military during World War I. The machine would have enabled Allied soldiers to drill a hole from their trench to the enemy's trench as a means of sending explosives behind enemy lines.

U.S. Secretary of War Newton D. Baker stated in a letter dated December 18, 1920, to Mr. Hughes: "I wish to...express the appreciation of the War Department...The change to open warfare, which followed shortly after our active entrance into the war, made this type of machine practically unnecessary. (This does not) lessen the obligation which the War Department feels toward you for the personal interest and effort."

Mr. Hughes died of a heart attack on January 14, 1924. His son, Howard Robard Hughes, Jr., eighteen and an only child with deceased parents, soon dropped out of Rice University to manage the daily operations of Hughes Tool Company.

Hughes Christensen, a Baker Hughes product line

In 1972, Howard Hughes Jr. sold Hughes Tool Company in an initial public offering. Fifteen years later and seventy-eight years after its founding, Hughes Tool Company merged with Baker International. The new company began operations under the name Baker Hughes.



In 1990, Baker Hughes acquired Eastman Christensen, which had evolved from the original Christensen Diamond Products Company founded March 1944 in Salt Lake City, Utah. Christensen Diamond Products introduced the first surface-set natural diamond core bit into the oil field in Rangely field, Colorado, three years after its founding.

In 1992, Baker Hughes merged the two divisions—Eastman Christensen and Hughes Tool Company—into Hughes Christensen Company. This Baker Hughes product line has invested in more research and development, received more patents, and led the industry with more firsts than any other drill bit manufacturer.

With Tricone, PDC, borehole enlargement, casing/liner, ream-while-drilling, and impregnated bit technology, Hughes Christensen's talented workforce creates products that drill faster, stay in the hole longer, and lower the cost-per-foot drilled for global oil and gas operators.

In 2009, Hughes Christensen observes its 100th year of service to the oil industry, beginning with Mr. Hughes' Two-Cone Drill Bit patented in 1909.

Baker Hughes observed its 100th year of service to the industry in 2007. Baker Hughes traces its beginning to the technological innovation and entrepreneurial spirit of Reuben Carl Baker who patented the casing shoe in 1907.



The History and Heritage Program of ASME

The History and Heritage Landmarks Program of ASME (the American Society of Mechanical Engineers) began in 1971. To implement and achieve its goals, ASME formed a History and Heritage Committee initially comprised of mechanical engineers, historians of technology, and the curator of mechanical engineering at the Smithsonian Institution, Washington, D.C. The History and Heritage Committee provides a public service by examining, noting, recording, and acknowledging mechanical engineering achievements of particular significance. This History Committee is part of ASME's Center for Public Awareness. For further information, please contact Public Information at ASME, Three Park Avenue, New York, NY 10016-5990, 1-212-591-8614, and <http://www.asme.org/history>.

Designation

Since the History and Heritage Program began in 1971, approximately 250 landmarks have been designated as Historic Mechanical Engineering Landmarks, Heritage Collections, or Heritage Sites. Each represents a progressive step in the evolution of mechanical engineering and its significance to society in general. Site designations note an event or development of clear historical importance to mechanical engineers. Collections mark the contributions of several objects with special significance to the historical development of mechanical engineering.

The Landmarks Program illuminates our technological heritage and encourages the preservation of the physical remains of historically important works. It provides an annotated roster for engineers, students, educators, historians, and travelers. It helps establish persistent reminders of where we have been and where we are going along the divergent paths of discovery.

The 120,000-member ASME is a worldwide engineering society focused on technical, educational and research issues. ASME conducts one of the world's largest publishing operations, holds some 30 technical conferences and 200 professional development courses each year, and sets many industrial and manufacturing standards.



Acknowledgements

The Hughes Christensen product line of Baker Hughes acknowledges the following individuals for their work in the nomination process, brochure development, and designation ceremony where the plaque was awarded: Howard Batt, Bruce Goldfaden, Bobby Grimes, Joseph Jaques, and Glenn MacDonald.

ASME International

Amos Holt, *President*
John Hawkins, *P.E., District E Leader*
Clark McCarrell, *P.E., Senior Vice President, Centers*
Capt. Vincent Wilczynski, *Vice President,*
Center for Public Awareness
Thomas G. Loughlin, *CAE, Executive Director*
Marina Stenos, *Director, Public Awareness and*
Leadership & Diversity
Edward Kudlis, *Coordinator, Centers Projects*

ASME History and Heritage Committee

Richard I. Pawliger, *P.E., Chair*
Robert Casey
J. Lawrence Lee, *P.E., Immediate Past Chair*
Mark W. Powell, *P.E., Chair, Brochure Sub-committee*
Paul J. Torpey, *Past President, ASME*
Herman Viegas, *P.E.*
John K. Brown, *Corresponding Member*
R. Michael Hunt, *P.E., Corresponding Member*
Robert M. Vogel, *Corresponding Member*
Robert O. Woods, *P.E., Corresponding Member*

ASME International Petroleum Technology Institute

Terry Lechinger, *Chair*
Bobby Grimes, *P.E., VP-IPTI*
Ken Bayne, *P.E.*
John Halkyard, *P.E.*
Denby Morrison
Joe Paviglianiti, *P.Eng.*
Dick Williamson
Michael Ireland, *Managing Director*

ASME South Texas Section

Vicki Blocker, *Chair*
Bernie Kent, *P.E., Vice Chair*
Greg Berry, *P.E., Past Chair*
Phillip Carpentier, *P.E., PMP, Advisory Chair*
Brian Webster, *Treasurer*
Glenn MacDonald, *P.E., History & Heritage*
Paul Lutes, *P.E., First Robotics*
Hieu Nguyen, *Secretary*

Baker Hughes Executive Council

Chad Deaton, *Chairman, President, and CEO*
Martin S. Craighead, *Senior Vice President and COO*
Derek Mathieson, *President, Products & Technology*
Peter A. Ragauss, *Senior Vice President and CFO*
Alan R. Crain, *Senior Vice President & General Counsel*
Didier Charreton, *Vice President, Human Resources*
Russell Cancilla, *Vice President, Health, Safety,*
Environment & Security



9110 Grogan's Mill Road
The Woodlands, Texas 77380-3615
Tel 281 363 6000