MODERN MOTORCYCLE TECHNOLOGY

Third Edition

Edward Abdo

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Modern Motorcycle Technology, Third Edition
Edward Abdo

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Preface

Modern Motorcycle Technology (MMT) is designed to meet the basic needs of students and individuals interested in the subject of motorcycle and all-terrain vehicle (ATV) repair and also by helping instructors present information that will aid in students' learning experience. The subject matter is intended to help students become more qualified candidates for dealers looking for well-prepared, entry-level technicians.

MMT has been written to make learning enjoyable; the easy-to-read and easy-to-understand chapters and the great number of illustrations will assist visual learners with content comprehension. The book consists of 20 chapters, and starts with the history of the motorcycle and ends with information about troubleshooting various conditions found on any motorcycle. Because of the similarity of the technologies used, the servicing of ATVs is automatically included in the text.

MMT can be used not only for pre-entry–level technicians but also as a reference manual for practicing technicians. Motorcycle technicians are currently sought after and will continue to be in demand in the future as technology advances in the manufacturing of modern motorcycle and ATV products. In today's world, technicians who have an education prior to working in the field are becoming more desirable to hiring dealerships.

I have been in the motorcycle industry on "all sides of the fence." I have been a rider and a racer most of my life, as well as a customer, technician, service manager, motorcycle trade school technical instructor, chief instructor, curriculum developer, manufacturer's service representative, and head of a technical training department tasked to ensure that over 4,000 technicians are up to date with technologies and technical instruction and am now the owner of a successful motorcycle and ATV shop. I have had a passion for motorcycles since my first mini-bike back in the 1960s, and I have a unique outlook on my job. I love doing what I do! This is something that everyone should strive for, as there is nothing more rewarding.

—Ed Abdo

New To This Edition

The third edition of *Modern Motorcycle Technology* (MMT) has been updated throughout and includes new content on the latest motorcycle models and technology from today's top manufacturers. This new edition features additional material on key topics such as fuel management systems, suspension systems, and electrical systems. It also provides an expanded suite of separately available supplementary teaching and learning tools—including a hands-on Student Skill Guide and electronic instructor resources available on a companion website and CD-ROM. MMT is a valuable resource for anyone seeking the knowledge and skills to succeed in today's motorcycle technology field.

Acknowledgments

Many people were instrumental in making this book a reality. There were numerous reviews from those in the motorcycle industry; the suggestions were excellent and helped to make this a better textbook. There are also other people who helped make this book possible whom I would like to acknowledge: Bernie Thompson, Jeff Percival, Andy Parks, Kirk Nussbaum, Bill Kish, Adam Miller, Shawn Moen, and the staff from PowerSport Institute were all very helpful with the addition of material in several chapters of this edition as well as assisting with the updated pictures found within the pages to follow. The staff from Motorcycle Mechanics Institute were also very instrumental in providing updated material for this book. A special thanks to Shannon Kirk for taking the action photos which includes my son used on the covers of this textbook. The late George Decker, who many years ago saw something in me that made him think that I could be a technician, hired me for my first job in this industry and became my mentor. There are three others who were all key in helping shape my instructional career: Art Ridgway, unknowingly to both of us at the time, showed me that teaching

what you have learned to others is not only self-satisfying but also rewarding in ways far exceeding my imagination. Art's passion to help others learn inspired me to want to teach others what I have learned over the years. Larry Barrington helped me prove to myself that I could get up in front of a large group of students and actually teach! Larry had a way of making me feel at ease in my early stages of teaching when I was questioning my abilities as an instructor. Doug McIntyre taught me more about myself than any other person I have ever had the pleasure to work with. His willingness to listen and help me through my problems when trying to sort through instructional design issues will always be remembered. Next, my wife Bonnie and son Nick (shown as #268 in the action pictures used on the covers of this book!) for their endless love. The two of them find ways to inspire me every day. There were many more people who have helped me along the way in this great ride of a career, but the page is now getting long, so I will just say thank you all! It is an honor to give back to an industry that has done so much for me. Without all the support I have been fortunate to obtain throughout my life, you would not be reading this.

Reviewers

The author and publisher would like to thank the following reviewers for their valuable input during the development of the first and second editions of MMT:

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Supplements

Student Skill Guide: This workbook is designed to provide students with activities centered around diagnostic and repair procedures commonly performed on the modern motorcycle. Each chapter contains questions and activities to reinforce the content in the respective core text chapter. The Skill Guide also contains many job sheets that allow students to put the theory to work in the shop with illustrated, step-by-step guided lab activities.

Instructor Resources: The Instructor Resources will help make classroom time more efficient and engaging with tools like chapter presentations in PowerPoint for each text chapter; an Image Gallery of photos and illustrations from the book; chapter tests powered by Cognero for use as exams, quizzes, or homework assignments; and the end-of-chapter questions available as Word files. An Answer Key is also provided for the end-of-chapter questions.

To access these Instructor Resources online, go to login.cengagebrain.com, and create an account or log into your existing account.

Contents

CHAPTER 1

Introduction to Modern Motorcycle Technology

Learning Objectives

When you have completed the study of this chapter and its laboratory activities, you should be able to:

- Understand a brief history of the motorcycle and the motorcycle industry
- Describe different types of motorcycles
- List some of the many motorcycle industry job opportunities

Key Terms

Advertising and marketing specialists
All-terrain vehicles (ATVs)
Custom cruiser
Customer service representatives
Direct drive system
District parts managers
District sales managers
District service managers
Dual-purpose motorcycles
Electric vehicle (EV)
Entry-level motorcycle technicians
Franchised dealerships
General manager
Hot-rod cruisers
Lot attendant
Motocross
Motorcycle
Motorcycle repair instructors
Motorcycle technician
Motor scooters
Multipurpose utility vehicles (MUVs)
Off-road motorcycles
Parts department
Parts technician
Quality control specialists
Race team support technicians
Research and development engineers
Road racing
Sales department
Service department
Service manager
Service technical training instructors
Service writer
Setup technician
Sport motorcycles
Sport-touring motorcycles
Standard street motorcycles
Street motorcycles
Technical advisors
Technical illustrators
Technical writer
Three-wheelers
Touring motorcycles
Universal Japanese Motorcycles (UJM)

INTRODUCTION

Motorcycles have a long history that dates over 100 years, and the motorcycle industry has continued to grow at a tremendous rate with peak yearly unit sales of new motorcycles reaching over 1 million from 2003 through 2008 and all-terrain vehicle (ATV) unit sales surpassing 800,000. Over the past few years, the economic condition of the marketplace has seen a reduction of new sales through 2015, although the market has recovered every year since the bottoming of the market in 2010. Servicing these machines is different in many ways than in the past. Over the years, constant breakthroughs in engine, chassis, and electronic technology have greatly changed how motorcycles and ATVs are developed and marketed to the consumer. Because of this, trained motorcycle technicians are in high demand throughout the country.

A BRIEF HISTORY OF THE MOTORCYCLE

According to *Merriam-Webster's Collegiate Dictionary*, the word **motorcycle** is defined as "a 2-wheeled automotive vehicle having one or two saddles." Of course, motorcycles are a bit more complex than that simple explanation.

In fact, motorcycles are a direct descendant of the bicycle. The early bicycle (actually called a velocipede, a bicycle with its pedals located on the front wheel) (Figure 1-1) appeared in the early 1860s and was also known as a "boneshaker," both for its jarring ride and for its tendency to toss the riders when riding on cobblestone roadways.

Since its invention, the motorcycle has been considered to be more than just a bike with an engine attached. Riding a motorcycle gives people a completely different perspective of the world around them as compared to driving in an automobile. Riding on the open road or along a trail is a feeling like no other. Furthermore, no matter which type or brand of motorcycle they have, all riders share a common bond between them. They are virtually all motorcycle enthusiasts and truly love to ride.

It could be argued that writing a book about the history of the motorcycle could easily take up more space than this entire textbook provides. Throughout the years, there have been literally thousands of different motorcycle manufacturers around the world. Therefore, we will briefly discuss only a few of the many highlights of the motorcycle's vast history.

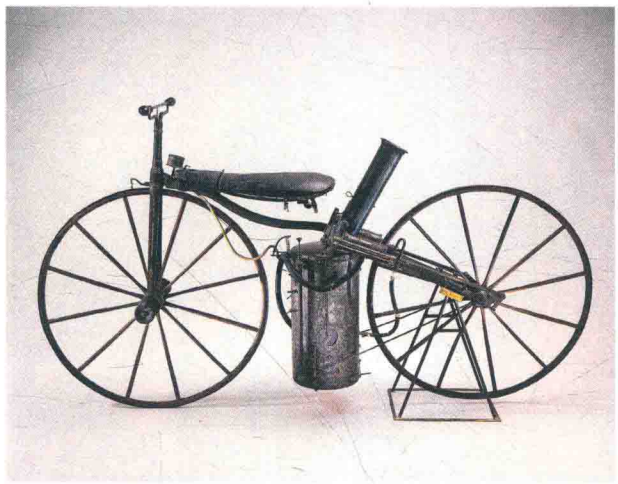
Courtesy Transportation Collections, Division of Work & Industry, National Museum of American History, Smithsonian Institution

Figure 1-1 The motorcycle is a direct descendant of the early bicycle, which was actually called a velocipede because of the placement of the pedals on the front wheel.

The Birth of the Motorcycle

There are many different opinions pertaining to who exactly invented the first motorcycle, but using the definition by *Merriam-Webster*, it could be Sylvester H. Roper of Roxbury, Massachusetts. He built a steam-powered machine in 1869 (Figure 1-2) that could be considered to be the *first* motorcycle.

Roper's machine was considered to be quite remarkable, as it looked very similar to bicycles of that era but utilized a small vertical steam boiler under the seat. The boiler supplied two pistons that powered a crank-drive system to the rear wheel. The throttle was controlled by twisting the handlebar forward and back. The Roper machine had the first known—albeit a primitive version—use of the twist grip control. The twist grip throttle control was reinvented a couple of times over the years,



Courtesy Transportation Collections, Division of Work & Industry, National Museum of American History, Smithsonian Institution.

Figure 1-2 This could be considered the very first motorcycle, but since it was powered by the use of a steam engine, it can be debated that it was not a motorcycle. This machine was created by Sylvester H. Roper of Roxbury, Massachusetts, in 1869.

Courtesy Softeis, published under the terms of the GNU Free Documentation License. http://en.wikipedia.org/wiki/File:Daimler-1-motorcycle-1.jpg

Figure 1-3 This is a replica of what many historians consider to be the first motorcycle to be powered by an internal combustion engine. A gentleman by the name of Gottlieb Daimler created it in 1885.

finally by the Indian Motorcycle Company—after this Roper design—and is still in use on today's motorcycles. Roper built more versions of his steam-powered motorcycle, and in 1896, at the age of 73, he showed up at a bicycle track near Harvard with a modified version of one of his designs. He was clocked at an unbelievable 40 miles per hour, and while slowing down, the bike went into a wobble, throwing Roper off the bike. Sadly, he died in this accident. Later, however, an autopsy is reported to have shown that Roper died of a heart attack and did not die from the fall.

Even though the Roper machine was designed years before, most historians credit Gottlieb Daimler with the invention of the motorcycle in 1885, as it was the first motorcycle in recorded history with an engine powered by petroleum (Figure 1-3). Daimler designed an engine and mounted it into a wooden-framed contraption in 1885.

As mentioned, the Roper machine is considered by most to be the first motorcycle even though it actually had four wheels. Historians overlook the two outrigger-type stabilizer wheels and consider this machine to be the grandfather to the motorcycle. Daimler's young son Paul was the first to give this machine a test ride. Daimler's machine had no pedals. Instead, the power was supplied only by the simple four-stroke engine design. Daimler later went on to build early automobiles. He left it to bicycle builders to further develop the motorcycle.

In 1892, Alex Millet invented a five-cylinder motorcycle and was the first to utilize pneumatic tires (Figure 1-4). The Millet-designed machine used a complex rotary engine built within the rear wheel. The cylinders rotated with the rear wheel, while the crankshaft was actually incorporated into the rear axle.

Although short-lived due to poor design, the first motorcycle built for sale (over 200 were sold) was the Hildebrand & Wolf Mueller (Figure 1-5) in Munich in 1894. This motorcycle utilized a water-cooled twin-cylinder engine that had a **direct drive system,** meaning that the wheels were directly attached to the engine and, therefore, would always

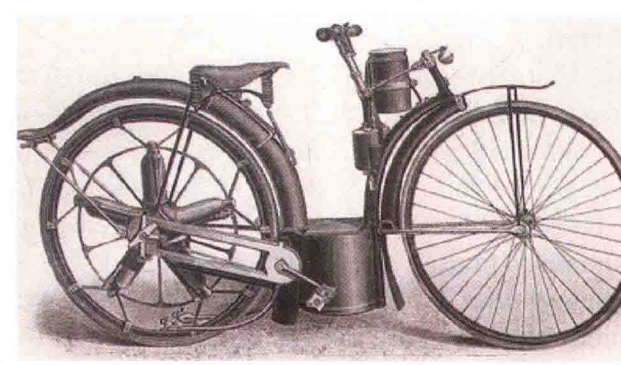


Figure 1-4 In 1892, Alex Millet of France built the first motorcycle with pneumatic tires. The engine was actually a part of the rear wheel and had five cylinders.

Figure 1-5 The German company of Hildebrand & Wolf Mueller designed the first motorcycle that was produced for sale to the public. Design issues made this machine very hard to ride, and therefore it had a very short life.

be in motion if the engine were running. This made riding this motorcycle design difficult.

In 1895, the French firm of DeDion-Buton designed an engine that would allow motorcycle mass production to become a reality. The DeDion-Buton engine (Figure 1-6) design was a small high-revving four-stroke single using the first battery and coil-type ignition on such a small engine.

The engine was lubricated using a total loss system that dripped oil into the crankcase via a metering valve; the oil then sloshed around the internals to lubricate the moving components before burning or being pumped out onto the ground through a breather tube. While many of these engines were used, the engine design was copied by two very notable manufacturers in the United States: Indian and Harley-Davidson.

In 1900, two men, George Hendee and Carl Hedstrom, formed a partnership to manufacture a "motor-driven bicycle for the everyday use of the general public" in Springfield, Massachusetts, the Hendee Manufacturing Company. Hedstrom designed a motorcycle that debuted in 1901. A single-cylinder 1.75-horsepower engine that was copied from the DeDion-Buton engine gave the machine the ability to travel at speeds close to 25 miles per hour (Figure 1-7). The real secret to this design, however, was its chain drive, which was

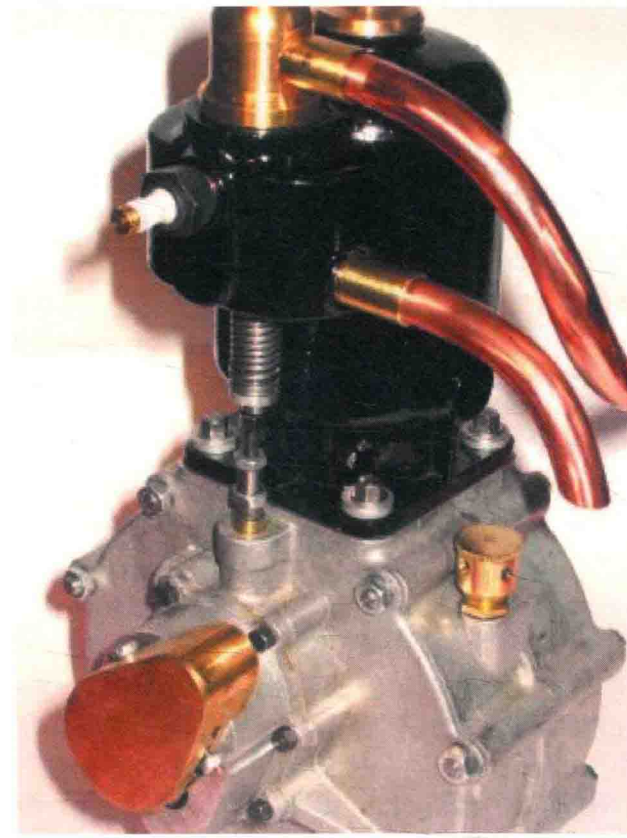


Figure 1-6 The French company of DeDion-Bouton built the first internal combustion engine that was mass-produced for usage specifically in a motorcycle.

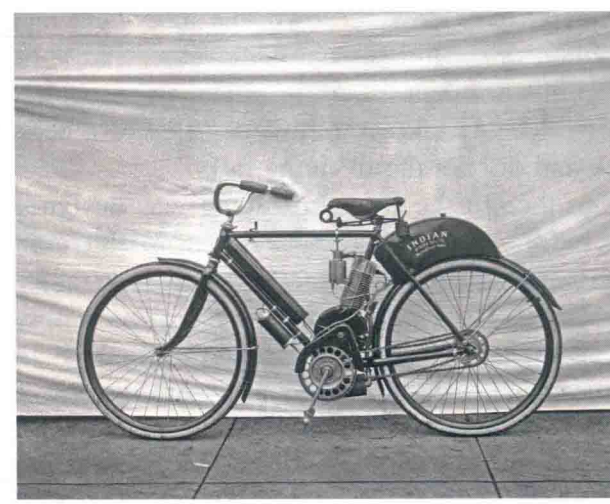


Figure 1-7 The first Indian motorcycle was produced in 1902 and was very similar in design to a bicycle.

superior to the belt-driven machines around at that time.

The partners picked the name "Indian" for their motorcycles, thus starting what was to become the largest production motorcycle company in the United States. Indian was a leader in early

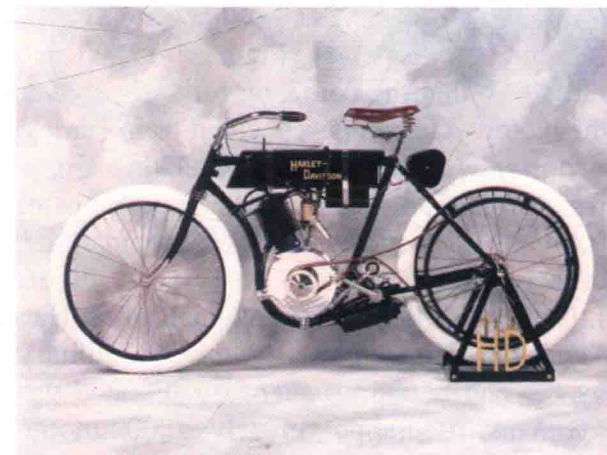
Figure 1-8 Similar in looks to the first Indian motorcycles, this 1905 Indian was called a "camelback" due to the shape and location of the fuel tank.

Figure 1-9 Over the years, many have attempted to bring back the Indian motorcycle, but the last true Indian was produced in 1953. This photo is of a 1940 Four, which could be considered the Cadillac of motorcycles in its day. They were smooth and flexible—at home trickling through traffic or cruising down the highway. These particular Indians were very popular with law enforcement agencies.

motorcycle design, registering patents on components that are still used today on modern motorcycles. The 1905 model was called a "camelback" due to the shape and location of the fuel tank (Figure 1-8). Indians were well constructed and often over-engineered. The company went on to build a V-Twin motorcycle with two- and three-speed gearboxes and further refined it with a swing arm rear suspension. In 1914, the world's first motorcycle with an electric start and a full electrical system was introduced to the industry. The Hendee Special propelled Indian to be the largest motorcycle manufacturer in the world, producing over 20,000 bikes per year prior to World War I. One Indian motorcycle that was very popular with police departments was the Indian Four (Figure 1-9). While there have been a few attempts to revive the motorcycle brand Indian, the last true Indian motorcycle was the 1953 Indian Chief.

In 1903, 21-year-old William S. Harley and 20-year-old Arthur Davidson created for the public the first production Harley-Davidson motorcycle (Figure 1-10). The factory in which they worked was a 10- by 15-foot wooden shed with the words "Harley-Davidson Motor Company" crudely scrawled on the door (Figure 1-11).

Some of the earliest Harley-Davidson motorcycles were built with racing in mind. In 1908, Walter Davidson scored a perfect 1,000 points at the Federation of American Motorcyclists (FAM) 7th Annual Endurance and Reliability event. Then,



Photographs courtesy of the Harley-Davidson Motor Company Archives. Copyright H-D.

Figure 1-10 The first Harley-Davidson was produced in 1903.

Photographs courtesy of the Harley-Davidson Motor Company Archives. Copyright H-D.

Figure 1-11 An artist's rendition of the very first Harley-Davidson factory. The building was in fact a 10- × 15-foot woodshed.

Figure 1-12 The first V-Twin built by Harley-Davidson had 7 horsepower and was built in 1909.

Figure 1-14 Harley-Davidson celebrated 100 years of manufacturing motorcycles in 2003.

only three days later, he set the FAM economy record at over 188 miles per gallon.

The first Harley-Davidson V-Twin was built in 1909; it had a displacement of 49.5 cubic inches and boasted 7 horsepower (Figure 1-12). It was not until 1914 that the company formally entered into the motorcycle racing scene, but team Harley-Davidson was nicknamed the "Wrecking Crew" because of their dominance in the sport. In the 1920s, board track racing was very popular, and Harley-Davidson dominated that sport (Figure 1-13). During World War I, nearly half of all Harley-Davidsons built were used by the U.S. military, and by the end of the war, it was estimated that the U.S. Army used approximately 20,000 motorcycles, with the majority being Harley-Davidsons. By the year 1920, Harley-Davidson became the largest motorcycle manufacturer in the entire world with over 2,000 dealers located in 67 countries.

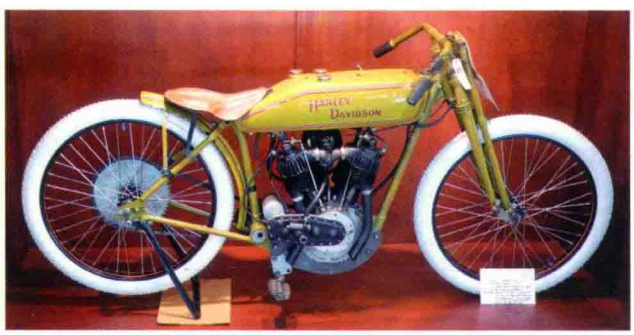


Figure 1-13 This 1923 board track racer was found in a chicken coop and restored to this pristine condition. It is currently ridden in exhibition races within the United States and has been clocked at over 75 miles per hour. Bikes such as this one dominated motorcycle racing in the 1920s.

This dominance lasted until the 1950s, when the British motorcycle industry came to full bloom. Today, the Harley-Davidson brand is an American icon, and their products appeal to many different types of riders. The only "true" American motorcycle manufacturer still in existence from the early days, the Harley-Davidson Motor Company celebrated its centennial in 2003 (Figure 1-14).

British Motorcycles

While British motorcycle production began in the early 1900s, it was not until the 1950s that motorcycle brands such as Triumph (Figure 1-15) and

Figure 1-15 Triumph was a strong contender in the United States from the 1950s up until the early 1970s. The company's downfall was its failure to change its products to align itself with the changing trends of the marketplace. This 1970 Bonneville was one of the last strong attempts to bring up market share, but in the end it failed to keep the company going.

Birmingham Small Arms, better known as BSA (Figure 1-16), were brought to the forefront of the U.S. motorcycle industry. Britain's motorcycle industry dominance was at its peak in 1959. Happy with their success, these companies felt somewhat invincible and failed to take note of emerging trends or to replace their aging designs. Most of the engineers and company executives came from prewar days and paid attention only to the glory days of the 1930s but unfortunately failed to look into the future. BSA merged with the Norton Villers Triumph, and the last BSA was produced in 1973. Triumph is the only British brand to make any successful attempts to reenter the motorcycle marketplace in the United States over the years.

European competition from Germany included the company BMW (Figure 1-17), which made a rapid recovery from postwar times, and the Italian companies Ducati (Figure 1-18) and MV Agusta (Figure 1-19). They began to intrude on market share with their desire to build more stylish machines. The final blow to the British motorcycle industry came from the Japanese as the U.S. and European markets began to import less expensive and more reliable machines. The Japanese motorcycles showed more innovation and engineering development, and the British companies were too slow to react to this competition.

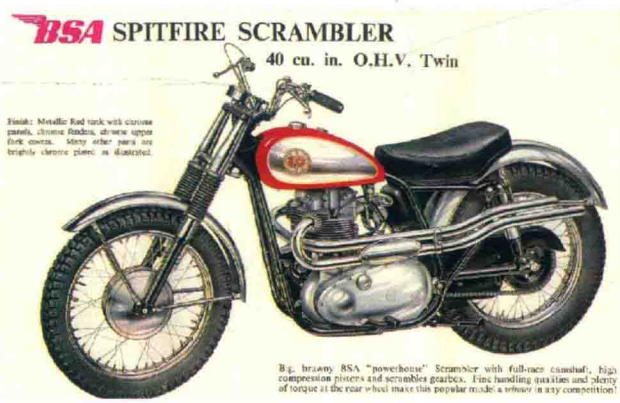


Figure 1-16 This vintage magazine advertisement of a BSA Spitfire Scrambler helped the British manufacturer create a strong consumer base with its power and looks.

Courtesy of BMW of North America

Figure 1-17 German manufacturer BMW came back after World War II quickly to build very stylish (for the time) and reliable machines.

Figure 1-18 The Italian firm of Ducati has always been regarded to have motorcycles that could be considered just as much art as functional. Machines such as this helped to capsize the British motorcycle dominance of the 1960s.

Courtesy of Motorcycle Hall of Fame Museum Collection

Figure 1-19 MV Agusta was another strong manufacturer that built motorcycles that the public wanted and therefore helped to reduce the British motorcycle dominance.

Japanese Motorcycles

The motorcycle industry throughout the world saw its biggest change in the early 1960s, when a company from Japan, headed by Sochirio Honda, changed the way people looked at motorcycling. The Honda C100 Cub (Figure 1-20) was by far the most successful entry-level motorcycle, and in the United States the company utilized the ever-popular slogan "You meet the nicest people on a Honda." The cub alone has continued to sell over a half a million units per year every year since its