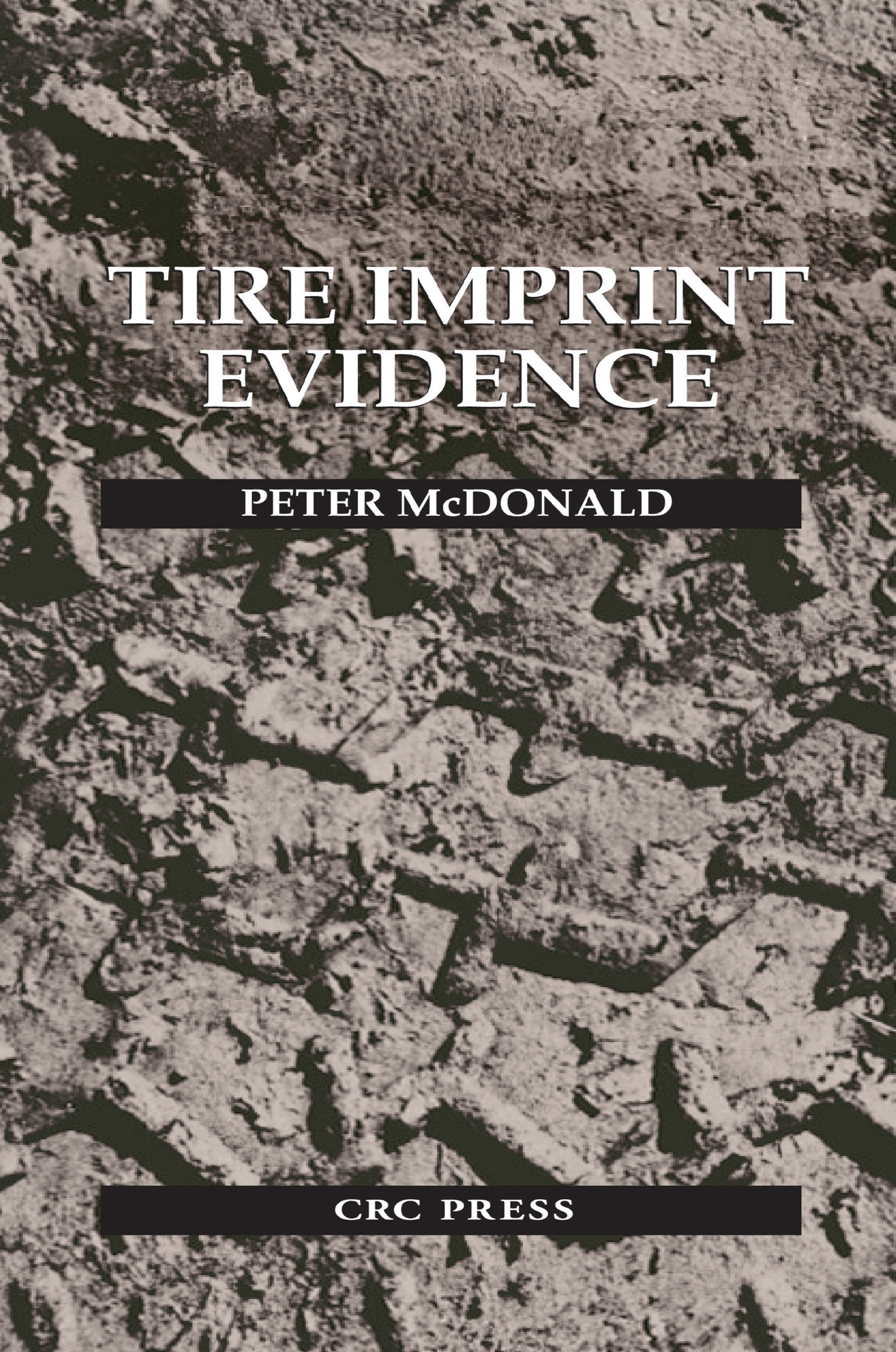

TIRE IMPRINT EVIDENCE

PETER McDONALD

CRC PRESS

Tire Imprint Evidence

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Tire Imprint Evidence

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To my wife and family,
I wish to extend a very special
acknowledgment of their support.

Contents

Preface

Marked on the sodden soil, was the trace of a bicycle.

"Hurrah!" I cried. "We have it."

But Holmes was shaking his head, and his face was puzzled and expectant rather than joyous.

"A bicycle certainly, but not the *bicycle," said he. "I am familiar with forty-two different impressions left by tyres. This, as you perceive, is a Dunlop, with a patch upon the outer cover. Heidegger's tyres were Palmer's, leaving longitudinal stripes. Aveling, the mathematical master, was sure upon the point. Therefore it is not Heidegger's track."*

"The boy's, then?"

"Possibly, if we could prove a bicycle to have been in his possession. But this we have utterly failed to do. This track, as you perceive, was made by a rider who was going from the direction of the school."

"Or towards it?"

"No, no, my dear Watson. The more deeply sunk impression is, of course, the hind wheel, upon which the weight rests. You perceive several places where it has passed across and obliterated the more shallow mark of the front one. It was undoubtedly heading away from the school. It may or may not be connected with our inquiry, but we will follow it backwards before we go any farther."

Arthur Conan Doyle, "The Adventure of the Priory School," 1901

Sherlock Holmes, at the beginning of the century, recognized the importance of identifying tire tread designs and observing unique accidental characteristics. He also determined the tire position and direction of travel. Today's investigators may not be so fortunate as to observe "a patch upon the outer cover." But we do have pitch sequence variations and much more to make our job easier.

The individuality of people and their fingerprints has become a well recognized forensic tool since it was introduced in 1901. Shoe prints and footprints have also become valuable evidence for the investigator. Currently, the identification of tire imprints, or "footprints," at the scene of a crime has become increasingly important in establishing that a suspect's vehicle was at a crime scene.

Most shoe prints are a pair. All the people I know wear shoes of the same design and size on each foot. They also buy them at the same time. However, many vehicle owners will replace worn or damaged tires as needed, and this can result in a vast difference in comparative worn imprints and often different designs and sizes at different wheel positions. Simply identifying more than one brand or size tire on a single vehicle can significantly affect the probability factor of that combination of tires appearing on another vehicle.

Since a vehicle is generally used when leaving the scene of a crime, a tire "footprint," or contact patch, is significant. Interestingly, a single tire "footprint" is approximately the same surface area as a large man's shoe print. However, tires generally have more than five times the load per square inch as compared to a shoe print. The resulting tire print, therefore, is often more clearly visible than a shoe print on a soft surface.

The growing awareness of valuable tire print evidence, in this mobile age, will hopefully assist investigators in their work. Unfortunately we tend to think of tires as lacking individuality—just piles of nondescript tires. It is interesting to note the similarities of shoe prints, barefoot prints, and tire footprints. The creative Wellco Military Footwear designers seemed to recognize the features of each. They have designed a boot with a velcro secured bottom that will accommodate an interchangeable tire tread sole, or a traction device sole, much like studded tires. The special "HO-CHI-MINH" barefoot sole was designed to confuse the enemy into thinking that only barefoot natives had passed. Like the interchangeable shoe sole, tire retreads can be similar and confusing.

When I first started writing this book, I intended to jump right into the subject of tire imprints and their analysis. However, it soon became obvious that I could not write about tires without first providing some fundamental information about their nomenclature, design, manufacturing, and functioning, and also some information about how they are sold. The first five chapters cover all of this briefly. If you do not read these chapters, you will find yourself lost in the later discussions, so I recommend you take a deep breath and plow your way through them. You will then be ready to understand the real subject of this book.

My wife, Linda, and I started this book in a wonderful, but very unconventional, way in this day of word processors. Many days were spent at our remote island, loading our canoe with books, writing material, and folding chairs—then paddling to a different island every day to write under the shade of a tree, then swim, and have lunch. A great way to develop thoughts. Of course one returns to the conveniences of computers and photographic facilities, but I recommend a natural setting for writing a book.

This book has been written primarily for crime investigators. However, the research techniques, standards, and procedures will no doubt be beneficial to police officers in general, crime scene specialists, forensic laboratory technicians, accident reconstruction specialists, judges, and lawyers. The full potential of tire imprint evidence has not been explored. If information presented in this book prompts crime-scene examiners, investigators, police, and the courts to recognize the significance of analyzing tire imprints correctly, then my goals will have been met.

Acknowledgments

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Tire Imprint Evidence

A Brief History of the Tire

1

Tires are the means to support, propel, and guide vehicles. The first tires at the turn of the century frequently lasted less than 1,000 miles. It was common to carry six spares. Today's modern tires often deliver more than 40,000 miles.

(Kovac 1978)

The first five chapters of this book provide basic information about tires that will assist today's tire imprint examiners. The next chapters provide discussions of specific details that are useful in making tire imprint identification and case studies involving such identification processes.

The Sumerians are generally credited with inventing the wheel some 5,000 years ago. Since then, the wheel has been continually refined to meet the needs of the vehicle it supported. In 1846, Robert William Thompson obtained a patent in England for an "aerial wheel," a concept similar to today's pneumatic tire, but this invention remained unused until the pneumatic tire was reinvented by John Dunlop in 1888.

The first tires were bald, and poor roads made traction designs a necessity. In 1907, Harvey Firestone is said to have suggested the first traction design, using the words "Firestone Non-Skid." The words "Firestone" and "Non-Skid" alternated positive and negative, so that the manufacturer's identity and design name were legible in the impression (see Figure 1.1). This tread pattern gave improved traction. In addition, although it was not intentional, the varied tread elements were probably the first noise-treated design. The round shoulder was probably good for handling too, and the tread pattern was good

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Figure 1.1. Alternating mirror image of tire name leaves legible impression. (*Courtesy of Firestone Tire & Rubber Co.*)

advertising. (If each manufacturer today identified its tires so obviously, investigators of tire imprints would find their jobs much easier.)

Goodyear's first tread design consisted of diamond-shaped elements. The company continued to use this basic design for many years. Even today, some tire manufacturers adapt basic tread features as a theme and continue that theme for many years in a variety of tread designs. Knowing this will help an investigator who is trying to identify a particular design.

As road conditions improved and major routes were paved, the early button-type tread designs were replaced by continuous-rib designs for high speed. In the 1930s, tread designs were primarily circumferential ribs of continuous tread rubber separated by grooves. Later, to improve traction on slippery surfaces, sipes (narrow slits in the tread surface) were introduced. The primary internal tire construction from before 1920 until the 1960s was bias ply, but now it is radial. "Bias" and "radial" refer to the angle of the cords in the tire plies.

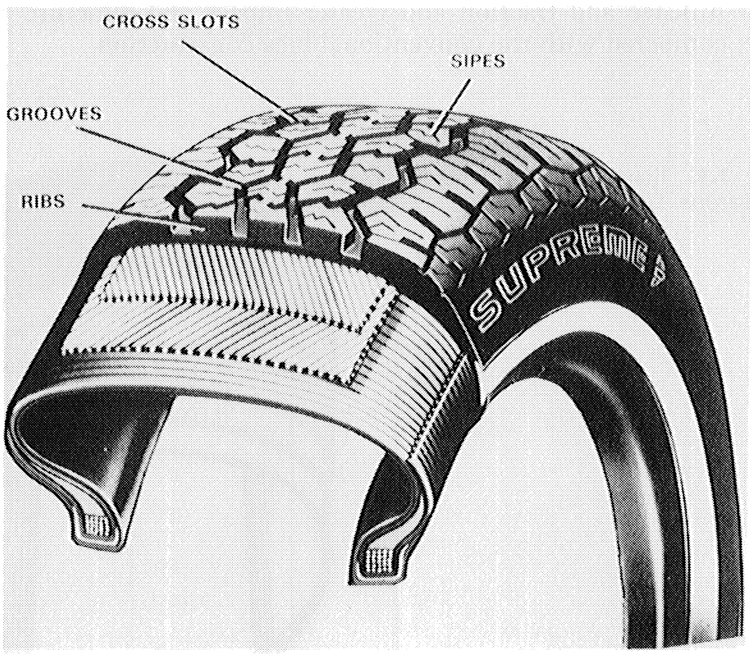
The history of tires in the twentieth century has to do largely with a progression of different tire constructions and tread designs. Investigators will find that certain tread designs that are appropriate for only one type of construction are therefore a clue for identifying a specific tire.

Tread Designs

Fortunately for the investigator, the design of the tread pattern affects the overall performance of a tire. Depending on the type of performance required and the construction used (bias, belted-bias, or radial), the tread pattern may be an indication of a specific type of vehicle. The typical circumferential zigzag tread pattern, which provides better mileage, traction, and reduces side-slippage, meets most driving requirements. However, a variety of lateral slots have been introduced for improved traction.

The tread is molded into a series of *grooves* and *ribs*. The ribs provide the wearing surfaces and the road contact that enable the driver to steer and stop. The grooves permit an easy, fast escape for water and give the tread edges a direct, positive grip on the surface being traveled. To increase the traction of any tire, the small slots called *sipes* are molded into the ribs of the tread design. As the tread area moves across the road surface, the sipes provide extra traction edges. On wet pavement they help wipe water away and thereby improve the traction (see Figure 1.2).

Figure 1.2. Radial tire cutaway showing ply construction. (*Courtesy of Firestone Tire & Rubber Co.*)



Types of Tire Construction

There are three types of tire construction: bias construction, belted-bias construction, and radial-ply construction.

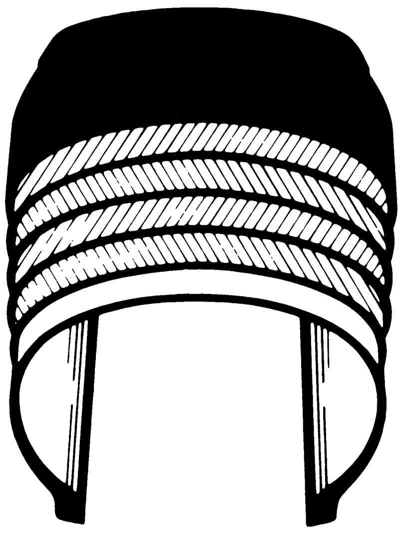
Bias Construction

Bias (meaning on an angle) construction may be two, four, or more plies placed on top of one another in alternating directions on the bias. The tire body ply cords run from bead to bead (see Figure 1.3). This basic, simple construction provides adequate traction and mileage performance.

Belted-Bias Construction

In belted-bias construction, the cord body is constructed as in bias construction, with the cords in the body plies running at an angle from bead to bead. However, two or more belts are then applied on top of the body plies directly under the tread area only (see Figure 1.4). Regardless of the type of cord material used, adding these high-strength, low-elongation belts lessens the stresses on the cord body greatly and stabilizes the tread area of the tire. Belted-bias construction provides better mileage and traction and greater impact and puncture resistance, compared with the conventional bias construction.

Figure 1.3. Bias construction. (*Courtesy of Firestone Tire & Rubber Co.*)



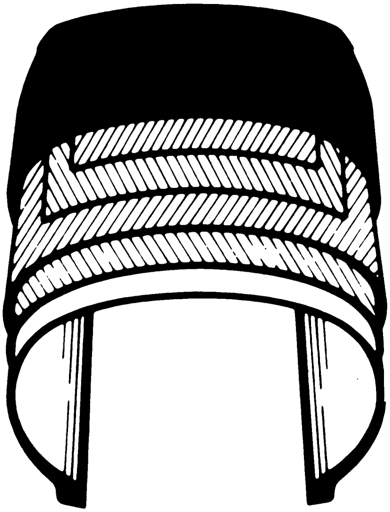


Figure 1.4. Belted-bias construction. (*Courtesy of Firestone Tire & Rubber Co.*)

Radial-Ply Construction

Radial construction utilizes one or more body plies, with the cords running *in a straight line* from bead to bead. On top of these body plies are two or more belt plies, referred to as "stabilizer belts" (see Figure 1.5). These stabilizer belts prevent "squirm" in the tread area and give the tire lateral stability.

Compared with conventional bias and belted bias construction, radial-ply construction provides the most mileage, the quickest steering response, the greatest impact resistance, the best traction, the best

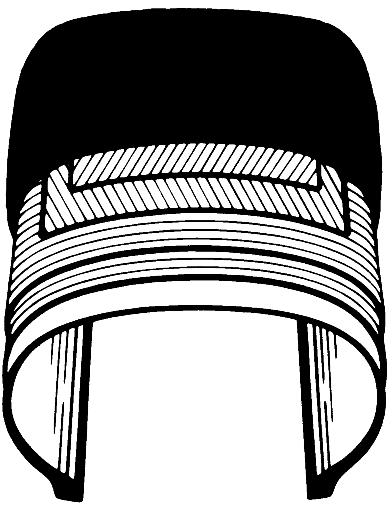


Figure 1.5. Radial-ply construction. (*Courtesy of Firestone Tire & Rubber Co.*)

cornering control, savings in fuel costs due to lower rolling resistance, and the smoothest ride at highway speeds (Firestone 1982).

Messrs. Gray and Sloper are generally credited with constructing the original radial tire in 1913, but radial-ply construction did not gain popular use in North America until the mid-1960s. Radials now account for well over 70 percent of the U.S. tire market. This figure has been steadily increasing since the early 1970s, when radials were first used as original equipment on some new cars. Consumers seem to recognize the superior performance and greater mileage of radials vs. bias or bias-belted tires.

Bias-ply-construction tires have continuous ribs for good reasons. The previous button-type traction designs would have failed at the higher speeds of today. In addition, they were noisy and rough-riding. Radial construction prevents "squirm" of the tire tread and makes practical the more open and aggressive tread designs that are common on radial tires, for today's higher speeds.

Tire Construction and the Three Cycles

Every passenger tire, regardless of type of construction, goes through three cycles (Figure 1.6) during one complete revolution of the wheel: the contraction (or footprint) cycle, the expansion cycle, and the normal stress cycle.

Figure 1.7 shows the tread of a conventional bias-construction tire as it goes through the three stress cycles in one revolution of a wheel. The top illustration in the figure shows a normal tread. The center illustration shows how the contraction cycle squeezes the tread together as the cord pulls at opposing angles. The bottom illustration shows how the tread design expands as the cord body reverses the direction of its pull in the expansion cycle.

In a belted-bias-construction tire, the added belts under the tread greatly reduce the pull of the cord body during the contraction and expansion cycles (see Figure 1.8). The result is less scrubbing on the

Figure 1.6. Tires rotate through three cycles (A) contraction; (B) expansion; and (C) stress.