10.

Patents, Profits, & Perceptions

The Single-Tube Tire and the Failure of the American Bicycle, 1897–1933

Paul Rubenson

The American single-tube tire dominated the United States' bicycle market for forty years, from the close of the 1890s Bicycle Boom to the Great Depression in the 1930s. The tire was of unique and simple construction, having its outer casing and inner tube vulcanized together as an inseparable unit, and was usually glued to a wooden-rimmed wheel. This tire type was almost unknown outside America.

During the single-tube's reign, bicycles fell almost totally out of general use in the United States—a false start that has hampered American cycling ever since. The relationship of the single-tube tire to the early decline of American cycling lends itself to the social construction of technology, or SCOT, which seeks to understand counterintuitive technical developments by studying real-life applications and the perceptions of users.

The single-tube tire's dominance defied the simple rules of supply and demand, and countered most conceptions of rational technical development. The single-tube did not thrive due to

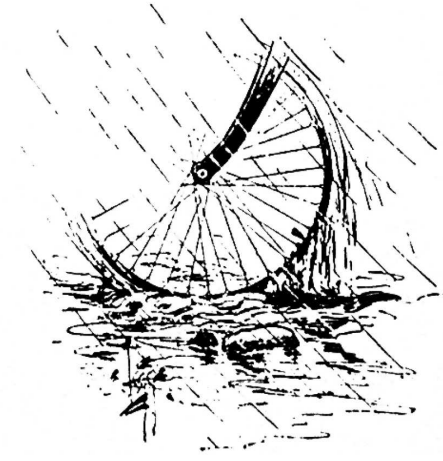


Fig. 10.1. Single-tube tire and wood rim in adverse conditions.

technical superiority, but rather through the machinations of industrialists, and because of a disconnect between consumers' ideals and their practical needs. Colonel Albert Pope and others manipulated patents, markets, and social perceptions to the tire's advantage. In the end, the tire's drawbacks not only caused its own downfall, but also impeded America's future prospects for practical cycling.

Background

Throughout most of the world, the early twentieth century was an important turning point for cycling. As bicycle technology stabilized and bicycle prices fell, cycling transitioned smoothly from a bourgeois pastime into commonplace transportation. Cultural enthusiasm for cycling waned in the 1900s, but production and registration figures for bicycles nonetheless climbed.

However, this did not happen in the United States. Instead, American bicycle production dropped off precipitously in 1898 and never fully recovered. Thirteen years after the Bicycle Boom, U.S. production was no more than a quarter what it had been, and perhaps as little as a tenth.[1] Consequently, the post-boom era is known in America as the bicycle bust.

Many historians assume the bicycle's early failure in the United States was inevitable—that the American public was never receptive to practical cycling, and that North American geography posed insurmountable barriers to cycle transportation. Many also assume the rise of the automobile prevented cycling from gaining a foothold. But careful analysis shows both interpretations to be false.

In a practical sense, turn-of-the-century America was not very different from regions where cycling nonetheless prevailed—poor roads, vast distances, and harsh climates did not dissuade practical cycling elsewhere.[2] In the smaller worlds of Americans at the time, bicycles would have offered a viable alternative to horses in the country and to streetcars in the city and,[3] when carried on railroads, bicycles could have added flexibility to distance travel as well.[4] The idea that automobiles displaced bicycles is impossible—bicycle use declined more than twenty years before automobiles became commonplace.[5]

The American Bicycle as a Socio-Technical Ensemble

A more likely explanation for the American bicycle's early failure is evident in its own distinctive design, and how poorly it suited the changing market. American bicycles were different from bicycles elsewhere, and comprised a unique collection of technological choices. Historians in the social sciences call this a unique socio-technical ensemble.[6]

In the case of the American bicycle, this ensemble featured the following technical elements: wood-rims, minimal brakes, hard saddles, high gears, light construction, the notable lack of practical amenities such as fenders, stands, or luggage

Fig. 10.2. U.S. bicycle production, 1897–1933.

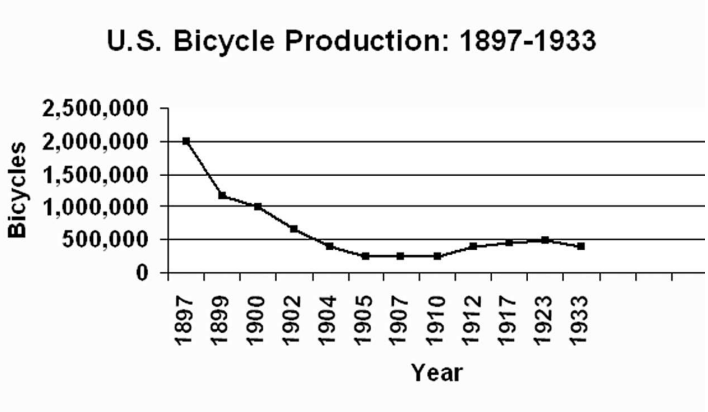
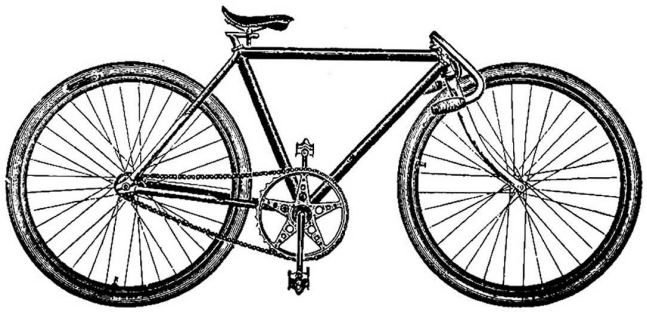


Fig. 10.3. An "extreme" example of an American type bicycle, 1898.



EXTREME TYPE OF 1898 MODEL COMBINING ALL LATE FEATURES

racks, and the use of fast, single-tube tires. In short, the typical American bicycle was a sports machine, or at least pretended to be so. This was understood at the time. Maria Ward, a popular cycling author, advised her readers that American bicycles had "evolved on the race-track and for the conditions determined thereon."[7] This stood in contrast to the sturdy touring roadsters that became ubiquitous elsewhere.

In the nineteen-teens, the ensemble evolved into a strained combination of sporting features and cumbersome accessories. While some additions were welcome, like stands, racks, and comfortable seats, most were useless gadgets. Yet the imagery of sport and speed remained. By the late nineteen-twenties, typical models weighed up to fifty pounds, but catalogs still described them as "light and swift"[8] and the awkward machines retained their high gearing, absent chain guards, and single-tube tires.

Of all the American bicycle's differences, its single-tube tires were the most profound. Tires are critical to bicycle design—they provide traction, isolate shock and vibration, and reduce rolling resistance. Most important, however, tires account for bicycles' most costly and troublesome routine maintenance.[9] On this point single-tube tires proved pivotal, and disastrous, for American cycling.

Competing Tires

In 1888, John Boyd Dunlop introduced inflatable pneumatic tires to cycling, securing the industry's evolution toward small-wheeled safety bicycles.[10] Within months, competing inventors jockeyed for position in a burgeoning pneumatic tire market.

Dunlop himself was the first to seize on the importance of patents. Unfortunately for him, his pneumatic tire patent was invalidated—a similar idea had been applied to carriages forty years earlier.[11] To save his enterprise, Dunlop began buying up specific design patents that had followed his tire's introduction. Chief among these was a patent from Charles Welch for an easily detachable "wired on" pneumatic tire, securing for Dunlop the simplest, most practical form of the pneumatic tire.

Dunlop's original tire had a structural casing that was awkwardly glued around the outside of the metal wheel rim. The fragile air-tube inside was not easily accessible for repair. In contrast, Welch's design allowed the outer tire to be easily removed. An inextensible wire hoop was molded into each edge of the tire's casing, whose diameter was carefully matched to the rim. The tire could be easily worked onto the wheel, and held fast when inflated. Dunlop also bought a similar American patent by A.T. Brown and G.F. Stillman. The resulting "Dunlop-Welch" pattern later became the basis for most pneumatic tire applications including

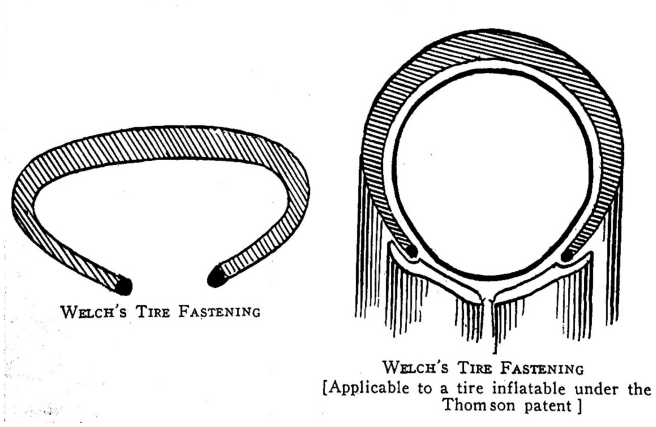
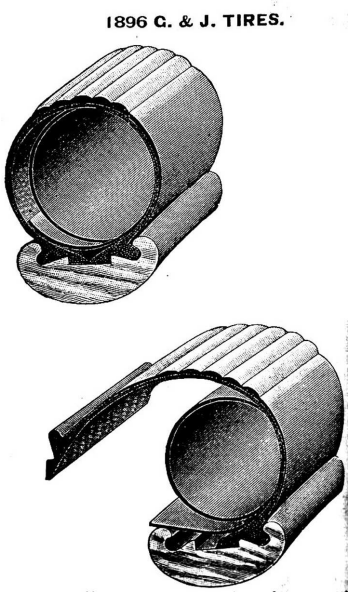


Fig. 10.4. Welch's tire fastening.



Right: Fig. 10.5. G.&J. clincher tire (double-clinch type).

automotive tires, but in the early years its hegemony was not assured.

In the American market, alternative pneumatic designs quickly sprang up to compete with Dunlop. One was the clincher, developed by Thomas Jeffrey and marketed as the G&J clincher. Like the Dunlop tire, the clincher was also easy to remove from the wheel. Rather than using inextensible wire beads, however, its carefully-formed edges simply locked into grooves in the wheel rim. The idea worked well and steered clear of Welch's patent. Dunlop was able to secure a similar English patent by William Bartlett, but Jeffrey remained independent.

A third alternative was the double-tube tire of Morgan & Wright. The double-tube's structural casing was sewn tightly around the inner tube and the whole assembly was glued to the rim, similar to modern racing "sew-ups." These tires were light, comparatively cheap to manufacture, and performed well. Their primary drawback was their being glued to the wheel.

But the most important challenger to Dunlop proved to be the single-tube tire. I.W. Boothroyd first described this tire in England in 1890, and American Pardon W. Tillinghast demonstrated a similar tire the same year. The single-tube tire was "composed of an inner tube, an intermediate layer of structural fabric, and an outer rubber covering, all vulcanized together into an integral annular tire."[12] It was, in essence, a glorified loop of rubber hose.

In 1891, the Pope Manufacturing Company, America's largest bicycle maker, introduced its first pneumatic-tired safety. It featured the first single-tube tires. Pope's choice would help these tires dominate the American market, and in doing so define a distinctively American bicycle.

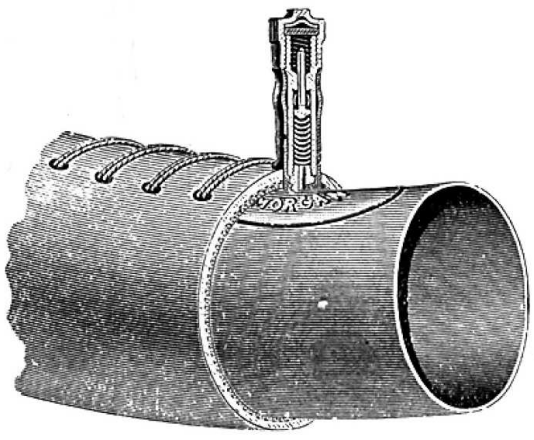
Colonel Pope

Colonel Albert Pope, president of the Pope Manufacturing Company, chose the single-tube tire because it was not patented, and thought to be unpatentable. Pope had built his business by controlling the bicycle industry through patent ownership, and refused to pay fees to others. His patent acquisitions began when he wrested control of the original Lallement velocipede patent, from which he earned $10 for every bicycle ridden in America.[13] Pope reinvested the income to bolster cycling—he supported road building, the League of American Wheelman, and lobbied on cycling's behalf.

The sudden success of the pneumatic-tired safety bicycle troubled Pope because of its close relationship to the foreign Dunlop patent monopoly. It didn't help that an American competitor held the best alternative tire, the clincher.

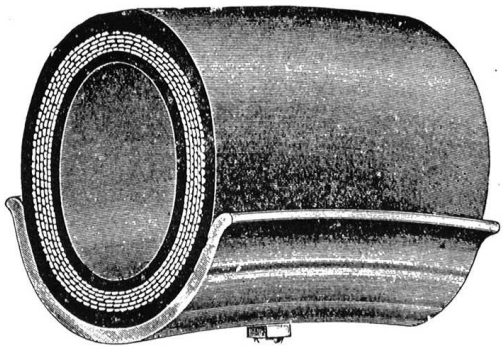
Pope was caught off guard. He had mistakenly placed his bet with traditional hard-tired high-wheelers. When pneumatic tires made safety

Fig. 10.6. Double-tube tire cross-section.

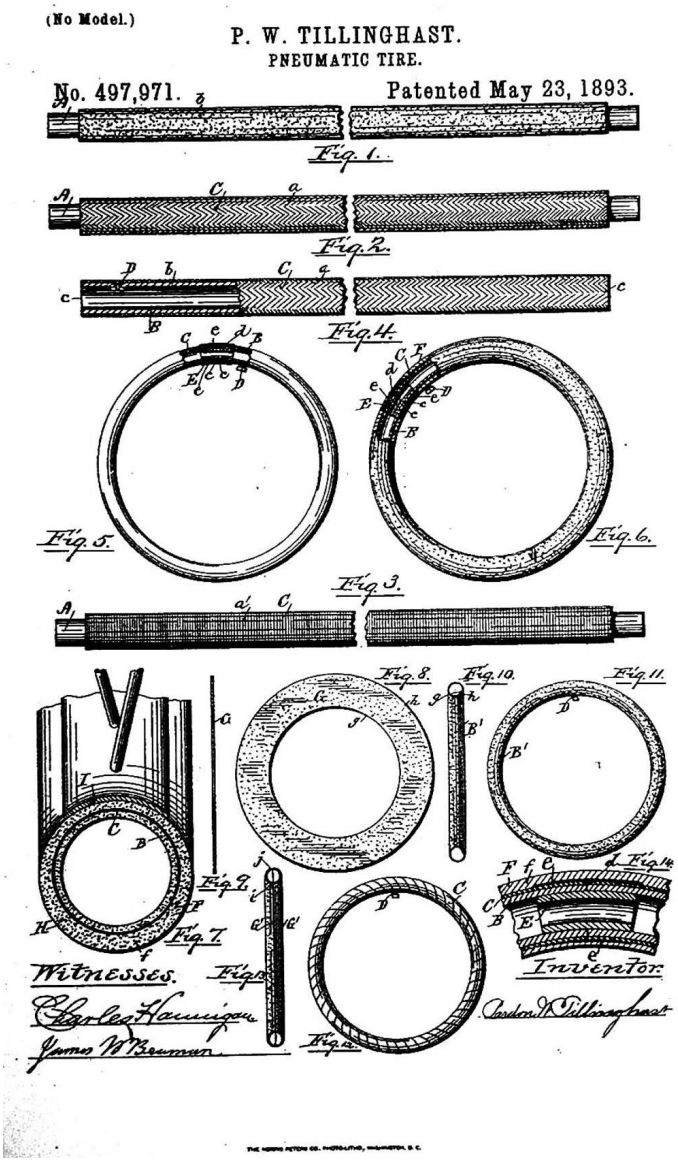


DOUBLE TUBE CYCLE TIRE

Fig. 10.7. An early single-tube tire cross-section.



SINGLE TUBE TIRE


(No Model.)

P. W. TILLINGHAST.

PNEUMATIC TIRE.

No. 497,971. Patented May 23, 1893.

Fig. 1.

Fig. 2.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 3.

Fig. 8.

Fig. 10.

Fig. 11.

Fig. 9.

Fig. 7.

Fig. 12.

Witnesses.

Charles Hamilton

James W. Brennan

Inventor.

Pardon W. Tillinghast

bicycles popular, Pope had to change course quickly. To do so and maintain his autonomy, Pope desperately needed a pneumatic tire. The single-tube tire was his only license-free choice, and he took it.

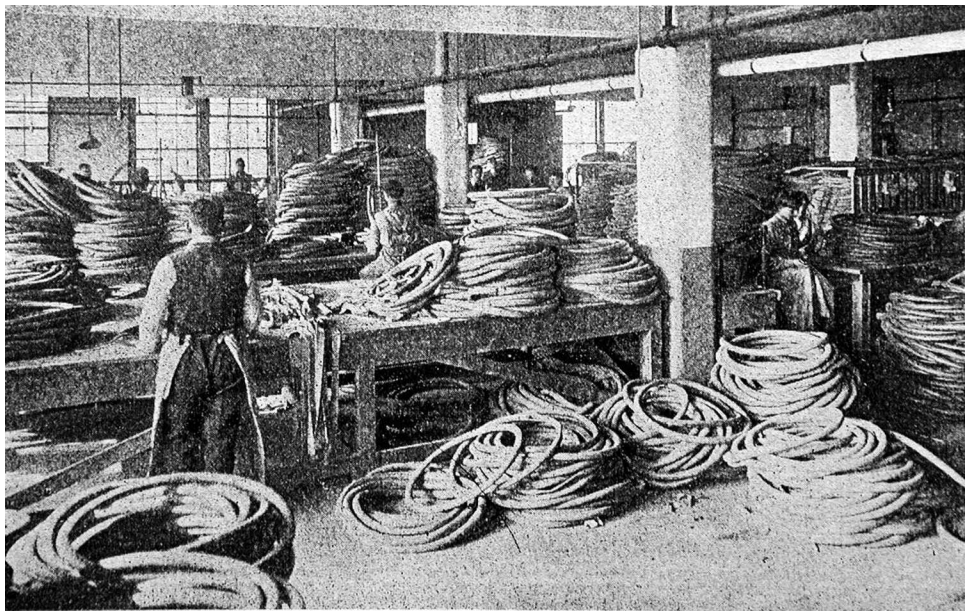
The Tillinghast Patents

Pope introduced single-tube tires on his Columbia, and encouraged the tire's wider adoption by the industry. Many makers found the patent-free tire appealing.

When Tillinghast saw his brainchild succeed, the inventor belatedly applied for and received two patents in 1892 and 1893. He waited three years to defend them, by which time forty-five single-tube manufacturers held 70 percent of the U.S. market.[14] When Tillinghast finally confronted the industry, few people paid attention—most doubted the tire's novelty because of its resemblance to rubber hose.

But Pope nonetheless purchased Tillinghast's patents, and then turned to his cohorts for fees. Twenty-one tire makers bought Pope's licenses and formed an association to enforce them. If the licenses were not respected, non-payers would be at an advantage.

The question remained whether the patents were defensible. In 1899, the Tillinghast Tire Association brought lawsuits against two major



Above: Fig. 10.8. U.S. Patent No. 497,971, by Pardon W. Tillinghast, May 23, 1893 for the single-tube tire.

Right: Fig. 10.9. Single-tube tire production, 1904.

producers. To everyone's surprise a Massachusetts court sustained the patents—a hose was not a tire after all.[15]

Single-Tube Tire Hegemony

In 1899, the Tillinghast Tire Association became The Single Tube Automobile and Bicycle Tire Co. Ironically, Colonel Pope himself bowed out just as the new company gained irreversible momentum.

Pope's share in the Tillinghast patents fell into the hands of America's largest industrial rubber conglomerate, The Rubber Goods Manufacturing Company. This company had already acquired the American Dunlop Tire Company and its U.S. patents. In 1907, the Rubber Goods Manufacturing Company was in turn taken over by its chief competitor, The United States Rubber Company.

In 1911, United States Rubber acquired all four important American bicycle tire manufacturers, including Hartford Tire, Morgan & Wright, and G&J. The new tire division became the United States Tire Company, and was a near monopoly because it brought together all the proprietary designs, patents, and manufacturing techniques used in the country.[16]

The monopolization of the U.S. bicycle tire industry proved the death-knell for the single-tube's alternatives. The single-tube had always been the American industry's favorite, and now there was no incentive for United States Tire to foster any other.

Single-Tube Performance

Pope's first single-tube tires did not get rave reviews on performance. One writer described his initial experience:

"Hosepipe" and "inflated cushion" were the terms of opprobrium that were hurled at it (…) [It] was of large diameter, tremendously heavy, and bore more resemblance to fire hose than to anything else I knew of (…) [I]t ran as if the tires were filled with water.[17]

But later, by reducing the wall thickness, introducing materials like Palmer "all warp" fabric,[18] and other refinements, the single-tube's performance came around. Single-tubes eventually rated well against Dunlop and other rivals, and finally surpassed them.

Above all, the tires became smaller and lighter. Industry-wide fads for skinny tires resulted in widths as narrow as $1\frac{3}{16}$ in. in 1903, and eventually settled around $1\frac{5}{8}$ in.[19] By the late 1890s, single-tube tires had a reputation that complimented American cyclists' sporting ideal. One writer observed that, "… the tendency in the United States was wholly toward single tubes, (…) it having been found that a small single tube, pumped hard, is the fastest of all for road use."[20]

The perception that single-tubes were fast tires may have been partly due to their use with wooden rims. McKee and Harrington of New York City pioneered the use of wood-rimmed wheels in1891, the same year Pope introduced the single-tube tire.

American white ash and rock elm were lighter and more resilient than steel, and stronger across the lateral plane. Some weighed up to 40 percent less than steel rims.[21] In combination with light single-tube tires, the total savings could be up to three pounds. This was considered important when it was claimed that "an ounce saved in the wheels [was] worth a pound saved in the frame."[22]

Also, wood rims took advantage of indigenous wood-craftsmanship. In contrast to the primitive wheels of the velocipede era, these new wood rims were a technological triumph, using the latest techniques of bending, joinery, and lamination.

Practical Drawbacks

The main disadvantage of single-tube tires was their impracticality. Single-tubes could be decidedly hard to live with. The first reason was the tire's poor repairability, and the second was the difficulty of mounting or removing them from the rim. Both problems affected the cycling experience, and both had economic impact.

From the outset, cyclists were concerned about repairing single-tubes. Because of the tire's unique construction, practical repairs were not obvious.

We asked sarcastic questions of each other about it; what would be done in case it did puncture, (…) and we agreed that it would be rather

expensive to have to throw away a tire whenever this happened.[23]

The challenge lay in the two types of damage pneumatic tires incurred, and the respective repairs needed to restore them. One typical failure was when the inner tube became punctured, and the other when the structural fabric was cut or torn. Tires with separate inner tubes allowed the matters to be handled separately—one need only remove the inner tube from the casing. Tubes could then be patched by the roadside; casings could be mended and reinforced. If either was beyond repair, it could be discarded without having to replace the other.

The single-tube tire, on the other hand, had all its components vulcanized together. The inner tube was trapped inside and inaccessible, and the structural fabric was sandwiched in the layers of rubber—impossible to isolate for repairs. The problem was inherent to the design.

Small punctures were not a great problem. If the fabric was intact, you could insert a "plug"—similar to repairs on modern tubeless car tires. Plugs were sometimes made of rubber bands, or took other patented forms. Repair kits had promising names like "Sure Thing," "Common Sense," and "Minute Repair Kit."

However, even straightforward punctures could bring trouble. For one, the rider couldn't always locate the actual damage. Single-tubes became "porous," allowing air to work through the fabric and find multiple exits. A nail going deep enough to injure the tire's interior on the opposite side would create an invisible leak. In this case, one could inject sealing solution into the tire and roll it around to try to seal the damage. But the only realistic option was to locate the damage with a probe, puncture it through to the outside, and put in a second plug.[24]

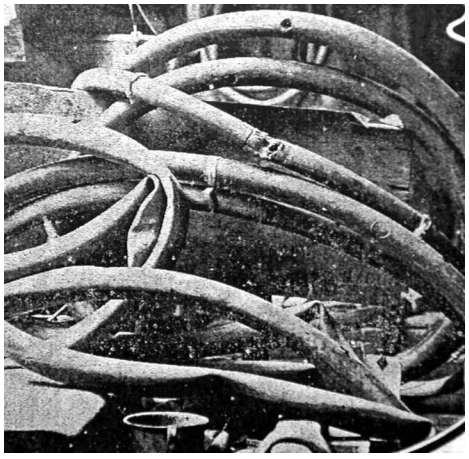


Fig. 10.10: Damaged single-tube tires.

As bad as punctures could be, damaged fabric presented even more serious problems. If this damage was reparable at all, it was only possible in a professional shop. Repair manuals wouldn't even describe the method, called vulcanizing—not even for accomplished cyclists. In this case, a repairman had to strip away the outer rubber, mend the fabric, and then rebuild the tire's rubber exterior. The process involved caustic compounds, heat, a vulcanizing mold, and absolute cleanliness.[25]

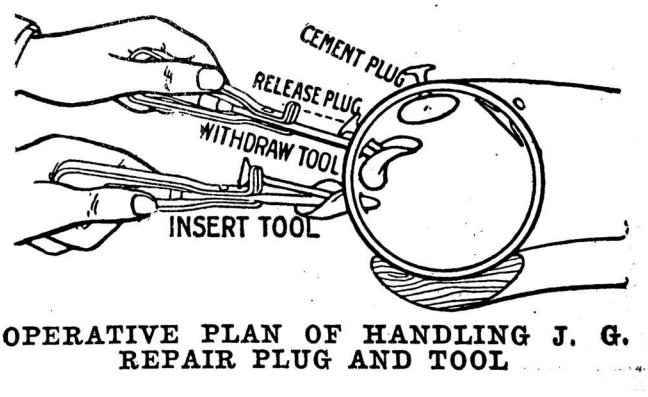
This expensive work had to be done with aggravating frequency. When asked, one repairman pointed to a stack of rebuilt tires and admitted that, "…doubtless half of them will come back to us one or more times during the course of the season to be doctored again."[26]

Vulcanization was expensive but, if successful, produced a sound repair. By contrast, roadside fixes for damaged fabric could only be described as ridiculous. Two such repair products were "tire tape" and metal plugs.

Pope himself promoted tire tape as a temporary fix. The cyclist simply wound adhesive tape tightly around both tire and rim, to seal and support the damage. The absurd "repair" looked like a bandaged arm.

Patented metal plugs were similarly comical. These odd devices helped when rubber plugs would not hold. Metal plugs came in three parts: a flat

Fig. 10.11. Rubber plugs.



oblong base, a threaded stem, and a thin "nut." To make a repair, one worked the base through the puncture, pulled the stem back to seat it, screwed the nut down into the tread, and trimmed off the stem. Unfortunately, the cyclist was left with a metal nut stuck in the tread, and the resulting clatter on the pavement.

The complexity, insufficiency, and expense of repair options meant that far more single-tubes were discarded than other tires, and replacements bought with far greater frequency.

Single-tubes also brought the expense of gluing, unlike Dunlops and clinchers, which were mounted without tools. Gluing was tricky, and the bond had to resist complex forces. Tires frequently came loose, sometimes just from standing in the sun, and could easily pull off the valve stem. More important was the possibility of "rolling" a tire off the rim while cornering. Tire mounting was best done by a shop, where it was among the "most frequent jobs" and required a flame-heated cement kettle.[27]

Later, liquid cements allowed cyclists to attempt emergency repairs, but the solvents were also hazardous. Glue-less attachment systems were tried, such as molded nipples that locked into the rim and serrated washers to grip the tire—but none caught on.[28]

The wood rims presented problems too, primarily from their vulnerability to damp weather. Some were wrapped in fabric to make them watertight, but none were as durable as steel. Wood rims also limited braking options because they couldn't provide a friction surface. For this reason, many U.S. bicycles eschewed brakes entirely, or depended on a single, unreliable rear coaster brake.

Economics

Given the apparent disadvantages, why did the U.S. bicycle industry prefer making single-tubes? First, they were cheap to make—as cheap, in fact, as rubber hose.[29] The tire was built on a mandrel, its ends brought together and spliced, and then cured in a mold. The tire was also cheap because it was simply glued to the wheel. There were no inextensible wires to be sewn in the casing, or reinforced clincher beads. The bottom line was that single-tubes cost half as much as other tires.

Industry liked cheap tires because they lowered new bicycles prices, a fact that became more pronounced as time went on. In the mid-1890s tire choice affected a bicycle's price by about 9 percent. But because bicycle prices fell faster than tire prices, in 1900 tire choice influenced prices by 34 percent, and in 1908 by a whopping 42 percent.[30]

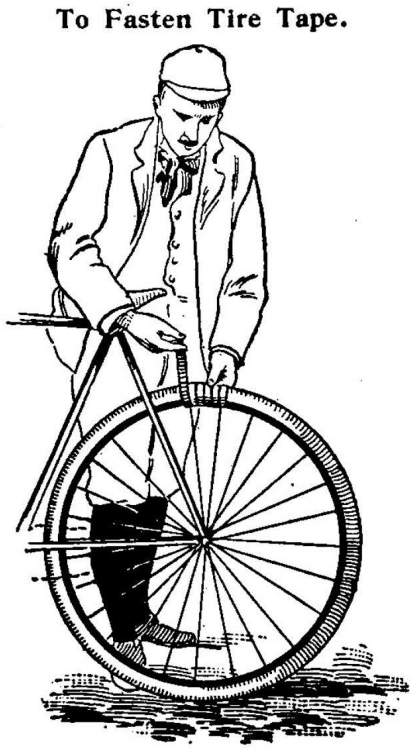


Fig. 10.12. Tire tape.

Fig. 10.13. Metal plugs.

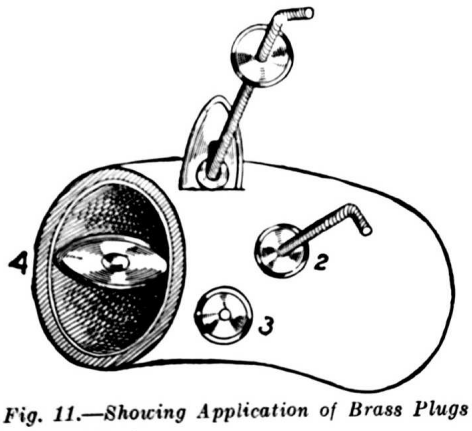


Fig. 11.—Showing Application of Brass Plugs

Another reason industry liked single-tubes was their need for frequent replacement—the tires themselves were profitable. In the glutted bicycle market, manufacturers could sell bicycles at a loss and recoup their profits with replacement tires.

In contrast, the economics of single-tubes were disastrous for consumers. During the Boom, recreational riders hadn't minded the single-tube's expense, and they liked the sporty handling. But later, practical-minded riders found the single-tube's high costs frustrating. Frank Schwinn, a rare detractor in the industry, fumed about single-tube tires:

> Just how much this silly tire policy held back the [bicycle's] development as an adult transportation factor will never be known.[31]

Foreign Perspectives

While American cyclists were largely oblivious to their comparative disadvantage, the contrast was clear to bicycle importers abroad. One Danish buyer stated flatly, "our people won't take single tube tires," and an Englishman dissembled the problem for American readers:

> Riders feel that they must have some easy and fairly quick way of effecting permanent repairs. They cannot be dependent upon repair shops, but must be prepared to make the repair themselves, anywhere and at any time.[32]

A Dutchman was simply flabbergasted by the Americans:

> While detachable tires are practically in universal demand, the [American] job lots were fitted with… cemented tires… [and] it appeared difficult to impress the fact upon the American mind.[33]

Not surprisingly, American exporters found few enthusiastic buyers.

Conclusion

What prevented Americans from making the changes required by changing conditions? Short-sighted business leadership was a prime culprit, and consumers' failure to champion their needs was another. Many at the time also noted the distracting intoxication of motor technology. Colonel Pope himself was said to be building automobiles "…for just one person: himself," as his bicycle empire fell

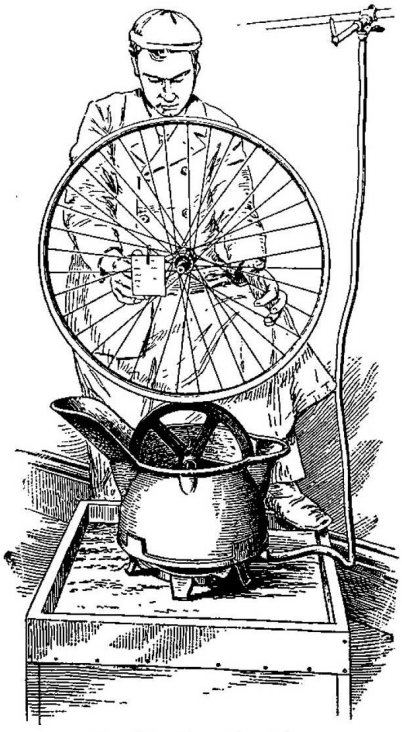


Fig. 15.—Cementing Rims

Fig. 10.14. Tire cementing station.

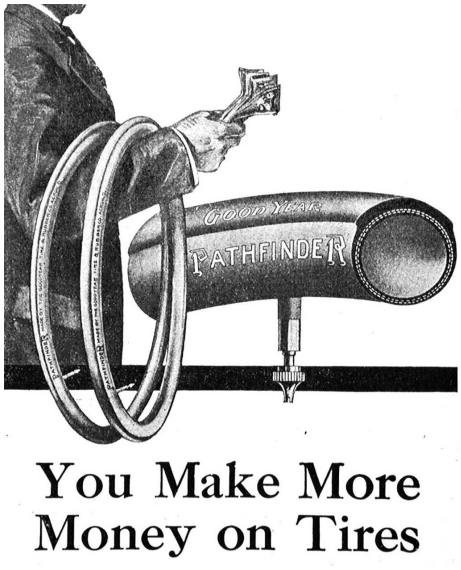


Fig. 10.15. Promoting single-tube tires to dealers, 1902.

to ruin.[34] The infatuation captivated bicycle makers and mechanics alike. In 1909, one frustrated businessman reported:

> Mr. Bicycle Man is spending all of his spare time tinkering with planes, propellers and whatnots… before long he is neglecting his business. On my last trip through New York State I found half a dozen such cases.[35]

It was said not even second-rate minds remained engaged in improving bicycles.[36]

The single-tube story finally ended in 1933, when forward-thinking Schwinn introduced detachable balloon tires on his breakthrough B 10-E.[37] Shortsighted business practices and consumer complacency had undermined a promising technology for forty years. Within a year, the single-tube all but vanished from the market.[38]

Endnotes

1 "Facts and Figures Show Bicycle Industry's Progress," *Bicycle News, the Bicycle Trade Authority* 3 (March, 1917), 5. Bruce Epperson, "How Many Bikes?", in *Cycle History 11: Proceedings: 11th International Cycle History Conference* (San Francisco: Van der Plas Publications, 2001), pp. 42–50.

2 Central Canada is a good comparison, where English roadsters were available through commonwealth trade ties. John Lehr and John Selwood, "The Two-Wheeled Workhorse: The Bicycle as Personal and Commercial Transport in Winnipeg," *Urban History Review* 27 (October, 1999), 3–13.

3 Richard Harmond, "Progress and Flight: An Interpretation of the American Cycle Craze of the 1890s," *Journal of Social History* 5 (1971–1972), 244–245. Tobin, Gary Allen. "The Bicycle Boom of the 1890s: The Development of Private Transportation and the Birth of the Modern Tourist," *Journal of Popular Culture* 7 (1974), 840–842. "An Editor's Nightmare: Visits America, Sees Things and Records Some Dreamlike Impressions," *The Bicycling World* 40 (November 9, 1899), 155.

4 "Bicycle's Rehabilitation: Light Shed on its Growing Favor with Certain Anti-Faddist Classes," The *Bicycling World* 47 (June 27, 1903), 405.

5 Karl Hodges, "Did the Emergence of the Automobile End the Bicycle Boom?" in *Cycle History: Proceedings of the 4th International Cycle History Conference* (San Francisco: Bicycle Books, Inc., 1994), 39–42.

6 Paul Rosen, *Framing Production: Technology, Culture, and Change in the British Bicycle Industry* (Cambridge, Massachusetts: MIT Press, 2002), 14.

7 Maria E. Ward, *Bicycling for Ladies: The Common Sense of Bicycling* (New York: Brentano's, 1896), 78–79.

8 Montgomery Ward & Co., "Oh Boy! It's a Winner: Hawthorne Flyer," *Catalog for Fall and Winter 1929–30* (Chicago: 1929), 664.

9 "The Tire Repairs that Come in the Spring—tra la!" *The Bicycling World* 51 (April 29, 1905), 130.

10 Safety bicycles' main drawback in comparison to dangerous high-wheelers was vibration from their smaller wheels. *Engineer* (1889), 158, reprinted in Bijker, Of Bicycles, Bakelites, and Bulbs (1995), 73.

11 Dunlop may have even been inspired by fellow Edinburgh inventor Robert Thompson's pneumatic carriage wheels of 1846. See: Alistair Dodds, "Dunlop and the Pneumatic Bicycle Tyre – the Edinburgh Connection" in *Cycle History 11, Proceedings: 11th International Cycle History Conference* (San Francisco: Van der Plas Publications, 2001), 104–110.

12 Pardon W. Tillinghast, *U.S. Patent No. 497,971* (Washington D.C.: U.S. Patent Office, September 2, 1892).

13 Englishman Harry Dacre wrote the song "Daisy Bell" in 1892 after paying Pope's royalty to bring his bicycle into the U.S. A friend suggested he was lucky not to have a "bicycle built for two," which would require twice the fee.

14 "Single Tubes Abroad: Two Kinds of Evidence Compared—Claimed to be of Equal Worth," *The Bicycling World* 43 (July 4, 1901), 312.

15 The First Circuit Federal Court of Massachusetts decided against the Reading Rubber Co. and a subsidiary of United States Rubber.

16 The United States Tire Company acquired, among its eighteen subsidiaries, the Single Tube Tire Company and its Tillinghast patents, the American Dunlop Company and its "straight-side" wired-on patent, Morgan & Wright and its double-tube patent, and G. & J. and its clincher patents.

17 "Tillinghast's Triumph: The Hosepipe Tire was First Derided—How Success Came," *The Bicycling World* 40 (November 23, 1899), 233.

18 "All-warp" fabric gave some single-tubes a resilient character similar to modern radial tires.

19 "Are Tires Too Small? The Question Asked and Dissected—Suggests Spring vs. Rigid Frames," *The Bicycling World and America Cyclist* 40 (October 5, 1899), 17. "Why Not Larger Tires?" *The Bicycling World* 47 (September 19, 1903), 711.

20 Henry C. Pearson, *Pneumatic Tires: Automobile, Truck, Airplane Motorcycle, Bicycle* (New York: The India Rubber publishing Co., 1922), 649.

21 Alex Schwalbach and Julius Wilcox, *The Modern Bicycle and Its Accessories: A Complete Reference Book for Rider, Dealer, and Maker* (New York: The Commercial Advertiser Association, 1898), 72.

22 "Wood vs. Steel Rims Again," *The Bicycling World* 47 (August 8, 1903), 572.

23 "Tillinghast's Triumph" (1899).

24 Charles W. Leng, ed., *Bicycle and Motorcycle Repairing, 7th ed.* (New York: David Williams Company, 1912), 155, C. von Culin, *The Bicycle: Its Care and Repair* (Delaware City, Delaware: C. von Culin, 1896), 74–76.

25 Schwalbach and Wilcox, *The Modern Bicycle and Its Accessories* (1898), 80–81.

26 "The Tire Repairs that Come in the Spring—tra la!" (1905).

27 "Treatment of Tires," *The Bicycling World* 43 (May 30, 1901), 220.

28 Something New in Single Tubes," *The Bicycling World* 40 (December 7, 1899), 321.

Schwalbach and Wilcox, *The Modern Bicycle and Its Accessories* (1898), 75.

29 "Hose and Tires: Resemblance Between the Two Articles—Even Price is Similar," *The Bicycling World* 43 (July 18, 1901): 341.

30 Calculations based on prices published by Sears, Roebuck, & Co, 1896–1908.

31 Frank W. Schwinn, *1942 Personal Notes on the Bicycle Industry* (Chicago: Archives of the Bicycle Museum of America, 1993), 19.

32 "Force of Habit," *The Bicycling World* 40 (October 26, 1899), 105.

33 "Dutch Importer Here: Talks interestingly of Situation Abroad and Points out Some American Shortcomings," *The Bicycling World* 47 (August 29, 1903), 632.

34 Bruce Epperson, "Failed Colossus: Albert A. Pope and the Pope Manufacturing Company 1876–1900," *Technology and Culture* 41 (2000), 320.

35 "Aeroplanes Affecting Dealers: Stroud Finds Some of Them Experimenting at Expense of Their Businesses—His View of Situation," *The Bicycling World and Motorcycle Review* 50 (December 18, 1909), 422.

36 Forrester, John, *Bicycle Transportation* (Cambridge, Massachusetts: MIT Press, 1983), 183.

37 The Schwinn B 10-E was the first true American balloon-tire cruiser. It ushered in a school of bicycle design that ultimately provided a basis for modern mountain bikes.

38 By 1934, bicycles from national mail-order houses were equipped with detachable balloon tires, and single-tubes were offered at a reduction. Montgomery Ward & Co., *Catalog no. 120 for Spring/Summer 1934* (Chicago: 1929), 352–353. Sears, Roebuck and Company, *Catalogue for Fall and Winter 1934–1935* (Chicago: 1934), 495–497.