The Bicycle, a Technical Precursor of the Automobile

*Martha Moore Trescott**
Department of History, Southern Methodist University

There are many ways in which the bicycle of the 1890s, both as an industry and as an individual machine, helped usher in the automotive age in the United States. The pre-1900 US bicycle industry has been found to have been considerably larger than previous estimates have indicated and it is likely that it affected many manufacturing sectors besides the automotive, such as machine tools, machinery sectors, and steel producers. A recent reassessment has placed peak production of bicycles for the 1890s at approximately 1 percent of GNP for the US in 1897. In addition, it is thought that between $1\frac{1}{2}$ and 2 million bicycles were produced in this country in that year alone and that about 5 million bicycles were in use in the US in 1900.[1]

The US bicycle industry of this period is well worth study in its own right, but it is also interesting to consider from the standpoint of its possible influence on supply and demand in the coming of the automobile industry to the US. Other historians have already highlighted some of these avenues of influence, both on the supply and demand sides.[2] In this essay, the supply side is particularly considered, with special emphasis on transfer of technology from the bicycle sector into automotive production during the 1890s and early 1900s.

I.

Historians of technology have previously treated aspects of this technology transfer.[3] In particular, Nathan Rosenberg [45] has included a relevant discussion, placing technological contributions from bicycles to automobiles within the larger context of "technological convergence" of production techniques for firearms, clocks and watches, sewing machines, bicycles, and automobiles and other machinery around the machine tool sector. This sector, in his view, had largely evolved from the production of textile machinery in New England. Rosenberg cites as some technological contributions from bicycle manufacture to automobile production improvements in machinery for grinding and gearcutting

and also the development of the oil-tube drill for producing bicycle wheel-hubs. He calls particular attention to the innovations of Henry M. Leland and the firm of Leland and Faulconer in the development of the bevel gear for the chainless bicycle, which enjoyed a brief heyday of popularity in the late 1890s [45, pp. 434-38].[4] Although the chainless safety bycycle did not achieve the popularity of the safety with sprocket and chain, the innovations in bevel gears for rear wheel drive of the chainless were of great importance in the early automobile. In fact, by 1902 Leland and Faulconer were making Cadillac automobiles which utilized bevel gearing on the rear wheels, just three years after the firm had developed similar gears and gear-cutting equipment for bicycle manufacture [37, p. 499].

Other machine tool innovations which enabled the production of precision parts important both in bicycles and automobiles centered in grinding machinery. Rosenberg has likewise noted some of these contributions, drawing in part upon the work of Robert S. Woodbury [45, pp. 435-37; and 62, pp. 109-14]. Aubrey Burstall has also commented on the significance of grinding innovations developed primarily for the manufacture of cup-and-cone ball-and-roller bearings [10, p. 355]. The mass production of the ball bearing was occasioned by the rise of the bicycle industry, both in Europe and the US [35, p. 15]. However, as Woodbury notes, these bearings "proved to be not very satisfactory until the 1890s," when the safety became so popular [62, p. 109]. Certainly cup-and-cone bearings became a standard feature of the safety of the 1890s, solving the ancient problem of mechanical friction [10, p. 355]. These bearings were typically used on the safety on the front and rear hubs and crank hanger (for the pedal cranks) as a survey of the trade catalogs of the day reveals.[5]

Rosenberg, Woodbury, and Burstall have, then, called attention to some contributions of certain kinds of metal-working technology, innovated specifically for bicycle production and adapted later to automotive and other manufacture. These contributions so highlighted might be viewed collectively as precision techniques, and certainly constitute one avenue of technology transfer from bicycles to automobiles. Yet there are others.

II.

In fact, the American automobile, especially as produced in the early 20th century in the Midwest, should be seen as the outgrowth of several kinds of manufacturing experience in the US. In several of these, the bicycle played a significant precursor role and in some it is likely it did not. One of the latter consists of techniques arising from the manufacture of carriages and wagons, emphasized by John B. Rae in his attempt to analyze the midwestern base of early automobile manufacture [42, pp. 28-

29].[6] Transfer of other technology not directly related to the bicycle sector into automobiles can be seen in contributions from engine making, especially internal-combustion engines. In fact, it may well be that Detroit, which was not the most outstanding bicycle- or wagon-making center, was the capitol of automobile manufacture early because of its preeminence as a center for the production of small launches (primarily for transport on the Great Lakes and related waterways) powered by internal-combustion engines and means other than steam [48, p. 227].[7]

However this may be, bicycles did supply the early automobile sector with significant technologies easily adaptable to automobile manufacture. Besides precision machine tools and parts produced by these tools, one calls to mind the pneumatic tire, which was an innovation used extensively on the safety bicycle and also on early automobiles, as John Rae and others have noted [42, pp. 6-7; and 49, pp. 14 and 20-21].[8]

Further, even though the bevel gear was an important contribution from the bicycle to the automobile industry, it should be remembered that the bicycle's sprocket-and-chain drive, often with at least two-speed gearing arrangements, also found application on some of the first motorcars.[9] This particular instance of technology transfer serves to highlight another very important area of technological innovation which gave impetus to rise of the US bicycle industry in the 1890s and which the bicycle industry, in turn, helped stimulate: the increasing availability of cheaper, lighter, and more durable steel.

Considerations of steel, which became increasingly available from American mills at cheaper prices during the last quarter of the 19th century,[10] enter into this analysis in several important ways. John Rae says that [42, p. 62]

> from the bicycle manufacturers the early automobile industry inherited steel-tube framing that combined strength with lightness, the chain drive, ball and roller bearings, and differential gearing....

The "ordinary," or high-wheel, bicycle of the 1880s sometimes used steel extensively, as in the frame and wire-spoke suspension wheels [38, p. 282]. Even though safeties of the 1890s often sported wooden wheels (which also were used on early automobiles), many used steel in the wheels. In addition, it was asserted in 1894 that "the seamless steel tube... is literally, figuratively, and every other way the backbone of the bicycle" [63, p. 136]. In fact, there is evidence that various sorts of steel tubing were innovated by the steelmakers for the bicycle market.[11] Also the bearings of the ordinary and safety and the chain of the safety were typically made of steel. An example of technology transfer in regard to chains was the Baldwin Cycle Chain Company of Worcester, Massachusetts, which began in 1900 "paying special

attention to the manufacture of a line of chains suitable for automobiles" [2, p. 542] as many early autos were chain-driven.

The major role of steel in the construction of cycles [50, p. 538] gave rise to techniques of manufacture and testing which transferred into the automobile industry. As early as 1878, in Hartford, Connecticut, Albert Pope began to produce bicycles "upon what may be termed," as the *Bicycling World* of 1881 [22, p. 326] stated "the truly American scale; that is, they started with a view to making every part of the bicycle by machinery, so that the parts should be interchangeable...." At that time, a visitor to the factory described the drafting room, the forge shop, the perch shop (where the backbones were formed), the various welding shops, the polishing room, the lathe room, and the paint shop [22, pp. 328-29], each treating and handling one or more of the "300 parts making up a bicycle" [5, p. 204].

> It is an interesting experience to begin at the forge shop, and follow, step by step, the process of manufacture, from the rough bar of steel through all the various stages, until one is ready to take the completed wheel at the office door and ride away [22, p. 329].

Testing finished bicycle components was also an integral part of the industry and became fairly sophisticated by the time of the coming of early automobiles to the American market. These testing procedures relate to the use of steel in bicycle parts, as many of the tests were developed by the bicycle industry. Throughout the middle and late 1890s, the American Iron and Steel Institute published tests for various bicycle parts [6, p. 410].

> The tubing is subjected to intense vibratory strains, so that it is evident that impurities, such as phosphorus and sulphur, should be absent as far as possible.... The experiments with rotating shafts by J. E. Howard refute many preconceived ideas and show that the greatest resistance to alternate stress is obtained with steel containing 0.50 percent of carbon.

In 1897 the Pope works "testing machinery consists of a 100,000-lb Emery machine and various appliances for testing the endurance of frames and wheels" [33, p. 516]. Another examination of bicycle tubing made use of a "lever machine for testing... under compression, either by bending, crushing, or splitting" [53, p. 469]. Further, tests were developed by bicycle producers not only for steel but also for aluminum, copper, iron, and wood.[12]

Cheaper, more durable, and more lightweight steel, then, entered the bicycle of the 1890s in the tubing, the spokes

(in some cases), the chain, and precision parts such as ball-and-roller bearings and also helped stimulate the development of tests applicable to certain early automotive parts. Indirectly, too, the availability of more varieties and shapes of steel undoubtedly fostered the rise of the sector of bicycle-parts makers who in some cases became automobile-parts makers.[13] It is interesting to realize that the average weight of the standard, adult safety dropped from about 42 pounds in 1890 to about 22 pounds in 1895, an average which was maintained throughout the late 1890s and into the early 1900s. It is likely that the increasing availability of cheaper steel helped account for at least some of the decrease in price of the standard safety during the first half of the 1890s when the bicycle's weight was falling rapidly.[14] (See Chart 1.)

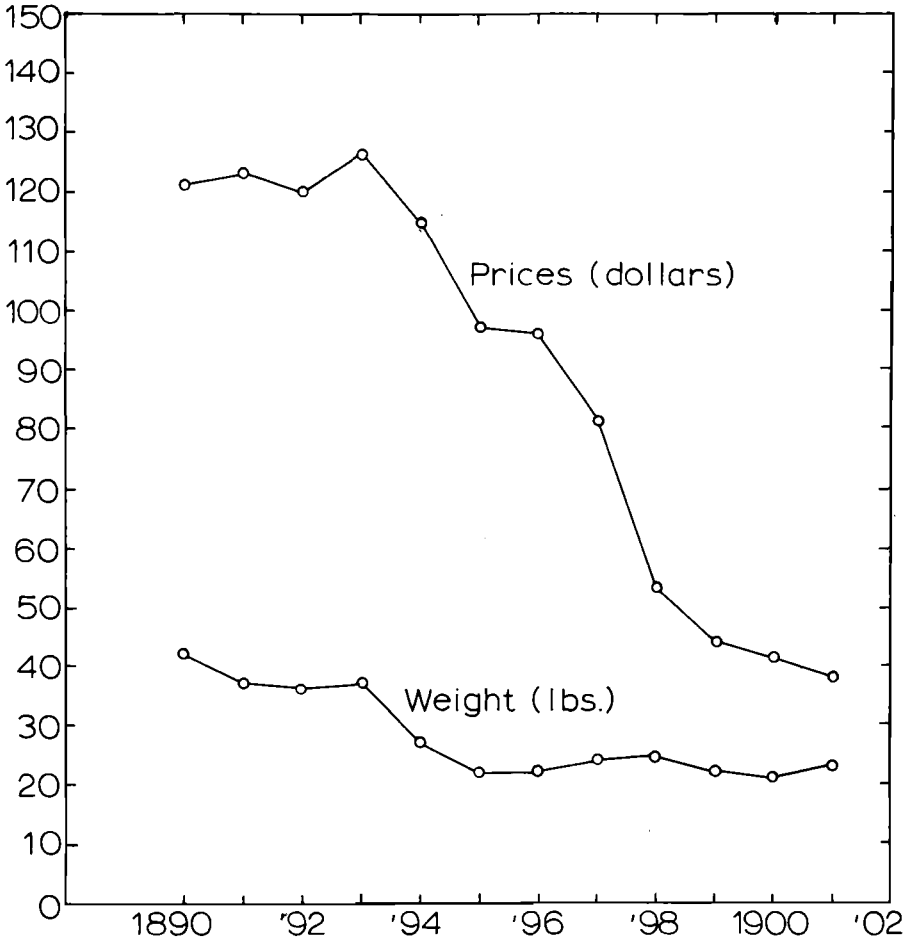
III.

Related to the coming of cheaper steel in a greater variety of shapes and sizes is not only the manufacture of tubing and precision parts (and likewise the machines to make these parts, machinery whose production also undoubtedly benefited from cheaper, more durable kinds of steel) but also the increasing use of stamped parts in the bicycle of the 1890s. Cheaper steel sold in sheet from the American mills enabled the evolution of stamping and press work for certain cycle parts, techniques whose adaptation (as both Rosenberg and David Hounshell have noted) were of utmost importance in the manufacture of the automobile [25, pp. 16 and 31; and 45, p. 438]. It is difficult to envision the cheap, mass-produced motorcar without the use of stamped parts and press work and it is likewise improbable that the US could have mass-produced the cheap safety of the 1890s without such techniques, as Hounshell has stressed [25].

The results of this research support certain tentative conclusions which Hounshell has made in [25, pp. 14-19 and 30-34] concerning some regional differences in the production of the American bicycle of the 1890s. Hounshell found what he has termed a midwestern "genre" as opposed to an eastern one and possibly a third, perhaps centering in New York State. According to his investigation, the midwestern genre of bicycle making was characterized in part by more stamping and press work than in the East, where precision manufacture continued to be relied upon to a greater degree before 1900. (Hounshell's analysis primarily treats the pre-1896 period [26]). Hounshell has contrasted two firms only, Chicago's large Western Wheel Works and Hartford's Pope Manufacturing Company. Western Wheel, he asserts [25, p. 31],

> by 1896...employed press techniques for almost every part of its "Stirling" [or "Sterling"], a cycle that was included in the "first class" of bicycles. These

Chart 1
AVERAGE WEIGHTS AND PRICES OF ADULT SAFETIES, 1890-1901



parts included the hubs, steering heads, sprockets, frame joints, crank hangers, fork and crown, seats, handlebars, and various brackets. Western mechanics reduced machining work to a bare minimum.

Indeed, even as early as 1890, it was claimed in *The Wheel,* a cycle trade journal, that "the immensity of the plant of the Western Wheel Works...has to be seen to be fully appreciated" and that even at that time they had at least 600 employees at work and were

planning to produce 25,000 wheels that season alone [59 (1890), pp. 472-74]. That output, if achieved, would have represented over 60 percent of total US production in bicycles for 1890, according to census estimates, which are undoubtedly too low.[15] Hounshell comments that "soon" after 1891 Pope was turning out 60,000 bicycles annually [25, p. 14].

If one views regional differences in bicycle manufacturing in the US in the 1890s on a broader scale than the case study approach allows, some interesting results are obtained from which certain conjectures can be made.[16] Table 1 shows a sample of the total number of firms making bicycles in the US, 1890-1900, from which Chart 2 has been constructed. What becomes clear from study of these data is that the western firms (here inclusive of and bounded by Ohio on the east, Minnesota on the north, Iowa on the west, and Missouri on the south) dominated the big boom of the mid-1890s, the one typically identified with "the" bicycle boom of the 1890s which has been cited as evidence of a countercyclical industry [23, pp. 145-46].

The trough in 1893 is particularly interesting to consider for our purposes. For after about August 1893, according to the intersection point of the graphs in Chart 2, the Midwest dominated the US bicycle industry up until about mid-1899 (when the bicycle trust was formed) in terms of number of firms. (From census estimates, it would appear that this holds true for *size* of firm as well.)[17] Thus when the boom in bicycle production (registered here in number of firms) is dissected geographically, it would appear that the truly countercyclical component during the depression which followed the panic of 1893 (which, incidentally, began to be felt strongly first in the summer of 1893, and here recall the intersection point of the graphs in Chart 2) is the midwestern industry. It is interesting to combine this timing in the depression's onslaught with (1) the boom in the midwestern bicycle industry, (2) the fact that the Midwest was the center of agricultural implement production in the 1890s, (3) the fact that some agricultural implement makers had gone into the bicycle business by the mid-1890s, as will be shown subsequently, (4) the fact that stamping and press work were very important both in the mass production of agricultural implements and the midwestern bicycle, and (5) the fact that, of all the durable equipment sectors in the US farm implements were the singly hardest hit by the depression of the 1890s except for locomotives and railroad cars, according to Charles Hoffman, especially during the years 1893-96.[18] Could it be, then, that midwestern mechanics, heavily geared to the farm implement sector, had both an especially strong incentive to diversify into other manufacture and a base of expertise particularly applicable to the mass production of many stamped bicycle parts? This question can only be answered with much more research, but it is worth raising here.

One thing seems certain -- that is that there had to be a

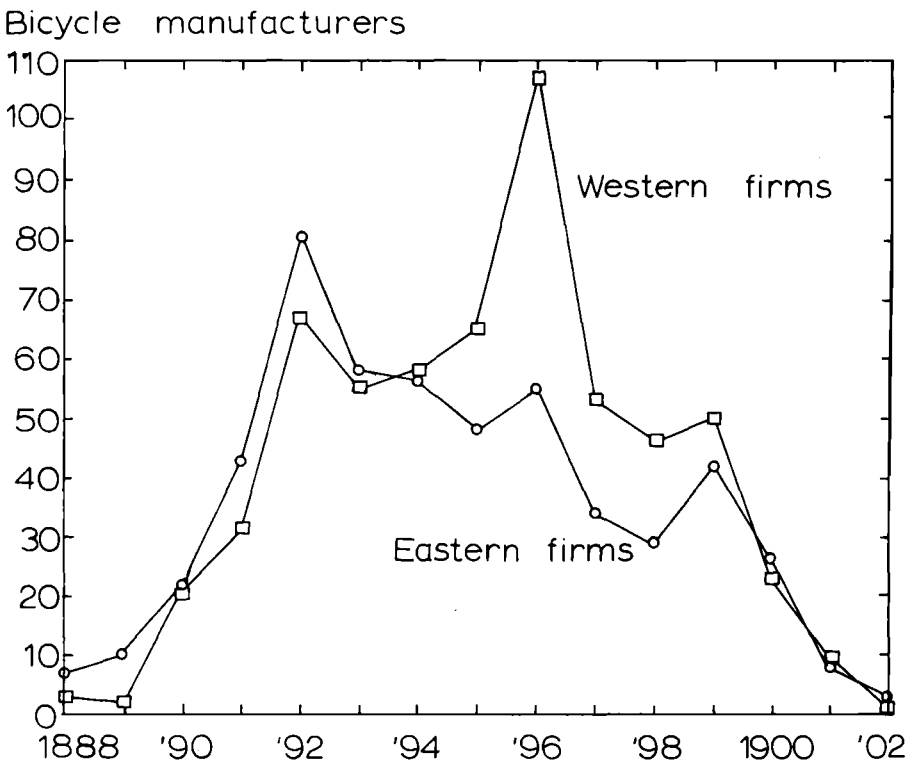
Table 1
NUMBER OF BICYCLE MANUFACTURERS IN THE US BY YEAR AND BY STATES, 1890-1900

Year	Mass.	Conn.	Other New Eng.	N.Y.	Pa.	D.C.	N.J.-Md.	Mo.	Ill.	Mich.	Ohio	Ind.	Wis.	Iowa	Total
1890	10	3		3	3	1	2	1	18		2				43
1891	14	3		12	9	2	3	1	20	2	4	4			74
1892	21	5	2	29	16	3	5	1	36	5	13	9	1	1	147
1893	14	4	1	25	9	1	4	2	26	5	14	5	2	1	113
1894	16	4	2	20	9	2	3	2	23	5	17	7	3	1	114
1895	12	4		23	8		1	2	29	4	18	8	3		112
1896	15	8		24	7		1	2	54	9	18	18	6		162
1897	12	4		11	6		1		25	3	15	7	3		87
1898	9	3		11	5		1		22	4	13	5	1		74
1899	7	4		21	9		1		32	3	10	3	2		92
1900	5	2		16	3				7	2	6	6	2		49

Sources: For a discussion of sources, see Notes 7 and 16.

Chart 2

WESTERN[a] AND EASTERN[b] MANUFACTURERS OF BICYCLES, 1888-1902



[a]Includes Missouri, Illinois, Michigan, Ohio, Indiana, Wisconsin, Iowa, West Virginia, and California.

[b]Includes Massachusetts, Connecticut, other New England, New York, Pennsylvania, District of Columbia, New Jersey, Maryland, and Delaware.

preexisting base of expertise upon which midwestern bicycle makers (some of whom sprang up almost overnight and were largely assembly operations)[19] could draw. Hounshell asserts that [25, p. 17]

> whereas bicycle manufacture in New England was taken up largely by arms makers, sewing machine companies, or similar small-item manufacturing concerns, western cycle builders emerged from carriage and wagon factories, wooden toy companies, wooden novelty specialists, or totally new enterprises.

This statement is similar to that of John B. Rae in his discussion [42, pp. 28-29] of the "marked Midwestern orientation" of the US automobile industry "almost from the beginning," when he states that

> the Middle West's chief initial advantage over its principal competitor, New England, was that the hardwood forests of Michigan and Indiana had made the region the center of carriage and wagon manufacturing, from which the transition to motor vehicles was natural.

(Incidentally, it is not even clear that New England was the Midwest's chief early competitor in auto manufacture, as New York may have been. It is unfortunate that space here does not permit consideration of New York's bicycle and automotive industries.)

Was the transition from wooden manufacture to either bicycles or motorcars really that natural? Surely carriage and wagon makers contributed expertise to the production of both kinds of vehicles. We can cite wagon makers who became early auto makers, such as Durant, Whiting, Fisher, and the Studebakers. Yet for every wagon maker who went into automobile production, there was perhaps his bicycle counterpart, such as Pope, Winton, the Duryeas, Willys, Stearns, Lozier, and so on. Therefore, once again it should be stressed that the case study approach, while necessary and useful, will not provide a complete picture or well-rounded explanation.

What will? In addition to case studies of individual entrepreneurs and firms, which is the subject of planned future work, regional manufacturing statistics can be used. Admitting the inadequacies of census data, we can nevertheless juxtapose census figures for a number of kinds of manufactures, 1890-1900, to try to spot glaring differences, which might then facilitate determination of regional comparative advantages in manufacturing. When this is done, although lengthy discussion of the findings is not possible here, one sees that neither Michigan nor Indiana was *the* leading producer of wagons and carriages, 1880-1900, though this industry in both states had undergone rapid growth, especially during 1890-1900. Even if one concedes that these states were impressive manufacturers of wagons and carriages, it would seem

that one could at best state that the manufacturing traditions stemming from this industry constituted only one component in the blend of manufacturing customs which merged to give the world the Midwest's early motorcar.

What are some of the other manufacturing practices which also might have combined to produce the American automobile? There are many, too many to enumerate here. However, one possibly significant one which has been overlooked may have emanated from a kind of production for which the Midwest as a region could claim an outstanding comparative advantage by the 1890s, as already stated: agricultural implements.

Illinois was unquestionably the leading center of agricultural implement manufacture by 1890, if value of output is the measure. Its product of over $24 million was more than double that of New York and nearly twice as large as that of Ohio, its closest competitor. By 1900 Illinois's lead in this production had increased to about a factor of four over that of each New York and Ohio [32, pp. 345-56]. If by the mid-1890s, as indicated by Table 1, Illinois led in number of bicycle firms in the US, Illinois had evolved any comparative advantage over other states in the metalworking arts, surely it would have been in agricultural implement production, including the machinery sectors which helped supply both parts and equipment to the farm implement producers.

Combining this information with facts from certain case studies helps to fill in the picture once again. Various agricultural implement producers diversified into bicycles, building them in their existing plants, erecting new plants for this production, or contracting with other establishments for this manufacture. In one way or another, such diversification was occurring by the mid-1890s, and my data show that this happened primarily in Illinois.

One case in point is Deere and Company. In 1894 Deere and Webber went into bicycle production, drawing upon the expertise of certain manufacturing establishments in Chicago. By 1895 Deere and Webber were selling the "Deere Leader" and the "Moline Special" and by 1897 were planning to build a plant in the Chicago vicinity, but the demand for bicycles fell and this plan was evidently never realized [1]. Also in Illinois, the Harber Brothers of Bloomington diversified into bicycles. In 1891 *The Wheel* [59 (1891), p. 75] commented about this firm that they "appear to have gone into the bicycle business in an excellent way. The firm have finely established business of the style conducted by Rouse, Hazard & Company, of Peoria, that is, they deal in farm machinery, wagons, buggies, etc." Although it appears that Harber Brothers did not make their own wheels at that point, by 1892 they were listed as selling their own brand of bicycle, the "Bloomington" [41, p. 374]. Whether Harber actually made this bicycle or had it made for them, the fact remains that they diversified into bicycles and that to do so they probably were drawing upon some midwestern expertise in this manufacture, as was Deere and Webber. (It may well have

been economical for midwestern manufacturers of agricultural implements and cheap bicycles, both using stamped parts extensively, to locate close to the supply of stamped inputs, whose low cost of production could easily be canceled by the cost of transport over any great distance. It is of interest that by 1895 Chicago appears to have been not only the trade center for US agricultural implements and bicycles but also a center for stamped parts. However, much more research must be done to verify this impression.)

A possibly interesting linkage between farm equipment and bicycles, on the one hand, and bicycles and automobiles, on the other, can be seen in the foregoing comment on Rouse, Hazard and Company and by charting the business involvements of Rouse and associates. The Rouse-Duryea Cycle Company of Peoria apparently was organized in 1890, while Rouse, Hazard and Company had been established in 1864. There is no evidence of Rouse, Duryea after 1892, but John Rae notes [42, p. 9] that

> the automobile era in the United States dates from September 21, 1893, when a motor carriage with a one-cylinder gasoline engine chugged noisily along the streets of Springfield, Massachusetts. It was the creation of two brothers, Charles E. ... and J. Frank... Duryea, bicycle mechanics...

The Duryea auto factory apparently had an assembly line as early as 1896 [24 (1896), p. 8]. Were these the same Duryeas as the Rouse associate(s) in the bicycle business? If so, it would be interesting to explore the history of these firms in depth, possibly for something significant about technology transfer not only from bicycles to automobiles but also from farm-implement making to bicycles.

To be sure, manufacturers other than makers of farm equipment and wagons and carriages went into bicycle production in the 1890s. Table 2 indicates some preliminary findings concerning this, and from these data one can see that sewing machine and firearm mnaufacturers certainly rank high in the sample. It is interesting, however, that the Midwest does not particularly dominate the eastern and middle states (combined) in terms of number of firms which went into bicycle production from sewing machine, clock and watch, and firearm production, whereas the Midwest is the only locale of farm equipment firms which went into the bicycle trade, according to this sample, which constitutes about 12 percent of the file of 400 US bicycle makers of the 1890s.[20] Indeed, Hounshell [25, pp. 13-14] has stressed that "the promise of the safety bicycle lured a number of New England-style armory and sewing machine establishments into cycle manufacture" and has cited individual sewing machine and clock and watch establishments in various regions of the country which entered bicycle production. The data in Table 2 also show an interesting difference

Table 2
ORIGINS OF SOME AMERICAN BICYCLE FIRMS OF THE 1890S, BY STATE

State	Type of manufacture									Total
	Sewing machines	Baby carriages, toys, sleds	Wagons and carriages	Clocks and watches	Fire-arms, locks	Machine tools[a]	Hard-ware[b]	Farm machinery	Furniture	
Massachusetts	2	1	1	1	2					7
Connecticut					1				1	2
New York			2		3					5
Pennsylvania	3					1				4
New Jersey-Maryland			1							1
New Hampshire, Rhode Island, Maine, Vermont							1			1
Missouri					1		1	1		3
Illinois	3	3		1	1	3		3	1	15
Ohio	3	1			1	2				7
Indiana					1		3			4
Total	11	5	4	2	10	6	5	4	2	49

Sources: For a description of the sources used, see Notes 7 and 16.

[a]In the machine tools category, general machinery other than farm machinery was included.

[b]In the hardware category, appliances were included. In separating machinery from hardware, size of equipment was generally a determining factor. Thus smaller implements were considered hardware, such as hand tools.

between manufacturers of baby carriages, toys, and sleds and those makers of wagons and carriages who diversified into bicycles. The former were concentrated in the Midwest, while the latter were in the eastern and middle states. Thus at least one aspect of Hounshell's conjecture about manufacturers of wooden toys and novelties as precursors of bicycle makers in the Midwest is upheld by these figures but not his conjecture concerning wagon and carriage makers. Finally, in the machine tool category represented in Table 2, one sees a surprising midwestern orientation.

IV.

It is difficult to know what these data imply. However, it seems that one important conclusion which is justified is that some farm implement makers did go into the bicycle business, especially in the Midwest and particularly in Illinois, and that one would have to at least consider techniques of manufacture stemming from agricultural implement making along with those used in producing other metal goods and wooden goods in the rise of the US bicycle industry in the 1890s. Indeed, focus on the techniques used to make farm equipment as having provided one base of expertise upon which bicycle makers of the Midwest (particularly Illinois) possibly drew seems all the more reasonable when one considers that both farm implements and bicycles are largely *metal* products, even though they may have some wooden parts.

What were some of the metalworking techniques, other than precision methods, which enabled the US to become such an outstanding mass producer of both relatively cheap farm machinery and bicycles before 1900? Hounshell has suggested that for the US to mass-produce the safety bicycle of the 1890s, techniques other than those stemming from "Yankee armory practice" had to be employed. Specifically, he stresses here press work and stamping. It is interesting that Nathan Rosenberg has likewise emphasized the importance of press work in both the production of bicycles and automobiles in the US. Rosenberg comments [45, p. 438] that

> intricate automobile components which once would have been produced by the lathe, drill press, milling machine, or casting or forging, were increasingly stamped directly out of sheet metal -- a technique which had been given considerable impetus in the production of bicycles.

What is the history of such stamping techniques? Of course, their development was enhanced by the coming of bicycles and automobiles, but what were some of the immediate precursors of such press work and stamping? Further, these techniques did not

just arise in the Midwest, but by 1900 census figures show that only three states produced over 1,000 stamping, flanging, and forming machines for plate and sheet metal. Although New York led the nation in value of this product, the data suggest that perhaps Ohio could produce this kind of equipment most cheaply, with Illinois second [46, pp. 383-84].

Juxtaposing these data with census data on agricultural implement production, one finds that in both 1890 and 1900, Illinois ranked first and Ohio second. Are there connections between stamping, agricultural implement production, and bicycle manufacture before 1900 in the US?

It is interesting that Rosenberg [45, p. 433] lumps agricultural implement firms with those making bicycles, typewriters, automobiles, and other machines as buyers of the universal miller. Surely, farm machinery makers employed methods and tools used extensively by eastern firms, as a glimpse of the early McCormick factories will show [34, p. 36]. However, Rosenberg hardly ever ventures out of the tradition of "Yankee armory practice" in his considerations, as Hounshell notes. Working within this framework, Rosenberg derives his hypothesis of "technological convergence" of the manufacture of sewing machines, clocks and watches, firearms, and other products such as (eventually) bicycles and automobiles, around a machine tools sector which had largely emerged from textile machinery makers, in his view.

However, could it be that there was another, more midwestern phenomenon of technological convergence, also around the machine tool sector but with this sector having in part crystallized around and ministering particularly to the needs of agricultural implement makers (as opposed to the earlier eastern textile machinery producers)? Further, could it be that this machine tool center of technical expertise contributed to give us important aspects of both the cheap, mass-produced bicycle and automobile? Could this machine tool sector, evolving stamping techniques and press work to a greater extent than in more eastern counterparts, have in part accounted for the "midwestern orientation" of the early US automobile industry *and* also for the Midwest's dominance in production of cycles during the bicycle boom of the 1890s?

The hypothesis, of course, does not require that many farm machinery producers became bicycle makers. Rather, transfer and adaptation of stamping and press techniques might well have been mediated through the makers of machinery for the production of agricultural implements, bicycles, and automobiles. Much more research is needed before any such hypothesis can be definitely put forth, but it would appear that the agricultural implement makers were among the first users of sheet steel in the US. For instance, John Deere is said to have been the first customer of plow steel rolled in the US (rolled by William Woods in Pittsburgh at Deere's direction in 1846) [52, p. 390]. Whether this account can be taken as completely accurate, still Deere must

have been among the first users of sheet steel, as anyone observing a moldboard plow could understand. It is also extremely interesting that in the 1907 description of the Deere blacksmith shop at Moline [15, p. 7] it was noted that

> we see on the right and left machines of many kinds, each of the most approved pattern, many of them built in their own machine shop... under the direct supervision of the works, from the small punch to the massive twelve-foot shears, powerful presses and heavy drops...

For instance, a drop-press process was described as having been "invented, perfected and patented at these works" around 1874. [15, p. 8]. Further, various punching operations were noted, and the use of sheet steel was also a subject of frequent comment here. A press called a bulldozer was also described, into which a steel beam (having been heated) was placed and bent into shape [15, p. 13]. This sort of press work was similar to that described in an 1876 publication on the Champion Bar and Knife Company, one of the firms which merged to form International Harvester later. The knife blade or section for the reaper and mower

> is first blocked out of a solid strip of the best American Steel [sic] (which has been found equal if not superior to English Steel [sic] for this purpose by a large Die Press [sic] that has a capacity of twenty thousand daily. This manner of cutting out the Section insures a uniform size to each blade. The Sections are then put into a furnace, heated and straightened by a Drop Press, which removes all spring from the blade, and squares it up. [27, p. 24]

Clearly, there is mass production here with powerful presses. It was asserted that for the harvest of 1876, 40,000 Champion Harvesters were shipped to various countries [27, p. 19]. In this publication, as in the 1907 Deere and Company document, one can see the growing importance to agricultural implement makers of American steel. Attached to the Deere pamphlet is an inventory of inputs, complete with tonnage of steel bars, plates, and shapes, plow steel, and sheet steel used in 1916, along with lists of equipment including various types of large presses and also the number of operators of punches, presses, and other equipment [15].

What was the evolution of these powerful presses which were coming into use at least by the 1870s in making agricultural implements and whose prototypes were later used in bicycle and automobile work? The timing of the rise of such presses seems potentially in harmony with the coming of cheap steel in the US.[21] Such documents as the foregoing seem to suggest that perhaps the agri-

cultural implement sector innovated in the use of American sheet steel in many ways and in certain machines which shaped and cut this sheet. There is no doubt that this sector was among the earliest US users of sheet steel, which was also an important input in the cheap, mass-produced safety bicycle of the 1890s and later the automobile. Although the connecting links have not been demonstrated concretely, there is sufficient evidence to warrant further investigation into the adapted Rosenberg hypothesis given earlier.

V.

When the "American system" of manufacture and "Yankee armory practice" were still in their youth, then, another practice of metalworking was arising in midwestern America, centering in the increasing demand for and use of steel in agricultural implements. Undoubtedly out of this practice (which gave rise to some very large mass production operations) have come innovations in press work and stamping, innovations which were likely to be easily adaptable to bicycle manufacture in the 1890s as it boomed to new highs in the midwestern US, not only in terms of number of firms but also in terms of size of firm and quantity of output.[22] Certain kinds of stamping and press work, then, crystallizing perhaps around agricultural implement making, were likely to be translated to the production of parts for an overland, self-propelled vehicle. (Farm machines were often types of overland vehicles; except that they were horse-driven in this period.) Perhaps, then, the bicycle served as one intermediary between agricultural machinery and automobiles; perhaps also the automobile was a more direct inheritor of certain techniques used in the production of farm implements. However this may be, agricultural implement manufacture should undoubtedly be seen as *one* type of manufacture which contributed to the coming of both the US bicycle of the 1890s stemming from (1) Yankee armory practice, (2) carriage and wagon and other wooden goods manufacture, and (3) as pertains to the motor car, production of internal combustion (and other) engines. The last named probably goes far to explain the Detroit location of much early motorcar production, as noted earlier, location which also might be in part explained by Detroit's importance as a center of railroad repair at that time.[23] In future investigations, certainly contributions to early automotive production in the US not only from agricultural implements and bicycles but also from the railroad sector should be explored, as stamping techniques were also undoubtedly important in this transport sector. Further, manufacturing contributions from industries in New York state, as well as in the Midwest, to the early motorcar should be examined.

This essay has served only as a beginning in the reevaluation

of certain aspects of supply which combined to give the world the midwestern automobile. Before the end of the 19th century, the Midwest could claim centers of production for (1) agricultural implements, (2) bicycles, (3) wagons and carriages, and (4) internal combustion engines; and American machinery makers, including producers of machine tools and presses, farm equipment, bicycles, and engines, all benefited from the coming of cheaper American steel, whose production they in turn helped stimulate. All totaled, this confluence of manufacturing techniques and traditions which helped produce the cheap US automobile may with future research lend insights into the particular vitality of American manufacturing generally after the Civil War, as both population and mass production techniques moved west and became adjusted to the new environment.[24]

NOTES

*Special thanks are due Paul Uselding for his many helpful suggestions and general encouragement over the years; this essay is dedicated to him. Also, Donald L. Kemmerer first called my attention to the existence of Deere bicycles in the 1890s, information which then led to the investigation of linkages between midwestern agricultural implement makers and bicycle manufacture, thus enabling certain conjectures to be postulated here. I also wish to thank Louis Galambos, Nathan Rosenberg, Harold Williamson, Robert Gallman, Paul B. Trescott, and various members of the Business History Conference who provided helpful comments and some of whom suggested that technology transfer to be the focus here.

1. In [54], a reassessment of the probable size of the industry, in terms of number of firms, inventory, and demand, was undertaken. Some of the data from that paper are presented here and the industry study will be the subject of a later essay.

2. For previous supply side considerations, see Note 3. For demand side studies, certain social histories are useful such as [16, 29, 35, and 49]. Also in [54] both supply and demand elements in both the rise of the US bicycle industry of the 1890s and the early motorcar industry in the US are considered. It may well be found that the demand side was the more important in the bicycle's influence on the coming of the auto industry.

3. For example, see [60, pp. 686-88] where bicycles are noted and [45, especially pp. 434-38] where explicit reference to bicycles as technical precursors of automobiles is made, and [42, especially Ch. 1] where the bicycle as automotive precursor (both in aspects of supply and demand) is noted. Also in [10, pp. 311 and 355] the importance of bicycle technology for later technology is discussed, as in [62, especially pp. 109-14; and 61, p. 122]. Finally, in [25] the most complete treatment of bicycle production by a historian of technology I have thus far uncovered has been given, although it contains little about the bicycle as precursor

of the automobile explicitly and primarily treats the pre-1896 period (according to [26]).

4. For a particularly good commentary on Leland's precision techniques, see [31], which focuses on the business and technical aspects of Leland's life. Also, see [43, pp. 214-15], which notes Leland's training in the Providence firm of Brown and Sharpe. The brief popularity of the chainless is discussed in many contemporary sources such as trade journals. Also in [28, pp. 327-28; and 7, p. 827], one can see relative production figures for chain and chainless type bicycles, 1900-1910.

5. See, for example, [39; 18; 19; and 14, p. 1], the last of which especially featured their "double-faced reversible and interchangeable cones." Ball bearings were also sometimes used in addition on the steering mechanism. Scores of trade catalogs were photocopied and searched, having been collected from the Smithsonian; the Baker Library; and individual companies such as Columbia Manufacturing Company (Pope successor) of Westfield, Massachusetts; Huffman Manufacturing Company of Dayton, Ohio; and various other sources. I am willing to make available this library of photocopies and indicate places searched to interested scholars. A fairly good but sometimes erroneous guide to trade catalogs is [44], which contains a chapter on bicycle catalogs.

6. It is interesting that my data, which are now contained in a card file of information on over 400 US bicycle producers, 1890-1900 (obtained from trade catalogs, cycle directories such as [41]), personal and business papers found in [58], and trade journals (including those which gave lists of exhibitors at cycle shows in the 1890s, as especially in [59]), such as [3, 8, 12, 24, 30, and 59], reveal that some firms such as Rouse and associates sold farm equipment, wagons and carriages, and bicycles, all three. What this may imply for manufacturing is yet to be determined.

7. This has been examined in greater detail in [54, pp. 21-22 and 26-27], the latter of which also discusses the production of automobiles in 1900 in the US, in which Illinois led in one category of automobile output and Indiana in the other. One needs to explain the shift in automotive production to Detroit as its center over the years 1900-1905.

8. The pneumatic tire for the bicycle has been attributed to the inventive efforts of an Irish veterinary surgeon, John B. Dunlop, in 1888. By 1892 almost all safeties were using this type of tire, both in the US and elsewhere.

9. See [42, p. 6]; also my card file shows among other relevant information, the existence of a Two-Speed Bicycle Company of St. Charles, Illinois, and a Two Speed Cycle Company of Chicago, evidently two different and unrelated companies [59 (1894-95), respectively, Supplement, p. i and pp. 32-34]. This file can be made available to those interested (see Note 7).

10. See particularly [9], which may be juxtaposed with Paul Uselding's conjectures about the comparative advantage of the US

over Britain by 1860-70 or so in building cheap machines [57, pp. 142-49]. It is also interesting to juxtapose Uselding's theory about cheap machines with the statement in [46, p. 386] that by 1900 the trend "in machine tools has been toward more efficient machines rather than in the direction of lower prices." This statement in no way invalidates Uselding's assertion but raises questions about what happened in the machine tool sector, 1860-1900. Further, because one can talk about the coming of "cheap" steel or "cheap" machines in the US does not imply that at any given point in this period American steel or machinery would be priced lower than such British products *at the mill or factory*. However, here transport costs and tariffs enter in, among other factors, to make even seemingly "more expensive" American steel or machines competitive with similar British products in American markets.

11. Compare, for example, [6, 21, 33, 53, and 63] with [21] on rolled steel tubing.

12. [47, 17, and 51]. Also E. C. Stearns, a well-known early motorcar producer, pioneered the use of aluminum in his bicycles before he went into the auto industry (see [4], for example).

13. In addition to the Baldwin Cycle Chain Company, cited earlier, one sees firms such as the American Roller Bearing Company supplying automotive producers as well as bicycle makers [59 (1900), pp. 44-90] for all exhibitors at the show. Contemporary trade journals are filled with information on such companies. In particular, [24] is good for data on transfer of cycle and cycle parts firms into automotive production. Also a fairly interesting comment on making bicycle parts as late as 1920 can be found in [55, p. 47].

14. I computed the average weight and price of the standard adult safety of the 1890s from scores of individual observations (totaling per year for the mid-1890s at times 75 or more) and data retrieved from trade catalogs, journals, and loose ads, among other sources.

15. This is discussed in detail in [54, pp. 6-9 and Appendix 1], which can be made available upon request. Also, this discussion is the subject of planned publication on the bicycle industry and the demand side. Suffice it to say here that my sample of bicycle producers shows 43 firms in 1890, as compared with 27 for the census enumeration [28, p. 325], and my sample may be anywhere from 40 percent to 75 percent of the total for the 1890s. There are various plausible reasons why the census might not have captured the industry more nearly. This is discussed in [54, p. 7].

16. Simultaneously with Hounshell's case study approach, I was tabulating the bicycle industry by regions. These approaches were independently completed, but later exchange of the results has led to fairly similar conclusions in many cases. I am indebte to David Hounshell for sharing his findings with me.

17. It may well be that the size of Illinois's bicycle manu-

facturing establishments remained larger than those in New York into the 20th century, even though New York boasted more such enterprises during and after 1900 [28, pp. 326 and 336-38; and 36, pp. 291 and 294-95]. Interesting corroboration between my data and those of the census can be seen by comparing the number of firms making bicycles in 1900 in New York and Illinois, 66 and 60, respectively as given in [36, p. 291] with the entries in Table 1, where these states are shown to have equal numbers of manufacturers of bicycles by mid-1899, possibly around the time the census was taken. My observations for the early 1900s should not be taken as valid, as this later period was not my main focus and sufficient data were not collected for these years. Viewing only census figures for 1890 and 1900, however, utterly fails to capture the boom in the number of Illinois bicycle makers in the mid-1890s, and might lead one to the misleading conclusion that New York had dominated the industry in terms of number of firms following 1890. Even though [28, p. 326] shows that New York led Illinois in number of firms, the average size of Illinois firms appears to have been about twice as large as that for New York in 1900, and this state of affairs continued into 1905, with the average size of Illinois bicycle firms appearing to increase relative to that of New York, even though the number of Illinois firms declined more than did the number of New York firms [36, pp. 294-95, in which the average size of Ohio bicycle firms appears to be even larger than that of Illinois].

18. This is discussed in some detail in [54, pp. 23-24 and 28], which also brings in considerations of the depression of the 1890s in other ways, as in [54, p. 12]. On p. 24 it is stated that "unlike all the other equipment categories except one, agricultural implements showed no increase in consumption at any time in this period [1893-96], until 1897, around the time bicycle production peaked."

19. At this time, I have no way of ascertaining how many bicycle manufacturers were purely assembly operations. Probably quite a significant percentage of the peak in number of firms in Illinois in 1896 represents "mere" assemblers. This is also the impression conveyed in [25, p. 18]. See also Note 25.

20. See Notes 6 and 15. This will be fully discussed in a later paper.

21. See Note 10; if one is contrasting the trend in the US, 1860-1900, toward more efficient rather than cheaper machines, one might have to differentiate here by *kind* of machine. That US mechanics had the ability to construct cheap machines quickly is demonstrated by the experience with bicycles in the 1890s, and an international comparative advantage here might well be seen in the rapidity with which the US shifted from an importing to an exporting bicycle industry. This shift is discussed at length in [54, Note 87].

22. The size of the industry will be the subject of a later

paper, but [54, especially pp. 3-12] contains some speculations.

23. I am indebted to Paul B. Trescott for pointing out in [20, p. 524], which notes that Detroit was a center for railroad repair, with the comment that "In any discussion of western machine firms, the repair shops of railroads are prominently featured, as well they should be. In Detroit, Cleveland, and other cities, they were among the best equipped and largest enterprises." Perhaps this sector deserves investigation of its possible influences on the rise of the automobile industry and also for any possible linkages through technology transfer to manufacture of bicycles and agricultural implements.

24. Unfortunately, this essay has not been able to encompass considerations of the organization of work in the 1890s bicycle industry, whereas Hounshell [25] has made a beginning here. It is an extremely important topic and undoubtedly has ramifications for early automotive production. It is likely that significant economies were achieved in the assembly operation in bicycle making in the 1890s and that these economies may account for some of the low cost of producing midwestern bicycles. As already stated in Note 20, probably a large proportion of the Illinois firms in 1896 were "mere" assemblers. It remains to be explored how they organized their work to mass-produce the cheap safety.

Also, market structure in the industry with some emphasis on the coming of the trust, the American Bicycle Company, in 1899 is the subject of work in progress.

REFERENCES

1. Charlotte Anderson, *John Deere Bicycles, 1894-1900* (Moline, Illinois: Deere and Company, 1972), where the firm of Deere and Webber, which was the Deere firm responsible for Deere bicycles, is discussed.

2. "Automobile Chains," *The Hub,* Vol. 41 (March 1900), p. 542.

3. *Bearings*, a bicycle trade journal searched for the 1890s.

4. "Bicycle Frame Tests," *The Carriage Monthly*, Vol. 32 (November 1896), p. 250.

5. "Bicycle Manufacturing," *Bicycling World,* Vol. 1 (1 May 1880), p. 204.

6. "Bicycle Tubing," *Journal of the Iron and Steel Institute,* Vol. 50 (1897), p. 410.

7. "Bicycles, Motorcycles, and Parts," *Thirteenth Census of the US, 1910, Vol. 10, Manufactures, Reports for Principal Industries,* pp. 825-28.

8. *Bicycling World,* a trade journal searched for the 1890s.

9. Philip Bishop, "The Beginnings of Cheap Steel," *Contributions from the Museum of History and Technology, United States National Museum Bulletin,* 218, paper 3, 1959, pp. 27-47.

10. Aubrey F. Burstall, *A History of Mechanical Engineering*

(Cambridge; MIT Press, 1965)

11. Neil M. Clark, *John Deere* (Moline, Ill., Desauliniers, 1937).

12. *Cycle Age and Trade Review,* a journal searched for the 1890s.

13. James K. Dawes, "Carriages and Wagons," *Twelfth Census of the US, Vol. 10, Manufactures, Part IV, Special Reports of Selected Industries,* pp. 293-322.

14. Day Manufacturing Company, *Fifteenth Annual Catalog,* n.d. (late 1890s).

15. Deere and Company, *From Forge to Farm, The Story of a Plow* (Moline, Illinois, 1907). I am indebted to the company for supplying also archival materials attached to this document covering 1881-1916.

16. N. L. Dunham, *The Bicycle Era in American History,* M. A. Thesis, Harvard University, 1956, held on microfilm at Eleutherian Mills Library.

17. A. L. Dyke, *Dyke's Automobile and Gasoline Engine Encyclopedia* (St. Louis, 1918).

18. Eagle Bicycle Company, catalog (Torrington, Conn., 1892).

19. _____, (Torrington, Conn., 1894).

20. Albert Fishlow and others, "Internal Transportation," in *American Economic Growth,* Lance E. Davis and others, eds., (New York: Harper, 1972), pp. 468-547.

21. "Giant Tube Works Locate in Massachusetts," *The Horseless Age,* Vol. 1 (April 1896), p. 7.

22. "A Great American Manufacture," *Bicycling World*, Vol. 2 (1 April 1881), pp. 326-31.

23. Charles Hoffman, "The Depression of the Nineties," *Journal of Economic History,* Vol. 16 (June 1956), pp. 137-64. (Hoffman has also written a book by the same title (Westport, Conn.: Greenwood Publishing, 1970).

24. *The Horseless Age,* a trade journal for the bicycle and automobile industries, searched for the 1890s.

25. David A. Hounshell, "The Bicycle and the 'American System' of Manufacture," unpublished essay, University of Delaware, 1975.

26. _____, letter to Martha Moore Trescott, 2 December 1975.

27. International Harvester archives, descriptive illustrations of precursor factories of the firm, 1876-77. I am especially indebted to J. D. Henn, corporate archivist, Chicago, who also has referred to the "McCormick Collection" at the State Historical Society of Wisconsin at Madison.

28. Axel Josephson, "Bicycles and Tricycles," *Twelfth Census of the US, 1900, Vol. X, Manufactures, Part IV, Special Reports on Selected Industries,* pp. 325-39.

29. Fred C. Kelly, "The Great Bicycle Craze," *American Heritage,* Vol. 8 (December 1956), pp. 68-73.

30. *L. A. W. Bulletin,* journal of the League of American Wheelmen, searched for the 1890s.

31. Mrs. Wilfred C. Leland with Minnie Dubbs Millbrook, *Master of Precision, Henry M. Leland* (Detroit: Wayne State University Press, 1966).

32. Joseph D. Lewis, "Agricultural Implements," *Twelfth Census of the US, 1900, Vol. 10, Manufactures, Part IV, Special Reports on Selected Industries,* pp. 343-47.

33. "Manufacture of Tubes," *Journal of the Iron and Steel Institute*, Vol. 51 (1897), pp. 516-17.

34. Cyrus McCormick, *The Century of the Reaper* (Boston: Houghton Mifflin, 1931).

35. Seamus McGonagle, *The Bicycle in Life, Love, War and Literature* (London: Pelham Books, 1968).

36. Robert H. Merriam, "Bicycles and Tricycles," *Special Reports of the Census Office (1905), Part 4, Selected Industries*, pp. 289-97.

37. C. B. Owen, "Organization and Equipment of an Automobile Factor," *Machinery*, Vol. 15 (March 1909), pp. 493-98.

38. Robert Perkins, "A Marvel of Mechanical Achievement," *Engineering Magazine,* Vol. 9 (May 1895), pp. 281-301.

39. Pope Manufacturing Company, catalog (Boston, 1888).

40. _____, *An Industrial Achievement, Pope Manufacturing Company, 1877-1907* (Hartford, 1907).

41. Luther H. Porter, *Wheels and Wheeling* (Boston: Wheelman Company, 1892). Cycle directory in back.

42. John B. Rae, *The American Automobile* (Chicago: University of Chicago Press, 1965).

43. Joseph W. Roe, *English and American Tool Builders* (New Haven: Yale University Press, 1916).

44. Lawrence B. Romaine, *A Guide to American Trade Catalogs, 1744-1900* (New York: R. R. Bowker, 1960).

45. Nathan Rosenberg, "Technological Change in the Machine Tool Industry, 1840-1910," *Journal of Economic History*, Vol. 23 (December 1963), pp. 414-43.

46. Edward H. Sanborn, "Metal-Working Machinery," *Twelfth Census of the US, 1900, Vol. 10, Manufactures, Part IV, Special Reports of Selected Industries,* pp. 381-88.

47. Archibald Sharp, *Bicycles and Tricycles* (London: Longmans, Green, 1896).

48. Alexander R. Smith, "Shipbuilding," *Twelfth Census of the US, 1900, Vol. 10, Manufactures, Part IV, Special Reports on Selected Industries,* pp. 209-39.

49. Robert A. Smith, *A Social History of the Bicycle, Its Early Life and Times in America* (New York: American Heritage Press, 1972).

50. "Some Applications of Steel," *Journal of the Iron and Steel Institute,* Vol. 48 (1895), pp. 536-38.

51. "Something About Aluminum," *The Cyclist*, Vol. 5 (19 March 1884), p. 333.

52. James M. Swank, *History of the Manufacture of Iron in*

All Ages (Philadelphia: American Iron and Steel Association, 1892).

53. "Testing Bicycle Tubing" *Journal of the Iron and Steel Institute*, Vol. 56 (1899), pp. 469-70.

54. Martha Moore Trescott, "The US Bicycle Industry of the 1890s and the Coming of the Automobile," mimeo of 63 pages, from which this essay and the oral presentation at Moline were excerpted.

55. US Tariff Commission, "Motor Cycles and Bicycles," Tariff Information Surveys (Washington, DC: US Tariff Commission, 1920).

56. Paul J. Uselding, "Elisha K. Root, Forging, and the 'American System'," *Technology and Culture*, Vol. 15 (October 1974), pp. 543-68.

57. _____, *Studies in the Technological Development of the American Economy During the First Half of the Nineteenth Century*, Ph.D. diss., Northwestern University, 1970, subsequently published (New York: Arno Press, 1975).

58. Warshaw Collection of American business history, Smithsonian Institution, Museum of History and Technology, boxes on the bicycle industry, use of which was facilitated by Donald H. Berkebile, a curator of transportation.

59. *The Wheel*, a bicycle trade journal searched for the 1890s.

60. Harold F. Williamson, "Mass Production for Mass Consumption," in Melvin Kranzberg and Carroll W. Pursell, Jr., eds., *Technology in Western Civilization*, (New York: Oxford University Press, 1967), pp. 686-87 for comments on bicycles.

61. Robert S. Woodbury, *History of the Gear-Cutting Machine* (Cambridge: MIT Press, 1958).

62. _____, *History of the Grinding Machine* (Cambridge: MIT Press, 1959).

63. "The Young Mechanic," *Engineering Magazine*, Vol. 7 (April 1894), pp. 135-36.