Bramley & Parker's Specification. English patent. No. 6027. November 4, 1830. See page 211.

CYCLING ART,

ENERGY,

AND

LOCOMOTION:

A SERIES OF REMARKS ON THE DEVELOPMENT
OF BICYCLES, TRICYCLES, AND MAN-
MOTOR CARRIAGES.

BY

ROBERT P. SCOTT.

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DEDICATION.

THIS WORK

IS

RESPECTFULLY DEDICATED TO THE MEMBERS INDIVIDUALLY, AND AS A BODY CORPORATE,

OF

THE BALTIMORE CYCLE CLUB.

PREFACE.

THE average intelligence of the Cycling fraternity can, with justice, be said to be above that of any other association of men and women, devoted to pastime, sport, and exercise, in the world; yet withal it is with some considerable feeling of anxiety that this book is sprung upon them. There can be no question but that we are a reading community, and yet all attempts catering to our wants, in the way of books, seem to have met with a less hearty support than should have been expected. The author of one of the greatest works connected with Cycling has recently informed us that he is still many hundreds of dollars behind, and other authors have good reason to complain that their books can be searched for even at club-houses, where they surely ought to be found. Books consisting largely of advertisements have, no doubt, paid the compilers, as have also the numerous periodicals, but when we ponder over the colossal efforts of Kron and Stevens, and think of the poorly-rewarded devotion of Sturmy "Faed," the Pennels, Stables, Cortis, and others, the encouragement is not at all stimulating to writers; especially since all books of these authors are of the most attractive character and easily comprehended, whereas a large portion of this work is written with a view to inspiring a close study of the art, and for that reason, if for no other, is liable to be dry reading. However, it is too late now to swerve from the task; if one more must be added to the procession of dejected, empty-pocketed venturers, "so mote it be."

No petition is made to the Fraternity to read this book in particular, but it is hoped that all cycling books and periodicals will be patronized, hereafter, with the usual liberality so characteristic of wheelmen in connection with other matters, and if this work should, in any way, foster this hope, its mission will be more than filled. In one way the writer has already been amply repaid; if he had never undertaken this task it is just possible that he, like many others, might never have followed a cycler through India, or have made the acquaintance of "The Best of Bull-Dogs."

The nature of this book has drifted, to some extent, from the rigid mathematical character originally intended, partially because it just drifted, and also perhaps intentionally, in order to give it a more popular bearing. If some severely practical readers should notice an attempt at humor, or an amusing turn given to what should be stern mathematical or mechanical reasoning, it is hoped that it will not be considered undignified or trivial, for it is done with an object; and if the popular reader should be averse to running off into abstract theories, let him but remember how little we realize that everything we do, or make, in our daily experience rests upon some fundamental principle which we ought to know and be able to explain. Who would have thought that the principles underlying the simple matter of balancing a bicycle would confuse even a school-boy? Perhaps it ought not; nevertheless, the article on that subject is cut rather short, for the reason that the writer, even with the help of others more competent, was unable to definitely determine all points in regard to it. My thanks are due to Prof. E. W. Davis, of Columbia, S. C., Gustav Bissing, Ph.D., of Baltimore; Prof. Robinson, of Columbus, Ohio; F. R. Smith, A.M., of Cambridge, England, and others, for valuable assistance courteously rendered.

Respectfully,

R. P. Scott.

Baltimore, 1889.

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PART I.

CYCLING ART,

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CHAPTER I.

INTRODUCTORY.

LOCOMOTION as applied to the question of transportation of matter in all its varied forms has always been, and will always continue to be, one of the great problems of advancing civilization. To such an extent does the element of transportation enter into our highly organized system of society that it is said to be the most powerful factor in the evolution of man. So confidently is this believed, that a great genius has been led to promulgate the theory that at some future time man will consist of a head and trunk; that all use for the limbs being entirely dispensed with in the art of moving and manipulating matter, these will gradually shrivel up and drop off, as it has been said the tail did when we no longer used it for swinging our bodies from tree to tree, like the proverbial monkey, or as a projectile force so valuable to the locomotion of the kangaroo.

The development of mechanical means for transporting and manipulating all matter has, to a wonderful extent, excused the use of man's legs and arms: and the facility with which a great mass is loaded for transportation, delivered at its destination, and there manipulated with scarcely the touch of human hands has, it must be admitted, greatly diminished the labor otherwise delegated to the limbs. It is possible that almost all matter could be moved, moulded into desirable form, and utilized by civilized man for all his requirements, by the use of mechanical means, and man could no doubt transport himself by the same means, without using his limbs, and thereby reach a very high state of civilization; but such means must include a great amount of mechanical appliance accompanying the transportation, the more in proportion to each as the number of travellers is less in the same circuit.

Now, I think we can well admit that the very highest state of advancement will be marked by the greatest facility each man has to go his own way, and when we come to think of the world crowded as it must eventually become, does it not seem apparent to the reader that, since the natural energy now encompassed within our system is sufficient to carry us about, it will be for the best to continue to use this energy in our locomotion and make our improvements with the view to such a use, not for the purpose of dispensing with the many mechanical conveniences that now subserve our demands, but in order to add a simple and convenient means of unit transportation over reasonably long distances in a reasonably short space of time and accomplish the same with the least possible increase of mechanism? Humanity without the power to transport itself is to us an almost incomprehensible idea, and at the present day it is almost equally hard to conceive the state of society in which the movement of large masses over even small distances was impossible; yet there was a time when man could do no more than transport himself, together with such articles as he could carry upon his back or hold in his hands. It was probably not till long after this that he constructed a sled from the bark of a great tree to receive his chattels, and pulled it along by some rude vine; still nearer to our own time comes the invention of the wheeled vehicle or wagon, and when we come to that marvel of modern inventive genius the railway and steam-driven locomotive we are within a period yet personally known to our oldest fellow-citizens.

So much inventive ingenuity, so much marvellous energy has been expended upon the solution of the problem of transporting large masses, in which we see the wheel has finally played an important part, that the question of the individual transportation of individual men has received comparatively little attention, and it is only within the last twenty-five years that an amount of labor and thought has been given to this problem at all commensurate with its importance. This recent labor and thought has not been expended in vain; it has placed the man, too, upon the wheel, which has done so much towards developing the use of other energy, and at last there spreads out before him a beautiful vista of independent locomotion unexampled in all the previous experience of his race.

As wheel suggests the name "cycle," let us call this art, appertaining to the man and the wheel, "The Cycle Art," or, more definitely, if we wish, the art of "Man-Motor Carriages."

CHAPTER II.

THE CYCLE ART.

POSTERITY will always consider this the embryo generation of the cycling art; it might well be termed the "living wheel age."

A number of valuable books have been written on the fundamental principles of locomotion by means of walking, riding upon animate beings, flying and creeping, and also upon all kinds of inanimate or mechanical motors, but little has been said about physical properties underlying the intervention of a wheel between the body of man and the surface to be travelled over, the motor being man himself.

The interesting art of man-motor carriages has already developed an industry of such great importance that the certainty as to its permanency is beyond cavil, and, believing that it will yet assume much greater proportions and become of more and more absorbing interest, there seems to be some excuse for an attempt to place even a limited amount of personal information before those connected with the industry and before the admirers of the art. There are few industries the product of which is dispersed among so varied a class of patrons, and scarcely none in which the patron takes so lively an interest in the respective articles produced.

In most industries, where a machine is the product, the consumer is expected to be an expert in the art to which the industry appertains, and is therefore supposed to be capable of individual judgment as to the merits of what he acquires; if a steam-engine is the object of the purchase, it is expected that an expert of some ability in the art will judge of and afterwards run and repair it; but how could this be expected with a bicycle?

There is probably no other machine used by mankind, with the possible exception of the watch, that does service to such a variety of individuals as the cycle. Now, it would be of little use to write a book for popular reading on the mechanical construction of a watch, because from its very nature none but an expert could appreciate the facts, if any were given; but greater hope might be entertained in regard to a larger machine, because the buyer can at least see what he is about. You never heard of a bicycle-rider blaming his repairer for stealing the wheels out of his machine and substituting others, because he can see, however inexperienced he may be, that this has not been done. Now, if we all could, by a little observation, learn one-half as much about our watches as we can about our bicycles, the poor watch-maker would never suffer the indignities so universally and unjustly heaped upon him. The primary knowledge above hinted at as possible, among the hoped-for patrons of this work, seems to be an auspicious circumstance in connection with an effort to teach them a little more.

CHAPTER III.

CAN WE IMPROVE UPON THE CREATOR'S METHODS?

"We find in a great number of standard treatises a sort of accusation brought against nature for having entirely wasted a great part of the force of our muscles by causing them to act under a disadvantageous leverage."—E. J. MAREY.*

À PROPOS of fundamental principles, what are the requirements needful for the most successful means of man-motor locomotion? In more homely phrase, how can a man, without calling upon the storage of energy other than that inherent in his own body, propel himself from place to place with the least amount of physical exertion? It is evident now, that under very many circumstances the means provided us by the Creator for such purposes are not the most economical; that is to say, it has been found that if we employ a medium through which to transmit our energy, the energy will be more economically expended, in carrying our bodies from place to place, than if we apply the force directly to the work as nature seemed to intend in presenting us with a pair of legs. The writer cheerfully concedes, for one, that for almost all purposes the legs are very practical; as, for instance, in climbing a tree or a pair of stairs, a rail fence, or even a very steep hill, or when, as in some of our early travels, we are compelled by an embarrassing paucity of funds to take to the cross-ties of a poorly ballasted railroad. And further, we admit that the invention of a pair of legs, if properly claimed in a patent, would, with perfect justice, have entitled the inventor to all

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* Animal Mechanism, 65.

uses to which they could be put, including the pumping of a bicycle. But we are perfectly willing to infringe the leg patent, provided we can improve upon it even for certain purposes, as we have in adopting the modern bicycle, in its use, for instance, upon a reasonably smooth level road. Why we have been able to thus improve upon nature's device is not quite clear. Undoubtedly, however, there is some unnecessary friction in the leg method ; it cannot be on account of impact with the air, because a man on a bicycle certainly catches as much air himself, in addition to that of the machine, as he would do in walking. Evidently, then, there must be more motion or extra friction or both in the body, in the leg method, than is really essential in conveying one over a good road. Probably the main cause of this friction is that the rider's body is supported differently; it requires less muscular strain to sit than to stand. We not only know this from experience, but it is proved by the fact that the temperature of the body is lower while sitting than while standing; also still lower when lying down, showing that less energy is being expended and less muscle consumed. Since the spirit of the writer began to wrestle with the foregoing leg versus cycle controversy, by happy chance he fell upon an estimable work* of which a careful perusal would almost make us think that nature really had an embryo cycle or wheel method in view when we were planned for legs. The great interest attaching to the above-mentioned work arises from the fact that the book was written before the cycle was at all broadly known to be of any assistance to the self-propulsion of man under any circumstances. This work must be read to be appreciated. I give some quotations, the application of which shows that, in the minds of some, the Creator had an idea of a wheel

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*J. Bell Pettigrew, M.D., F.R.S., F.R.S.E., F.R.C.P.E., "Animal Locomotion."

within a wheel; in short, that nature seemed to want to roll.

Let us quote from page 51, "Animal Locomotion."

"When the right leg is flexed and elevated, it *rotates* upon its iliac portion of the trunk in a forward direction to form the *arch* of a *circle* which is the converse of that formed by the right foot, if the *arcs* alternately supplied by the right foot and the trunk are placed in opposition, a more or less *perfect circle* is produced, and thus it is that the locomotion of animals is approximated to the wheel in mechanics."

Hence we *roll*,—but not far enough,—we approximate in nature, but reach the goal by man's genius; shown in the full circular wheel.

It will be seen from the following (p. 51) that the bones in man are not arranged for high speed; hence we must make up for this deficiency.

"The speed attained by man, although considerable, is not remarkable; it depends on a variety of circumstances, such as height, age, sex, and muscular energy of the individual, the nature of the surface to be passed over, and the resistance to forward motion due to the presence of air whether still or moving. A reference to the human skeleton, particularly its inferior extremities, will explain why the speed should be moderate."

Page 52. "Another drawback to great speed in man (as distinguished from animals) is, . . . part of the power which should move (serve as a motive power) . . . is dedicated to supporting the trunk."

Now, in the cycle method we support the trunk all right, but should apparently make more use of the arms,—inventors take notice.

Page 56. "In this respect the human limbs, when allowed to *oscillate*, exactly resemble a *pendulum*."

Here is the trouble with nature; there is too much osciliation instead of continuous rotation; nature does not go far enough.

Page 58. "The trunk also *rotates* in a forward direction on the foot which is placed on the ground for the time being; the *rotation* begins at the heel and terminates at the toes."

Thus the rotation is all right so far as it goes.

Page 60. "The right side of the trunk has now reached its highest level and is in the act of *rolling* over the right foot."

Hence see the effort of nature to roll.

Page 61. "In traversing a given distance in a given time a tall man will take fewer steps than a short man, in the same way that a large *wheel* will make fewer revolutions in travelling over a given space than a smaller one. The nave of a large *wheel* corresponds to the ilio-femoral articulation (hip-joint) of the tall man, the *spokes* to his legs, and portions of the *rim* to his feet."

We thank nature very much for this suggestion of the wheel; without it perhaps we should never have conceived of the veritable wheel itself.

I also find from another work:*

"Living beings have frequently and in every age been compared to machines, but it is only in the present day that the bearing and the justice of this comparison is fully comprehensible."

Page 67. "One might find in the animal organism many other appliances the arrangement of which *resembles* that of *machines* invented by man."

Page 91. "Let us examine from this point of view the articulation in the foot of man: we see in the tibio-tarsal articulation a *curvature* of small *radius*."

Page 112. "In addition to this the body is inclined and drawn up again; at each movement of one of the legs it *revolves* on a pivot."

And so on in all works on animal locomotion will ever be found a continual reference to radius, roundness, and rolling.

These quotations show that while we must acknowl-

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*E. J. Marey, College of France, Academy of Medicine, "Animal Mechanism," 1887, p. 1.

edge that the fundamental principles involved in the cycle were anticipated, to a certain extent, by nature, we may yet take great credit upon ourselves for developing the new or improved method to such a perfect and useful degree.

To the oscillating features found in the human organism the genius of man has added a full circular revolving mechanism, pushing further nature's aspiration to roll. Nature rolls a little, and then rolls back again; man has so improved upon himself by the addition of a wheel that he can roll on forever. It is quite evident that by such means he saves much energy; let us now determine if possible how this saving can be still further increased.

The whole question of the advantages of the cycle method or wheel locomotion must resolve itself into one of reduction of organic friction as shown by fatigue in the body. All inorganic friction, such as metallic friction in the machine and upon the road, must be finally overcome at the expense of organic friction due to the exercise of the muscles in man. Without stopping to discuss such profound questions as to just what organic friction is, or as to how the display of energy creates friction, we will confine ourselves to the more tangible problem,—to wit, improvements upon the improvement; that is to say, granting the cycle method to be an improvement upon the leg method, we will discuss improvements in the cycle method.

We feel perfectly justified, from our own experience and observation, in adopting, as a basis upon which to build all future improvements, the broad principle underlying the intervention of continually rolling wheels between the rider and his road-way. Now, we ask, what are the requirements appertaining particularly to this wheel method?

In order to approach the subject logically, I repeat that the fundamental requirement is the reduction of organic friction or fatigue of the body.

The above requirement is met in two ways: First, directly; that is to say, by working the muscles of the body to the best possible advantage; secondly, indirectly, by reducing the inorganic friction such as is found in the machine and in its action upon the road.

We shall attack first the reduction of direct organic friction by discussing the manner of applying the energy of man to revolve the wheel; his position and economy of power; and secondly, the reduction of the indirect or inorganic friction in the machine by regulating the size of the wheels and weight thereof, the jolt or jar, the friction of the parts one upon another, loss of momentum, and such other problems as may present themselves in the course of our discussion.

The terms used in this book hereafter will be largely arbitrary. Man-motor and locomotive carriages, velocipedes, unicycles, bicycles, tricycles, tandems, and all such terms will be included more or less in the broad terms "cycle" and "cycle-method." Wherever any distinctive feature is to be made prominent, then such qualifying adjuncts or special terms will be used as express it.

In speaking of different styles of bicycles, we will adopt the name "Ordinary" for the prominent form of machine which is provided with a large wheel fifty to sixty inches in front, with a crank movement, and the usual fifteen- to twenty-inch rear wheel. The recent rear-crank driver, with the two wheels of about equal size, we will recognize as the "Rover" pattern, in deference to the people who first pushed it into the market and so named it. Other terms will be adopted which will be self-evident to all acquainted with the art.

Attention is called to the engravings in Part II. of this book, which will give an idea of the different forms of machines used in the art.

CHAPTER IV.

THE DIRECT APPLICATION OF POWER.

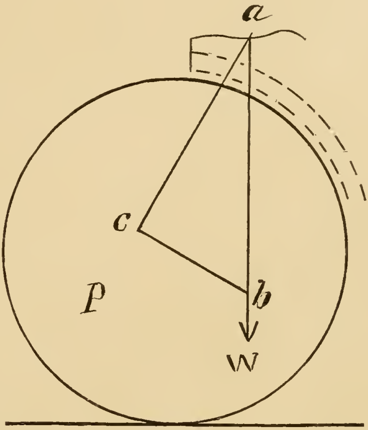
It is evident that one of the greatest, if not the very greatest, of the requirements of a practical road wheel, or a man-motor carriage, is that the power of the rider shall be transmitted to the said wheel in the most direct manner possible; that is, by causing the strain to come upon the muscles in such a way that these muscles shall be placed in the best possible position to overcome such strain, and to take advantage of such conditions as nature has already provided for, in training our muscles to the work we have had to do under the old *régime*, without the wheel.

The muscles of man are best adapted to a direct pull or push. If we push upon a weight with the muscles at an angle to the direction in which we want the weight to move, the effective power is limited in the same way that the effect upon a weight is limited if we push at it in a direction at an angle to that in which we wish to move it; that is to say, not the total, but only a portion of the power will be effective in moving the weight.

The above facts apply particularly to our subject when we desire to transmit motion to a wheel by means of the weight or gravity of our bodies. Gravity acting downward in a vertical line, if we are not placed over the resistance, the resultant effect is in proportion to the cosine of the angle at which we work, as follows:

Let W = the weight of the man and a be the centre of gravity and also the location of the source of power of said weight, and let c represent the point at which it is desired to apply the power to turn the wheel.

Now, it is known that the weight W, acting by gravity in the direction ab, may be taken as proportional to the length of the line ab, and the portion of the pressure P in the direction ac, which will be effective to turn the wheel, may be taken as proportional to the length of the line ac; that is, $\frac{P}{W}=\frac{ac}{ab}$, or $P=\frac{ac}{ab}W$, where $\frac{ac}{ab}$ is evidently always less than unity. Now, if the angle bac is thirty degrees, and $W=150$ pounds, W times $\frac{ac}{ab}$ is 130 pounds. Or, by trigonometry, the weight W, acting in the direction ab, by gravity as in working a cycle, will have a resultant in the direction ac representing the power acting to turn the wheel equal to $W \cos bac$. If the angle bac is thirty degrees and $W=150$ pounds, then $W \cos bac=130$ pounds. Now, in order to still get one hundred and fifty pounds of force on the wheel, a pull on the handle-bars would have to be given sufficient to make up the lost twenty pounds, which the rider would get without any pull on the bars if placed directly over the work. This pull, while not fatiguing to the legs beyond the necessary requirement of power, is an entire loss of work in the arms, and must tell on the system. This is all an additional loss to that which ensues from the fact that nature has fitted us to stand upright and not to work in an angular position; our every-day experience in walking gives us practice in a direct vertical strain on



Power angle.

the muscles of the body, and we should make it a point to apply our force as nature intended, in so far as it is applicable to our wheel method. These conditions apply more or less to any form of locomotion, and particularly to the cycle.

From the foregoing remarks we are amply justified in drawing the conclusion that the resultant force available in the application of the physical power of man is in proportion to the cosine of the angle at which he exercises this force. We are well aware that many apparent variations will occur when so rigid a mathematical fact comes to be applied to the exercise of man's energy in driving a bicycle; but all we care for is to lead the reader well up to the point by means of reasoning, which we hope will give at least a partial hypothesis for a conclusion well demonstrated by practical experience. We assert that when we consider the application of the *gravity* of the body to work on either a bicycle, or to other work of similar requirements, our mathematical demonstration is strictly true. It is justifiable, therefore, from a purely theoretical stand-point, to say that the rider of a bicycle wants to get directly over the work; let us see how our experience demonstrates this conclusion.

Take first the differences between a modern ordinary bicycle and the old velocipede, or "bone-shaker," so called. The former is lighter and better made; but the one great difference is that the rider is more nearly over his work. It was this one advance which encouraged the development of other minor differences which had been roughly thought out before. In fact, the Patent Office shows that many of these improvements were on record, but there would have been little use for them if the rider had not worked himself up into a place where he could do something. Just who raised him up from a midway position between the two wheels, the saddle seventy-five degrees back of the vertical through the drive-wheel axle, as in the old boneskaker, to nearly the top of the forward wheel, working at an angle of thirty degrees, as in some ordinaries, we will not attempt to say; but when he got there he has been willing, for a long time at least, to try to stay there, even at the expense of frequently going *down* on the other side, much to his annoyance, particularly as the general construction of the thing compelled him to go down the other end up, which end nature did not intend for terrestrial impact. It may as well be stated just here, however, that when our rider raised and moved his saddle forward he would have gone clear up to the vertical had it not been that it was absolutely impossible for him to stay there at all without hanging a heavy counter-balance somewhere in the neighborhood of the rear wheel, a scheme which, by the way, has been really recommended in modern cycle history.

One excuse for dwelling upon the foregoing dissertation is that many casual observers and some riders, strange as it may seem, assert that in the development of the modern rear-driving Rover pattern, we have been retrograding to the old velocipede, whereas, in fact, we have made another step forward of a similar nature to that spoken of before in raising the rider up above the point of application of power. In the Rover machine we have landed the rider practically where, as before said, he could not remain at all before; but in this new machine he has gained the advantage of being able to stay there.

Thus our rider has been gradually getting up and over the work. Various devices have been used in order to facilitate this operation, but, unfortunately for our power-development theory, many of the changes have been coupled with the safety feature so prominently that, in efforts by makers to place the rider in the best possible position for work, the safety feature is all that the casual observer has been able to see; therefore it is that in several machines, such as that called the "Extraordinary Challenge," the sales have been made more on the strength of safety than on their other great point of real merit, the advantage in power. In such machines, the rider has often been surprised to find that he had more power than he supposed, but having bought his mount with a view to safety, and it being still found to contain almost as great an element of risk as he before incurred, considerable disfavor has been the result. Had the element of increased power been thoroughly understood and appreciated, such machines would, in spite of the great deterioration in appearance, have been regarded more kindly.

No better illustration in other arts of the desire and tendency of the operator to get over his work can be had than in that of the ordinary foot-lathe. No maker of lathes would think of attaching a treadle in such a manner that the workman could not perch himself directly over it. In some experiments on foot-lathes, the writer found that he could run at a given speed and resistance three times as long when over the work as when standing some twelve inches back and he had to reach out for it; in fact, it seems quite evident that our theoretical conclusion is fully established in actual practice.

Granting then that the direct vertical application of power by the rider is a desirable acquisition, let it be called a fundamental requirement. It must not, however, be supposed, in this connection, that the foregoing in any way justifies the swimming position, or kicking back, which some experimenters have of late been prone to adopt. We must approach but never get beyond the vertical limit.

Since this manuscript has been ready for the publisher, articles in the *Bicycling News* by "Warrior" and "Semi-Racer" have come under my notice, from which I clip sections, appertaining to this subject, as follows:

"If, as 'Crawler' says, it is a very great improvement to have the saddle well over the pedals, how comes it that the contrary is now so universally advised, and as much as four inches recommended between the line of saddle-peak and the line of crank-axle? There never was a greater mistake made than when the saddle was generally placed in advance of the crank-axle. Apart altogether from its effect on the steering or easy running of the machine, there are two very strong reasons why the saddle should be kept well back. In the first place, it is quite impossible to sit upon the tuberosities designed by nature to carry the weight of the body unless the legs are flexed at the hip-joints. The parts resting upon the saddle are, otherwise, soft and delicate structures, liable to injury from the violence of the saddle. Were it for no other reason, this is enough to determine the position well to the rear of the crank-axle. But another reason: it is not a fact that one has greater power with the saddle, as suggested by 'Crawler.' One may certainly throw his *weight* alternately upon either pedal readier, because he is nearer a standing position; but, on the other hand, with the saddle well back and the handles well forward, the purchase so obtained gives far greater power from muscular contraction than the mere weight of the body gives, and, indeed, many more muscles are called into action when the saddle is kept back.—WARRIOR."

"With regard to gearing, I consider that the position of the rider has much to do with this also. A rider sitting well back can use his ankles much more effectively than one right over the pedals, and can consequently exert a driving force through a considerably greater part of the stroke, whereas the vertical rider depends chiefly upon the weight of his body during a comparatively short portion of the down stroke for propulsion, and upon the momentum of the machine to carry him over the dead centre. It will be found, therefore, that the rider using his ankles properly will be able to drive at least three inches higher with the same amount of force, and, at the same time, there is much more equable strain on the machine.—SEMI-RACER."

The quotations show one great trouble in writing a book: such a long time elapses between writing and publishing, that new facts and opinions come up in the mean time which demand attention and suggest alteration, as, for instance, my former paragraph in regard to the swimming attitude should have been expanded.

"Warrior" carries his theory to extremes. He is all right in cautiously avoiding an unduly-forward saddle, but when he places the front tip back of the vertical through the crank-axle, he goes too far and is utterly wrong.

The cause for such diversity of opinion in this matter is that it is tested under different circumstances. In riding over an easy, slightly rolling country, the tendency to get back on the saddle is indisputable, for reasons noted by "Warrior" and fully treated of in my chapter on "Saddles and Springs in Relation to Health;" but notice how we slip forward, almost off the saddle, when we have any work to do, as in mounting a difficult hill; and also notice that the farther forward we get, and the less the angle at the pedals between the saddle and the vertical, the less will be the pull on the handle-bar. (See early part of this chapter.)

In this connection the very long saddles, largely adopted in America, are of great advantage, since, when not working hard, the rider can sit well back and then slide forward when occasion demands. What "Warrior" means by "greater power from muscular contraction" is rather ambiguous. I may admit that more power can be consumed when the saddle is back, but I deny that more effective power to turn the wheel can be maintained. The rider may get more exercise from "muscular contraction" than from the effect of his weight, but he will cover less distance with equal fatigue.

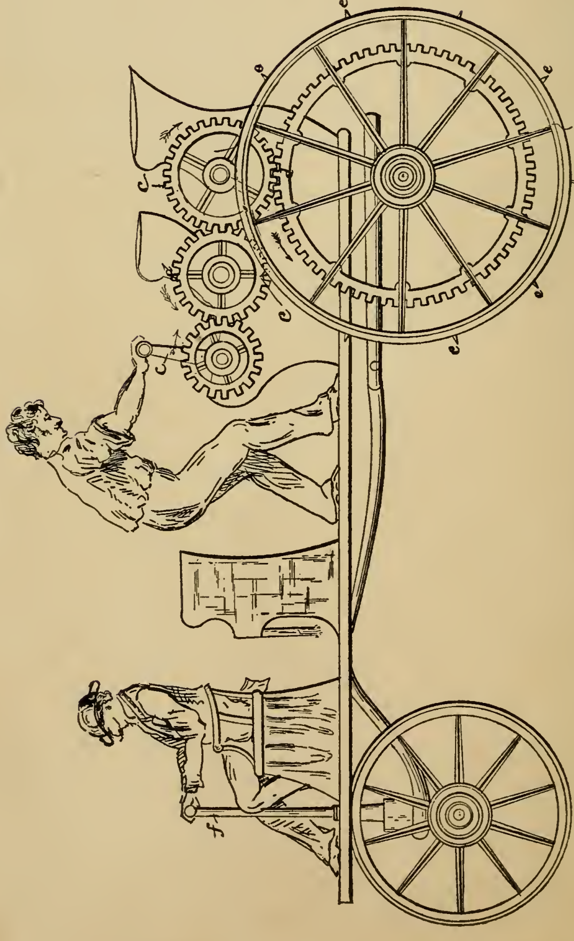
As to "Semi-Racer," his statement, that more ankle-motion is available when sitting back, is absurd. Will he not lose in "clawing" force below what he gains above?

In my chapter on "Ankle-Motion" I would say that the wonderful power therein asserted as possible was attained by having the saddle well over the work. Before disposing finally of this digression, let me express my pleasure that these subjects are meeting with general and enlightened discussion. However much opinions may differ, I regret, as a loyal Yankee, that we in America have to depend so largely upon cross-water importations for the initiative; but it is hoped that such importations may always be on the free list, maugre the high-tariff proclivities of the writer and many others like him on this side.

The next point of importance is the mechanical means whereby the rider transmits a revolving motion to the drive-wheel, and to lead up to this let us discuss the evolution from walking to riding. The actual development has been of a legitimate character; first, walking; second, walking with the trunk supported on rolling mechanism; third, propulsion by means of mechanical things like legs, the entire body supported upon rolling mechanism; fourth, propulsion and support all by means of, and upon, rolling mechanism.

The Dennis Johnson wheel.

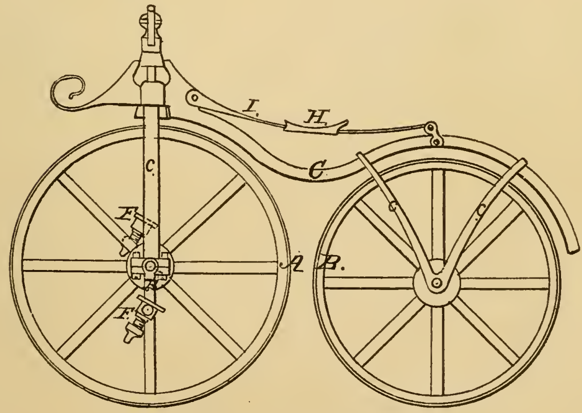
The early bicycle, such as that of Dennis Johnson, patented in England, No. 4321, 1818, did not support the rider entirely free from the ground. It consisted in a pair of wheels placed under him, constituting a sort of third or rolling leg, the feet, though not for support, still touching the ground. This machine is a fair sample of an intermediate stage between the era of oscillating devices subjoined to the trunk by nature —to wit, the legs—and that of the present cycle. In



The Bolton machine.

the Johnson machine the legs are used for projectile force only, and serve as a motor, the weight of the body being supported on rolling mechanism as aforesaid; hence it was a more natural and palpable sequence to walking than other prior contrivances in which the rider was raised upon a platform such as shown in the machine of Bolton, patented in the United States, September 29, 1804.

The Bolton and similar machines really belong to a different class from that of Johnson, but if we confine ourselves to our bicycle or balancing-machine, thus throwing out the Bolton class, the development from the leg to the wheel method proceeded in order, for we have next the Lallement crank-wheel, United States patent, November 20, 1866, which represents substantially the present single-track type.

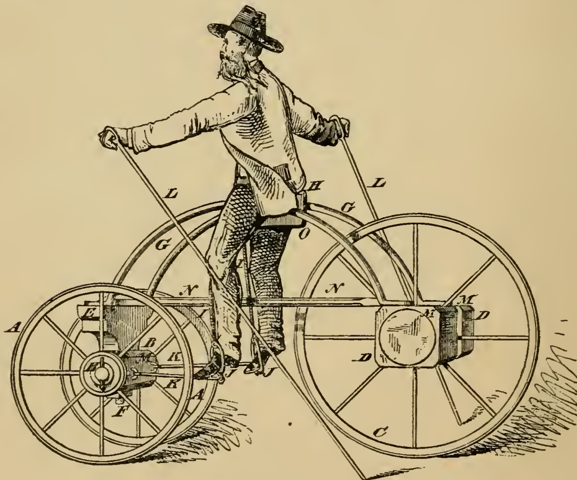


The Lallement machine.

One illustrious gentleman, Croft by name, patented a machine in the United States, August 21, 1877.*

* This is not a misprint for 1777.

In the Croft machine a pair of bars held in the hands are used with which to propel by pushing against the ground, instead of using the legs as in the Johnson. By supporting the body entirely free from the roadway,



The Croft machine.

Croft takes a step in advance of Johnson, but he still retains his propulsive power by means of oscillating devices having contact with the ground, and in this respect might be said to use a pair of mechanical legs. He combined a walking method with that of rolling, as was the case with Johnson and Baron Draise, but he seemed to think a mechanical extension to the arms a better medium through which to pass his energy than nature's own devices for that purpose. Quite a number of inventors have gone astray on this question of the power of the arms in these manumotors. No doubt the arms could be made to help, but our present physical development suggests the legs as better; especially if one or the other plan is to be used alone. True, the

Croft machine could use the entire body, as in the case of a man shoving a flat-boat or scow upon the water, but the inventor's engraving does not show any such effort as necessary. What a pity that we did not have a single-track machine, propelled by the Croft process, between the time of Johnson and Lallement; how nicely it would have helped us out in our chronological development. We of the wheeling fraternity may, however, take a crumb of comfort from the fact that the two bicycles, or balancing machines, did make their appearance in respectful logical order.

In naming the Bolton, Johnson, Lallement, and Croft machines, I have not taken the trouble to ascertain whether they all were the very first machines of the kind in the art, nor would it matter whether they were or not, unless it could be shown that others were of equal prominence. We should not recognize mere vagaries as an advance in the art: the above gentlemen patented their machines, and it is therefore reasonable to suppose that they were real workers, and not simply chimerical characters flitting about in the minds of recent explorers. The famous Draisaine is worthy of mention, but our man Dennis will answer all purposes of illustration. Galvin Dalzell is now reputed to have been the first to raise himself from the ground on a single-track machine, and back as far as 1693 one Ozanam, a Frenchman, is said to have made a four-wheeled vehicle of the Bolton type, but driven by the legs.

Blanchard, about 1780, did some work in connection with the subject, and one Nicephore Niepse, we are told, made a machine of the Johnson type about the year 1815. For further information on this subject, see "Sewing-Machine and Cycle News," in *Wheelman's Gazette*, September, 1888.

In quite a recent edition of *The Wheel* the editor gives us a little foretaste of a book to which we look forward with interest. In it he mentions improvements by Gompertz in 1821, Mareschal, Woirin, and Leconde as having worked on cranks in 1865, and David Santon as having brought a wheel to America in 1876.

L. F. A. Reviere, of England, is said to have made the large front and small rear wheel; C. K. Bradford, of America, the rubber tire; E. A. Gilman, of England, anti-friction bearings, and A. D. Chandler, of Boston, is mentioned as an importer and rider of 1877.

CHAPTER V.

THE CONNECTING LINK BETWEEN THE LEGS OF NATURE AND THE WHEEL OF MECHANICS.

We now proceed to compare the different modes which have been devised to transmit power from the rider to revolve the wheel; of these there are two principal classes, the simple crank and the lever and clutch. These devices or connecting links relate to the motion of the legs as well as to the power transmitted through them. It is not necessary to treat of the horizontal motion of the limbs, as it is of little consequence provided the rider remains substantially over the work. Power is applied mainly through the vertical resultant, and the consequent fatigue is the effect of the amount of energy given out in a vertical direction. Crank riders acquire a horizontal power, or resultant force, by what we call ankle-motion, which has, to quite an appreciable extent, overcome the most serious inherent defect of the crank device; without this force the dead centre appertaining to the crank, in which the vertical resultant has no power to turn the wheel, would have made it a prey to the champions of other contrivances.

The above remarks in regard to horizontal motion and resultant force apply equally well if the rider is not over the work, except in that the phraseology would be different. A man in straightening out his leg can apply power in a certain direction or in a certain line; now, if he is not over the work, this will not be a vertical line; hence the term horizontal motion would have to be called motion at right angles to the line of transmission of power.

The importance of the dead centre is too great to be passed over without some further discussion. It would be a source of great satisfaction if a general conclusion could be reached in this crank versus lever and clutch controversy, but aside from the difficulty of drawing our conclusion there is a lack of a specific hypothesis in regard to an important element of the problem,—to wit, that as to the nature of the road and other resistance and consequent speed attainable or usually desirable. There is little doubt but that, so far as present developments show, the crank machine has excelled upon a smooth road and at high speed; yet this very fact leads us to suspect that perhaps for rough roads and at slow speed it might be objectionable, for it is easy to see that all questions of dead centres would eliminate themselves at high speed. Taking a steam-engine, of the crank and pitman type, for example, there is no trouble so long as speed is kept up, but it is well known that a certain velocity must be maintained or the crank will stop at the dead centre, even when provided with a heavy fly-wheel. Now, in a bicycle there is practically no fly-wheel at all, and, to pursue the comparison still further, we know that if the fly-wheel of an engine were removed great trouble would ensue; still it might be possible to keep running if the speed were great enough. It is evident, from common observation, that for intermitting slow and high speeds an engine, or any other machine, constructed without a fly-wheel must be provided with some means for continuing the power or carrying it over what would otherwise be dead centres. Multiple cylinders and rotary engines are made to serve this purpose.

The commonly accepted idea that a cycle for racing purposes upon a smooth road is a certain guide as to the requirements under other conditions is therefore hardly justifiable. For best results the form of mechanism used as the connecting link between the legs of nature and the wheel of mechanics must be determined, or at least be modified, by the conditions under which we intend to work. This problem is not at all confined to the art of cycling, it appears in many departments of mechanics. The same question has been mooted in respect to sewing-machines, and non-dead-centre attachments have been made and used upon them, but naturally the demand was not urgent, as this machine comes within the realm of high-speed devices with fly-wheel and evenly-running resistance. In scroll sawing by foot-power and in portable forges, non-dead-centre clutches are used with great effect. Hence our general mechanical experience makes it safe to say that such modes of continuous application of power have valuable uses applicable to this problem. It is not attempted to set up a definite unequivocal comparison or dictum in this matter as applied to cycles, for it is the desire of the writer and his right to make conclusions comparable only to the proofs recognized in practice, which in this case, in the cycle art, appear to be in favor of the crank machine. However, the writer's opinion, based upon his theory and individual experience, is that we have more to fear from the weight, complication, and friction of parts in the lever and clutch than from the inherent principle of transmitting power upon which it works, and that some non-dead-centre device will finally prevail in the best all-around road cycles, if it can be relieved of purely mechanical objections which somehow seem to be naturally coupled with it. If the writer's conclusion in this respect is tenable, the induction would follow that such a system, or connecting link, forms the most economical mode of applying power. The body can stand a steady, even pull upon its energy better than uneven intermitting jerks, and I feel sure new riders who have not acquired the ankle-action on the crank cycle will agree in this. This theory will apply to hill-climbing, in which lever and clutch machines have made so enviable a reputation. The rider has in clutch machines an even, steady resistance during the entire downward thrust, and he does not have to get all his power doubled up into a few inches of motion.

The two principal classes of connecting links, the crank and ordinary form of lever and clutch, need no explanation or discussion beyond their fundamental characteristics, but there are several combinations of lever and crank which are of interest and properly come under the head of modifications of the crank. These modifications are numerous in the market, and there exists cardinal distinctions between them. We annex diagrams of five distinct types which fall into two groups, the first group being a combination of lever and crank, in which the foot has an oval motion, as shown by Figs. 1, 2, and 3, the arrows showing the direction of progression.

GROUP I.

FIG. 1.

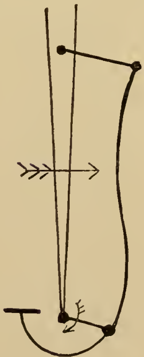
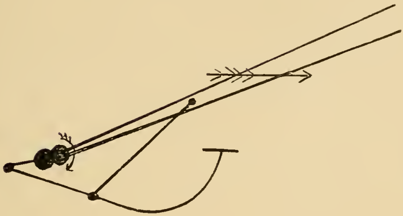


FIG. 2.

FIG. 3.



GROUP II.

FIG. 4.

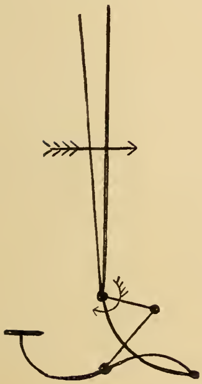
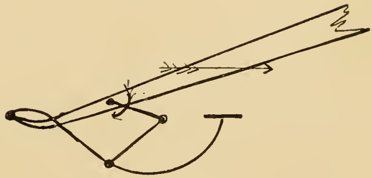


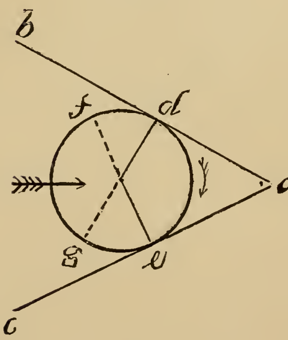
FIG. 5.



The second distinctive arrangement of lever and crank is where the lever is pivoted so as to return over the same track in which it descends, as shown in Figs. 4 and 5. The first group, with its oval motion, has a decided advantage in regard to dead centre or continuous power; since by an ankle-motion the rider can transmit some power in a circular direction to the crank; that is to say, he can actually push to some extent in a forward horizontal direction. But it will be seen that the pivotal connection shown in Figs. 4

and 5 does not allow of any such possibility; the rider must have momentum enough to throw the cranks over the dead centre or he is lost. In Fig. 4, which represents a form of pivoted treadle used on a reputable make of front-driving machine, it will be noticed that the rider has less than one-half of the revolution of the crank in which any power can be transmitted at all, which becomes apparent in observing a pedal in such devices while in motion, from the fact that it descends more rapidly than it ascends, thus giving the rider less than half the time in which he can transmit any power. We are now speaking of one side only of the machine; taking both sides together, there are two short arcs of a circle in which there can be no propulsive power transmitted to the wheel on either side. Fig. 6 illustrates this as follows:

Fig. 6.



In the descent of the lever from *b* to *c* the power will only be transmitted through the arc between *d* and *e*; taking an equal arc from *f* to *g* for the power given on the other side, we have the two small arcs *f d* and *g e*, all of whose points are dead points, and we might say we have a dead line. Upon the other hand, if the machine happens to be driven in the opposite direction from that of which we have been speaking, or, in other words, if the pedal is in advance of instead of in the rear of the driving-axle, as seen in Fig. 5, we have an advantage, since the arcs *f d* and *g e* would represent arcs in which the rider has power on both treadles instead of on neither, and it might be said that, instead of having an arc of dead centre or no power, we have considerably less than no dead centre at all. The lever and crank, Fig. 5, is a device used on some rear-driving machines,—the pedal descends slowly and ascends rapidly; certainly a desirable arrangement. That is to say, if the arc *d e* raises and *d f g e* lowers the pedal, it will then raise quickly and lower slowly; whereas, if *d e* lowers and *d f g e* raises the pedal, it will raise slowly and lower quickly.

The study of wheels in the market made with front-driving mechanism, on the plan of Fig. 4, suggests an incontrovertible argument in favor of getting over the work, in spite of the difficulty noticed in respect to dead centres; such machines actually have a creditable reputation as powerful hill-climbers and rough-road machines, which can only be explained on the theory that the vertical application of power more than makes up the deficiency caused by the arc of no power at all.

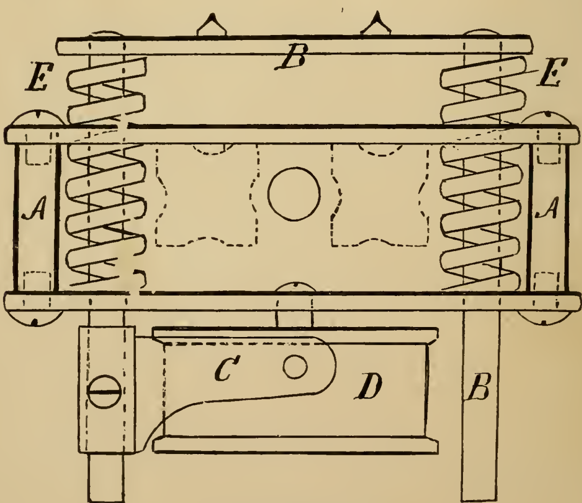
In speaking of the second group, Figs. 4 and 5, it must be understood that the matter of driving from either the front or the rear wheel has nothing to do with the principle, except in so far as it regulates the arrangement of the pedal and the direction of translation appertaining thereto. The difference in principle depends on whether the driving or the returning arc of the crank is towards or farther from the pedal. It strikes me that the style of lever and crank of the first group is a kind of cross between the direct crank and the pivoted lever and crank of Group II., and especially of Fig. 4 of that group, since it possesses some of the advantages and some of the objections found in both.

I find from observations, which will be spoken of later, that the ankle-power in the direct crank is very considerable, and that it is diminished in the oval-motion lever, Group I., and that it disappears absolutely in the pivoted lever, Group II. These facts are really evident, but as they came within the domain of other experiment, I merely state the result.

CHAPTER VI.

GRAPHIC ILLUSTRATION OF THE APPLICATION OF POWER TO CYCLES—KINEMATICS.

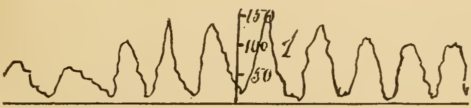
THE manner in which the construction and general arrangement of the driving mechanism, the road surface, and other conditions control the application of power is a curious study. In connection with it I have made an instrument to illustrate the same graphically, which, for the sake of a name, we will call the "Cyclograph," an engraving of which will be found below.



The Cyclograph.

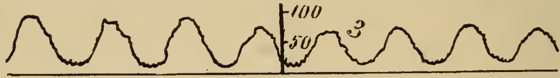
A frame, *A A*, is provided with means to attach it to the pedal of any machine. A table, *B*, supported by springs, *E*, *E*, has a vertical movement through the frame *A A*, and carries a marker, *C*. The frame carries a drum, *D*, containing within it mechanism which causes it to revolve regularly upon its axis. The cylindrical surface of this drum, *D*, is wrapped with a slip of registering paper removable at will. When we wish to take the total foot-pressure, the cyclograph is placed upon the pedal and the foot upon the table. The drum having been wound and supplied with the registering slip, and the marker *C* with a pencil bearing against the slip, we are ready to throw the trigger and start the drum, by means of a string attached to the trigger, which is held by the rider so that he can start the apparatus at just such time as he desires a record of the pressure.

The following are a few sample sections cut from registering slips illustrating some of the points discovered in these experiments. Only a few strokes of the crank or lever can be shown; it is evident that great space and expense of reproduction would be required to give the entire record for even a small part of a mile. It will be understood, I think, without further explanation, that these curves show the extent and variation of pressure of the foot upon the pedal in order to drive the respective machines under circumstances named and described by the figures and thereafter.

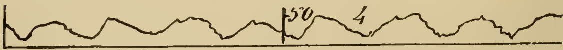


52-inch Ordinary; race-track; getting up steam.

52-inch Ordinary; race-track; speed, eighteen miles per hour.

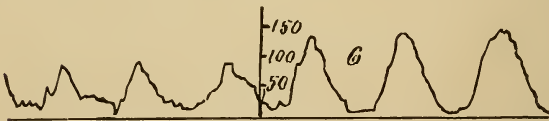


52-inch Ordinary, race-track, speed, ten miles per hour.

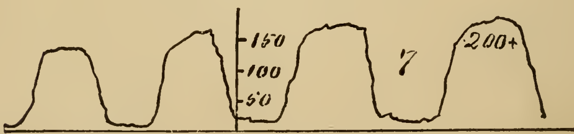


52-inch Ordinary; race-track; speed, ten miles per hour.

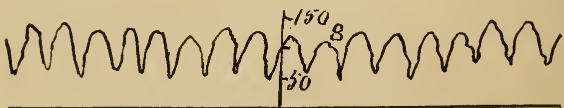
52-inch Ordinary; up hill, grade, one foot in twenty-five; speed, about eight miles per hour.



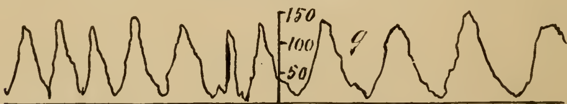
52-inch Ordinary; starting up hiil.



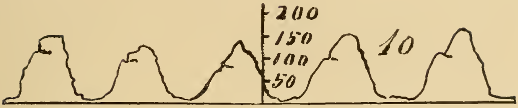
52-inch Ordinary; up hill, grade, one foot in ten; stalled at four miles per hour.



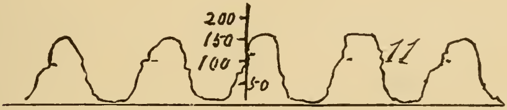
52-inch Ordinary; up hill, grade, one foot in twenty-five; curves of both pedals superposed.



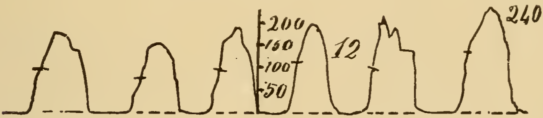
52-inch Ordinary; back pedal; down hill, grade, one foot in twelve.



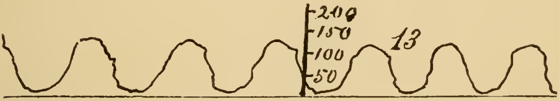
Rear-driver Rover type, 54-gear; up hill, grade, one foot in twenty; speed, nine miles per hour.



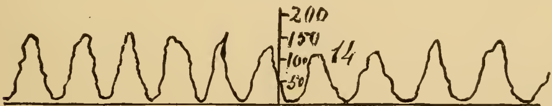
Rear-driver Rover type, 54-gear; up hill, grade, one foot in twenty; continuation of No. 10.



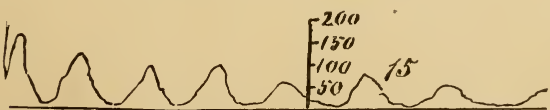
Rear-driver Rover type, 54-gear; up hill, grade, one foot in seven; speed, ten miles per hour.



Lever rear-driver, 30-inch wheels, gear about 50; up hill, grade, one foot in twenty; speed, eight miles per hour.



Lever rear-driver, 30-inch wheels, gear about 50; up hill, grade, one foot in twenty; speed, twelve miles per hour.



Lever rear-driver, 30-inch wheels, gear about 50; up hill, grade, one foot in twenty; continuation of No. 14, over top of hill.

A six-inch crank was used upon the machines in these experiments, and the lever action was such as to be comparable to a fifty-inch gear. The height of a point on the curve shows the extent of and variation in power upon the pedal, and the translation from left to right the time. In consequence of the limit of pressure occurring but once in each stroke, the number of undulations determines the speed, since it would show the number of strokes in a given time, and we know the number that make a mile.

The number of pounds' pressure at any point on a curve is shown by the figures upon the perpendicular line, as, for example, in No. 1 the apex of the curve just to the right of the scale is about even with the hundred-and-fifty-pound point; this pressure was maintained for a very short space of time, since the curve travels a very short distance to the right at this point; in other words, it is quite sharp at the top.

Stronger springs were used on the Cyclograph in testing the safeties, as I found myself liable to compress them beyond their limit; hence the scales must be closely observed in making comparisons. Among the interesting results noticeable in these experiments I find, for instance, in Nos. 3 and 4, an abnormal deviation in the height of the curves at the same speed upon the same track at nearly the same time, though running in opposite directions. Finding this strange difference of some fifty pounds in pressure, I noticed an almost imperceptible breeze against me in the one, and in my favor in the other, direction.

No. 12 illustrates how a hundred-and-fifty-pound man gets up a pressure of two hundred and forty pounds presumably by a ninety-pound pull on the handle-bar.

In No. 9 we see how one hundred and fifty pounds pressure is applied in back-pedalling down a grade of one foot in twelve. That the curve would not be very regular is easily impressed upon the mind of the average rider.

One part of curve (not shown), of peculiar contour, terminated experiment No. 9 at a rut a little farther down the hill, with dire results to the operator and provoking influence upon the running gear of the 'graph, which has been making some erratic curves of its own, now and then, ever since.

Comparing Nos. 5, 10, and 13, the curve of the lever machine (13) indicates that, while pressure is not so great as in the others, it is held for a longer time, shown by the greater height and sharper tops to the curves of the crank machines.

The short cross-lines about three-fourths up on the left sides of the undulations in Nos. 10, 11, and 12 designate the points at which the crank crosses the perpendicular at the top. There is quite a pressure, and it is a little odd that it should be found at this point; it can only be attributed to ankle-action back of the natural dead centre.

In No. 6, and to some extent in all the others, observe the jagged appearance in the general advance of the curves, which must be due to vibration: these results were all obtained upon tolerably smooth roads, mostly in Druid Hill Park, Baltimore. No. 6 was taken upon a road perhaps a little rougher than the track around the lake, but still upon an unusually smooth surface, and it was a surprise, not to say an alarming discovery, that this vibration should occur under such circumstances.

The lake track, upon which results 2 and 3 were found, was in perfect condition, smooth as a surface-plate, and without the customary sprinkling of pebbles so common when dry weather has loosed the settings of these tiny obstructions and suffered them to roll out upon the roadway; yet these figures show the saw-teeth, and I have been unable to find a road smooth enough, or jointed machine frames and springs good enough, to make unwavering symmetrical lines. These little deviations in the curves always seem to show themselves to the extent of several pounds in height in spite of all alleviating conditions, suggesting that we have much to strive for in the construction of the ideal wheel free from all concussion. In order to judge accurately of the total amount of power to turn the wheel, we have to consider the register of both pedals superposed, as in No. 8, but the curve made upon one generally answers all purposes. The possibilities in this study are unlimited, and, with a perfectly-accurate instrument, it strikes me, the results of much more definite bearing than those acquired in the silly practice of testing machines by the strength of men.

I have refrained from giving any tests as to the comparative power required to drive machines of the same type and of different manufacture, differences being liable to result from a bad condition of the machine, such as the want of oil, or from happening to get hold of an unusually bad sample, making the liability to do injustice too great. The writer does not feel himself called upon to judge of or express differences in quality of workmanship in general, if for no other reason than that by the time the matter goes to press, such merits or defects as he might have discovered may change. Workmanship does change, principles never can ; and, what is more, the hypotheses and conclusions in regard to principles, treated of in this or any other book, are always open to contradiction ; if injustice is done to any maker of wares in a matter of principle, said maker always has a remedy in defence, and if he can disprove assertions made his justification is complete, whereas if a mistake of fact is recorded, such as the operation of a certain machine, and the machine upon which the alleged fact is based happens to disappear, the party interested is denied a just remedy. There are of course certain criteria of good workmanship, and the same should be touched upon in order to teach the reader how to judge of it ; but beyond this no writer should be allowed to go, unless at least he has been paid for advertising competing wares at regular rates.

The cyclograph attached to the revolving pedal shows the total amount of pressure required to do a certain work on a machine; but if it is desired to ascertain the track resistance or the friction of parts alone, it is necessary to so place the instrument as to register the tangential resultant in turning the crank, taking no note of any power thrown away by indirect application; that is, if we wish to register the circular or tangential resultant, the cyclograph is attached by its frame rigidly to the crank or lever of a cycle, and the revolving pedal, which has been detached, is hung upon the spring platform. This last arrangement is used in experimenting to ascertain the extra power available by ankle-motion, as will be shown hereafter.

ANKLE-MOTION AS SHOWN BY THE CYCLOGRAPH.

Throughout this work a slight tendency to urge the element of dead centre as against the crank-cycle may have been discovered. Makers and riders who find fault with this apparent praise of lever and non-dead-centre devices can derive considerable comfort by the study of ankle-motion. No better introduction to our diagrams, showing the possibilities arising therefrom, can be given than the following extract from the *Irish Cyclist*, via *The Bicycling News and Wheelman's Gazette:*

"ANKLE-ACTION.

"Among the many thousands of riders in this country, says the *Irish Cyclist*, very few have any desire to improve their style or realize for a moment the vast importance of correct ankle-motion. You meet a rider plodding along, working his legs like pistons, with a heavy, lifeless motion. Remonstrate with him, and see what he will say: 'Oh, he can go well enough; he does not believe ankle-action makes such a difference, and he does not want to "scorch" in any case.' Now, we want our readers to grasp these facts. Any rider can acquire a tolerable ankle-action by careful practice, and the acquisition of such will increase his power by nearly one-fourth, and will enable him to ride hills never before attempted, and to keep up a better pace at the expense of the same amount of energy. This being so, the acquisition of such art should be a *sine quâ non* to every rider. That it is so can very easily be proved. In following the pedal the foot describes a complete circle. Suppose the circle to be divided into eight segments, taken in order from the highest point.* With a rider who does not use his ankles, force is applicable only through segments 1, 2, 3, 4, and in segments 1 and 4, the force not being applied at right angles to the end of the crank, a large proportion is wasted, and consequently it is only thoroughly effective through segments 2 and 3, or during one-fourth of the revolution. The rider who has mastered the mysteries of ankle-action will drop his heel as the pedal approaches the highest point, and he can apply a certain amount of force through segment 8. After passing the so-called dead point, his heel being still dropped, the force is applied at right angles to the crank, or nearly so, and consequently he can utilize his full power through segment 1. By rapidly straightening the ankle when entering segment 2 an additional impetus is imparted, and, as before, full power can be applied through segments 2 and 3. Entering segment 4, the heel should be raised and the pedal clawed backward, and this clawing action will enable the rider to work past the dead point and well through segment 5. Consequently, the man who rides with his ankles stiff can only work through segments 1, 2, 3, 4, or half the whole circumference, and his work is thoroughly effective only through segments 2 and 3, or one-fourth the circumference, whereas the man who utilizes his ankles can work through segments 8, 1, 2, 3, 4, and 5, or two-thirds the whole circumference, and his work is thoroughly effective through segments 1, 2, 3, and 4, or one-half the whole circumference. The advantage gained in the latter case is self-evident. The acquisition of the art is often tedious and troublesome, but if cyclists only knew the enormous increase of power which results they would not be content until they had mastered it. From the cycling volume of the Badminton Series, written by Lord Bury and G. Lacy Hillier, we take the following instructions:

"'Seated either on a bicycle slung so that the wheel may revolve, or upon a home-trainer, the beginner should raise the pedal to its highest point, and then, steadying the wheel with the brake, place his foot upon the pedal, carefully fitting the slots in his shoes into their places, and seeing in any case that the foot is straight. Then, using the thigh muscle for the most part, let him thrust the foot (and pedal) forward in a horizontal direction; in fact, a sort of sharp forward kick, having the heel dropped as low as possible, the toes well up, and the foot firmly set on the pedal, which will be at an angle. This should be practised carefully with the brake slightly on, and for this purpose, though a bicycle may be used, a tricycle will be found

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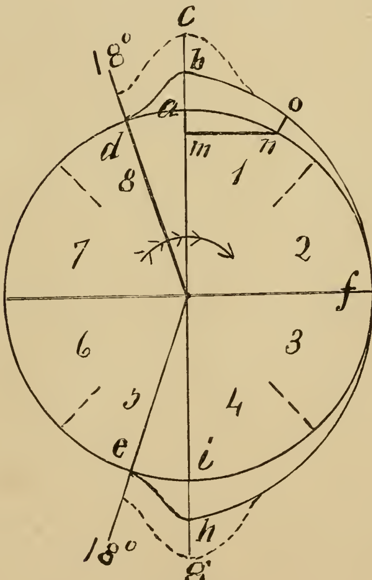
* Observe Fig. 1, p. 58.

much handier. If no home-trainer is available, the brake can be put slightly on by means of a piece of string or strap to the lever, tied to any convenient point, and the novice can spend a few minutes daily practising this exercise ; in carrying out which programme the left foot should at first be used more than the right. As soon as the usual awkwardness of the ankle-joint has been worked off this action will be found remarkably effective in starting the machine ; after a time the ankle muscles, and those of the calf, will become stronger, and a sharp straightening of the ankle, as the pedal passes through segments 1 and 2, will materially aid the propulsion of the machine. This straightening of the ankle will be continued until the foot is brought into a position at right angles to the leg, the muscular effort of which should now have by equal gradations become directly downward. The pedal will now assume a horizontal position, and the power of the leg with the weight of the body and the pull of the arms will all be exerted to force it downward ; at this point the crank throw is in the most effective position, and the hardest work is put in. When the pedal begins to follow a backward course, the ankle-action becomes of the greatest value. The toe is gradually dropped, and the heel raised as the pedal gets nearer and nearer to the lowest point, the action having at length reached the backward or "clawing" stage. To secure the full advantage of ankle-work, this "*clawing*" action must be very carefully practised ; the toes should be sharply pressed upon the sole of the shoe as if they were trying to grasp something, whilst the ankle should be straightened as much as possible, the foot being almost in a line with the leg, the calf muscles being strongly retracted, and the backward pull (which of course requires fitted shoes) can be made practically effective through segment 5, and also of service well into segment 6. The ineffective portion which exists on either side is soon reduced to a very small part of the circle, for as soon as segment 7 is entered upon the heel should be sharply dropped, and an upward and forward kick or thrust, as described in the directions for the first position, will lift the pedal forward and upward through segment 8, when, of course, the whole series of actions will be repeated.'—*Bicycling News.*"

Using the arrangement of cyclograph spoken of, by which ankle-motion may be shown, I find that I can begin to get a tangential resultant force on each crank at an angle of eighteen degrees back of the vertical line through the axle of the drive-wheel, beginning at *d* and ending at *e*, Fig. 1,—in all, thirty-six degrees over a half-circle on each crank.

The diagram shows the sections 1 to 8, and also gives an idea of the extra power. To see the direct circular resultant force to turn the wheel, imagine the length of a crank from *m* to *n* without ankle-motion and then *m n* plus *n o* for the length of the crank with ankle-motion added. I have been able at each of the points *a* and *i* to get thirty pounds when the crank crosses the vertical line at the top and bottom. Thus it is discovered that by means of this ankle-motion on both cranks simultaneously, I can get a force of sixty pounds in the direction to turn the wheel, at a time when absolute dead centre would otherwise occur, amounting to two-fifths of the maximum pressure resulting from my entire weight on one crank at the best possible point, directly out in front, going down.

FIG. 1.



Ankle-power.

I have more than verified the results shown by the cyclograph by suspending a fifty-four-inch bicycle, with six-inch cranks, above the floor, placing myself in the saddle, and having an attendant attach a twenty-pound weight at a point on the rim, ninety degrees from the bottom. This weight I was able to raise at the dead-centre point of both cranks,—that is, vertically up and down,—which shows a real power at the pedals of ninety pounds, or forty-five pounds on each, and I do not suppose that I am by any means an expert in ankle-motion. The above ninety pounds is a much greater showing than I made on the cyclograph in actual running, but it is reasonably certain that, by practice, even such an amount could be obtained.

In the case of no ankle-motion,—that is, with a direct downward pressure on the crank,—a tangential force in the direction available in turning the wheel begins as the crank crosses the vertical at the top, and then increases as the sine of the angle the crank makes with the vertical, until such angle reaches ninety degrees or extends out horizontally, after which the power decreases as the sine of the angle the crank makes with the vertical below the centre until the crank crosses at the bottom, at which point the power ceases.

To represent this variation of power by actual length of lines, appended will be found a diagram, Fig. 2, showing the tangential resultant or force to turn the wheel, imparted by a one-hundred-and-fifty-pound man with and without the use of ankle-motion.

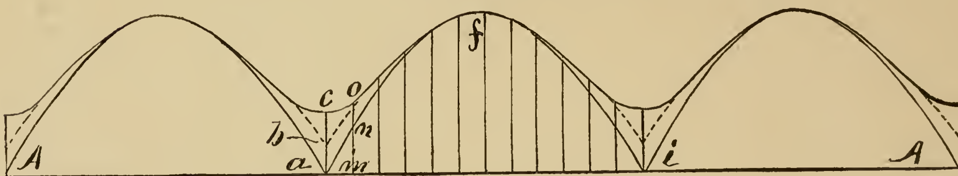
A A is a line showing the divisions of the angles through which the crank passes in its revolution around the axle. The line *a f i* is a sine curve.

Using the middle section and beginning at the point *a*, which is that at which the crank crosses the vertical above the axle, making a zero angle therewith, we have a direct downward pressure and, without ankle-motion, zero power. Now, by means of ankle-motion on one crank at this point we get thirty pounds of power, represented by the length of the line from *a* to *b;* and by ankle-motion on both cranks we have sixty pounds, represented by the total length of the line from *a* to *c*. After the crank has advanced forward fifteen degrees, we have thirty-nine pounds of direct power (*m n*), and then adding the ankle-power of twenty-three pounds (*n o*), we have a total resultant of sixty-

FIG. 2.

Ankle 60 23 9 7 3 0 0 0 3 7 9 23 60 Power.

Total 60......... 62......... 84......... 112......... 133......... 146......... 150......... 146......... 133......... 112......... 84......... 62......... 60......... Resultant.



Degrees. 0 15 30 45 60 75 90 75 60 45 30 15 0 Degrees.

Weight. 0 39 75 105 130 146 150 146 130 105 75 39 0 Resultant.

Ankle-power sine curve.

two pounds, represented by the length of the next line (*m o*), and so on up, the direct power increasing and the ankle-power diminishing till we come to the top of the curve *f*, when we have one hundred and fifty pounds of direct power. Passing through the angle of ninety degrees, and now counting from the vertical below the axle, we decrease in power inversely as we increased before.

Fig. 1 will show a little more graphically to the eyes of some casual readers how the power expands. Take *d a f i e* as the regular swing of the crank with no power at *a*, then *d b f h e* as the increase of power on one and the dotted lines *e* and *g* as the auxiliary ankle-power on the other crank added.

CHAPTER VII.

BALANCING, AND SOME QUESTIONS OF POTENTIAL ENERGY—HILL-CLIMBING.

It seems pertinent at this point to make some further distinction between two distinctive classes of road wheels. The conception in the mind of man of road carriages which require an element of balancing was a recent event in the development of vehicles in general, and the similarity of the words bicycle and tricycle, together with the fact that both are included in the generic term velocipede, has led many to overlook a distinction of balancing, which should class them under very different heads. Both are velocipedes if we mean machines run by foot-power; both are man-motors in the light that human force or energy actuates them; but the two-wheel single-track machine must employ a particular faculty on the part of the rider, not required in running one of stable equilibrium.

It seems superfluous at this stage of development of the art to enlarge upon the fact that a bicycle has to be balanced by a particular action not required in any other form of carriage; but when inventors will keep on getting up means to lock the steering device, and riders will persist in reminding us that the steering head "moves too easily," it is severely pertinent to remark that while a certain law of whirling bodies might show us that a wheel will not fall over quite so quickly when rolling as when standing still, yet it is not this law so much as the action of steering that differentiates the bicycle, or single-track carriage, from other machines. The action of the handle-bar while in motion does substantially, in balancing the bicycle, what you would do if you were balancing a cane vertically on the end of your nose: if the cane starts to fall, you run in that direction with your nose till you get under the centre of gravity again. But the bicycle can only fall sideways, so, when it tends to fall in that way, or when the centre of gravity gets to one side of the vertical line from the point of support on the ground, you cannot run directly sideways with the support as you would in the cane illustration, but you can run indirectly sideways, nevertheless, with the point of support, the only difference being that you must run considerably forward at the same time in order to shift the lower extremity, or point of contact and support, in that direction.

After considerable discussion of this apparently simple subject with eminent gentlemen well qualified to speak on such topics, the following appeals to my mind as a more definite and complete explanation than that given in the nose and cane case, bringing in an element of the problem omitted above, to wit: in running the point of support of contact across and under, as it approaches the vertical plane of gravity and general forward momentum, the steering wheel lies slightly across this plane, and its own plane is still out of vertical, leaning a little, as it did before, with the centre of gravity back of the point of support; the forward momentum then throws the entire system upright. In rapid running this momentum does a large proportion of the work, and it has been vigorously maintained that all balancing is due to this element; for small motions, however, the cane explanation is quite sufficient.

The foregoing explanation of uprighting the bicycle is, to my mind, almost *entirely* independent of any law of whirling bodies as generally understood.

An article showing that this subject is not devoid of interest or obsolete is given below from the *Bicycling World*, in which I think the law of whirling bodies will apply. "The Rochester wheelmen debated the question, 'Why does a bicycle stand up while rolling and fall down as soon as onward motion ceases?' The answer decided to be correct was, that 'the bottom of the wheel can have no side motion because it rests on the ground; and since the bottom is constantly becoming the top and the top the bottom, if the upper part of the wheel gets any lateral motion, it is checked by being brought round upon the ground again before the motion has too much influence.'" I do not suppose this ingenious decision, rendered by the high and mighty Solons of the Rochester Club, was a serious one; however, we do find that just such logic is quite common.

It is not plain whether the question discussed was that of a bicycle with or without a man upon it, but I take it to be the latter. Some of the gentlemen had no doubt noticed that to give the machine a shove it would keep upright for a longer time running than when standing unsupported. This is purely a case of the law that whirling things tend to keep their own plane, as illustrated in the gyroscope and the spinning top. In the running bicycle without a man upon it to constantly rectify its position, the principle is simply one of the parallelogram of rotations. If the wheel from any external force starts to fall over, or, in other words, to revolve around a horizontal line normal to its geometric axis, then, since the wheel is already revolving about its axis in the axle, the resultant of these two rotations will be a rotation about an axis inclined to the former axis of the wheel, which means that the wheel will begin to circle around a centre at some distance from the wheel on the side towards which it starts to fall. This new axis about which the wheel revolves will of course be in a plane perpendicular to the new plane of the wheel, and will be inclined downward from the horizontal plane through its centre, so that the wheel is no longer running in a vertical plane.

The rotation about the centre outside of the wheel, towards which centre the wheel leans, brings into play a centrifugal force acting to upright the wheel; that is, to bring it back to a vertical plane. Now, if the wheel be run along a straight groove, so that circling around a centre is prevented, then it will fall as quickly as when standing still; or if, in the bicycle, the steering-wheel be locked so that it will not turn out of the plane of the two wheels, there would be no uprighting resultant, and the machine, according to Newton's law of independent forces, would fall.

SOME QUESTIONS OF POTENTIAL ENERGY, MOMENTUM, AND HILL-CLIMBING.

When a cyclist climbs a hill, he not only overcomes the friction which would be generated if he travelled over the same length of level road surface, but he ought to be supposed to establish a certain amount of potential energy, or energy against gravity, and therefore should lose none. Yet he does lose considerable somewhere or he would not dread the hilly road as he does. In this matter of potential energy in hill-climbing upon a cycle, the subject assumes a different aspect from that of rolling on or off obstructions, as in rough-road riding treated of elsewhere. In climbing a hill there is no loss of momentum from a too sudden change in its direction; the matter of inertia does not figure in the case in any way, and we have a mere question of the rise and fall of a weight under certain modifications, said weight being the rider and his machine, said rise the ascent of the hill, and the fall the descent thereof. In a purely physical sense, then, we store up a certain amount of energy, or, in other words, put so much energy to our credit as against gravity, and theoretically we have a right to expect to get the benefit of it.

To illustrate this potential energy, suppose we place a pulley at the top of a hill and a rider at each end of a rope running over the pulley, with one man at the bottom starting up and the other at the top starting down the same hill. The descent of one man would draw the other up, excepting that each would have to work only just enough to make up the loss from friction, as he would in case the road were level and of equal length. I have little doubt that in such a pulley arrangement there would be much less loss of power and energy than riders now experience in the actual practice of hill-climbing. To illustrate with one man how the potential energy should be returned and thereby benefit the rider, let us place him at the top of a hill at the bottom of which another hill of the same height begins, whence, by the acceleration of gravity, the rider ought to find himself at the bottom of the first hill with an amount of momentum acquired that would send him to the top of the next; in other words, we might naturally expect when we roll down one incline to roll just as far up another of the same grade, or of the same vertical height regardless of the grade, or else we should expect a return of the energy in sending us capering over a level road without further labor, until the kinetic energy is exhausted. We find, however, that such a desirable result does not appear, and we notice that, however long, beyond a certain limit, the hill may be, we have no more momentum or kinetic energy at our disposal than we would in the case of a shorter hill. To what can this loss be attributed? There is but one visible cause,—to wit, our work against the air.

If all riding were done in a vacuum, we would more nearly get back our energy, but somehow or other the vacuum is generally in the rider and doesn't count, so there is an end to that. The rider, then, loses the momentum he would acquire from gravity because the friction of the air is resisting his progress at the rate of, or according to, the square of his velocity. In order to store up all the energy in a falling body we must allow gravity to increase the velocity as the square root of the distance. But it is easily seen that a rate of speed will soon be reached such that the air by impact will entirely annul all increase of velocity, and therefore all of the momentum we can expect to have at the bottom of the hill is just that which was acquired at the time and point at which the impact of the air balanced the accelerating force of gravity. This will soon come to pass, even omitting other friction, which, in connection with hill-climbing, we can afford to omit with good reason, because we should expect to have that to overcome if the road were level. The mere difference in the length of the surface travelled over will not bother a cyclist if it be a good level road, so we must blame it all on the air ; I see no other way out of it. No manner of springs or anti-vibrators will help us out of this difficulty. If our rider puts on the brake, then of course there is no question as to where the work goes ; but, as we all know, with a safe machine and an expert rider this is not often done in an ordinary country.

In defence of our theory of loss of energy on very long hills, observe the fact that a mere rolling road is not generally despised by the cyclist ; in fact, many prefer it to a dead level, the writer being decidedly one of their number. The short intervals of labor and rest, the continual barter and sale with gravity, in the transfer of energy to and fro, is not by any means an uncomfortable diversion to either our minds or bodies ; but when we come to suffer the usurious interest demanded by the action of the air against us, we simply draw the line, and go by another road, even though the surface thereof be not of the most inviting character.

Some ingenious mechanics have devised mechanism whereby they propose to store up the power lost in the brake action ; but it is doubtful if any riders would care for it after they become expert and daring, which they all do in course of time in spite of all admonition against undue risk.

Speaking of potential energy and momentum, we naturally come upon the question of machine weight. It is a peculiar fact that the weight of the man does not form so important a part in the bicycle exercise as that of the machine, so that if a rider be heavier by twenty pounds than another, it will not generally count against him; but if that weight is in the machine, competition is out of the question. Nature seems to make up in muscle, or supply of energy in some way, for the extra weight in the man, but said nature is not so clever when this weight is outside of him.

It is sometimes thought that a heavy man or a heavy machine will descend a hill faster than a lighter. This is not reasonable. The accelerating force of gravity being independent of the mass, the heavy system will have the same velocity at the bottom, and momentum being represented by mass, times velocity, the increased mass will increase the momentum; but the speed is the same: this extra momentum is required in raising the heavier system to the same height as the lighter. But even if the rider should get the benefit of all the energy he stores in climbing a hill, there is still an indisputable objection to a heavy wheel,—to wit, a man can labor long and continuously at a strain within reasonable limits, and can do a large amount of work thereby; but to strain the system beyond those limits, and attempt to store up too much energy in too short a space of time, is to make nature revolt, resist the imposition, and refuse to be appeased for some time to come and often not at all; in short, an overstrain is bad, and by a heavy machine, no matter what amount of energy you may store up at the top of the hill, if in so doing nature has been overtaxed, it will result disastrously. So we see that, outside of all mechanical questions of momentum and potential energy, there is a vital objection to heavy machines on purely physiological grounds.

CHAPTER VIII.

COMPARISON OF THE CURVES OF TRANSLATION, IN MACHINES OF WHICH THE DIAMETERS OR COMBINATION OF WHEELS DIFFER, OF A POINT TAKEN IN THE SAME RELATIVE POSITION ON THE SEVERAL SADDLES—CONSEQUENT CONCUSSION AND EFFECT UPON MOMENTUM.

In discussing this matter it has been taken for granted that the proper point upon which to base calculations is that point in the saddle at which the motion of the machine may be supposed to be transmitted to the rider; this happens to be very near the centre of gravity of the system, and is also quite near the centre of gravity of the man. The motion is of course partially transmitted to the rider at the pedals, but we will for the present waive that modification.

Simple as the running of two wheels over an obstruction seems to be, there are some interesting points to study. It was a surprise to the writer, and it is his hope that it may be of interest to others, that the saddle, and of consequence the rider, actually goes backward at times when the wheels are running forward; as, for instance, when the machine rolls slowly from a four-inch obstacle, as shown by the curve of the point in the fifty-two-inch Ordinary given below, and also particularly in the advance upon the same of the Star rear-driver. This reversion of momentum sometimes results in a drop of the rear wheel, but it is always an actual reacting force in the front. We feel the curves very plainly on a rigid machine, but it is a satisfaction to know exactly what they are and what the springs must overcome.

MOTION AT THE SADDLE AS WHEELS ROLL OVER AN OBSTRUCTION.

FIG. 1.

Ordinary, 52 F., 18 R.; 4-in. obstruction; saddle twenty degrees back.

FIG 2.

Rational Ordinary, 52 F., 18 R.; 4-in. obstruction; saddle thirty degrees back.

FIG. 3.

Lever Rear-driver Star, 18 F., 52 R.; 4-in. obstruction; saddle twenty degrees forward.

MOTION AT THE SADDLE AS WHEELS ROLL OVER AN OBSTRUCTION.

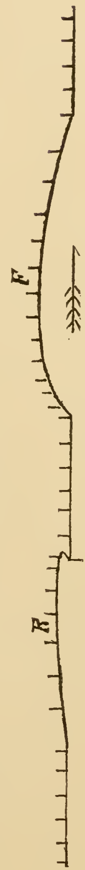
Fig. 4.

Star, 20 F., 52 R.; saddle vertically over axle.

Fig. 5.

Star, 24 F., 39 R.; saddle over axle.

Fig. 6.



Kangaroo, 40 F., 18 R.; saddle twenty-five degrees back.

MOTION AT THE SADDLE AS WHEELS ROLL OVER AN OBSTRUCTION.

FIG. 7.

Rear-driver Rover, 30-in. wheels, eleven inches apart; saddle forty inches high, twelve inches forward.

FIG. 8.

Rear-driver, 30 F., 24 R.; saddle forty inches high.

FIG. 9.

Dennis Johnson, 30-in. wheels; saddle thirty inches high, midway between wheels.

The diagrams show the paths of the point in the various machines passing over a four-inch obstruction; *F* designates the front and *R* the rear wheel, and the arrows indicate the direction of translation,—that is, the way the machine is running. The degrees designate the angle between lines from the drive-wheel axle, one extending vertically and the other through the saddle; sometimes also expressed in inches of horizontal distance between verticals through the rear axle and saddle. The heights or top points of the curves from the base line show the amount the machine is raised at the saddle as each wheel passes over the obstruction; these heights give inferentially the position of the saddle between the wheels, or, rather, between the vertical lines through the respective axles thereof, since the nearer over a wheel the saddle is placed the more it will be elevated when the wheel passes over the obstruction. Again, from the location of the saddle with reference to the axles we can determine the amount of weight carried by each wheel, the weight each carries being proportional to the respective distances from the saddle horizontally. The sum of the heights of the two curves from the general level will be the height of the obstacle.

Theoretically there is no difference in the amount of work required to pass over an impediment, no matter where the saddle is placed, as the man must be raised in all to the height of the same, and it does not matter whether he is lifted up half way twice or all the way once in so far as the amount of labor is concerned. The man and the machine must be lifted up to a certain height in some way; as it happens, it is more comfortable to be lifted twice through half the distance than all at once; but this should not affect the actual work done nor the energy expended.

Our scale in the study of this question is one-sixteenth of an inch to the inch; therefore in these diagrams one-eighth of an inch represents two inches in the full-size bicycle. In this connection also it must be taken into consideration that the effect upon momentum is not shown entirely by the contour of these lines; the sudden stoppage or checking of the system is generally shown by a vertical tendency in the curve, but a very disagreeable shock to the body may occur and momentum be lost without any deviation in the curve whatever when, for instance, in the most pronounced case, the saddle goes straight back upon its course. This is shown by means of the short vertical or diverging lines upon the curves. These short lines show the distance forward the point in the saddle travels in proportion to the advance of the wheels in a forward direction in space; each short line indicates an advance of two inches in the wheels. When the lines are below the curve, the saddle has actually dropped backward,—that is, it has been directly reversed in its course.

When the short lines upon the curve are close together, it shows that the saddle and rider are being checked proportionately as these lines are less than one-eighth of an inch apart. On the other hand, when the normal pace of the momentum of the heavier parts is slower than that of the wheels, it is shown by the lines being more than an eighth of an inch apart. In this case there is a tendency to increase the momentum instead of decreasing it,—a state of affairs not so much to be deplored if it were not evident that it is equally checked at some other point.

We know, in practice with the Ordinary, that the loss of momentum by sudden checking can only happen to the full extent when the pace is reasonably slow; should the momentum be too great it will simply refuse to be interfered with in its forward course, and the rear wheel will leave the ground with a result and in a manner quite well known.

In the safer forms of bicycles,—those from which a header is improbable,—without proper springs, the rider will simply slide forward on the saddle, causing considerable loss of momentum besides that due to vibration, since he must afterwards slide himself back again.

Referring to the diagrams, Fig. 1 shows the Ordinary bicycle with a fifty-two-inch front and an eighteen-inch rear wheel. The front wheel mounts the obstacle with some difficulty, the curve upward being rather sudden in its change of direction from the base line, thus showing that the momentum is checked very rapidly; see the short vertical lines upon the curves, which are about one-half the distance apart of those on the base line between the curves and at the ends. Also notice that *F* (the front wheel) carries three-fourths of the weight, one curve being about three times as high as the other.

Particular attention is called to the easy and gradual curve shown by the mounting of the small rear wheel *R;* it would seem to show that the great clamor of theorists for large rear wheels in the Ordinary is somewhat unwarranted; the drop down and back in rolling off the obstacle will be seen to be quite sudden, but notice not very much more so than in Fig. 2, which shows the Rational, so called, with a fifty-two-inch driver and twenty-four-inch rear wheel. The large rear wheel affects the drop to some extent, but in all obstacles under four inches in height there is no perceptible benefit derived, at least not such as to warrant the extra weight and disarrangement of the steering.

Fig. 3 shows a machine with a fifty-two-inch rear driver, *R*, and an eighteen-inch front steering wheel, *F*, with the saddle twenty degrees in front of the vertical line through the driving axle. The curves are just the reverse of the Ordinary; in the latter the quick drop, down and back, of the rear wheel in leaving is comparable to the backward thrust of the front wheel in Fig. 3 running upon the obstruction. No machine in the market at present makes exactly the curve of Fig. 3; it is about that which the American Star would make with its saddle a little farther forward, and that of a recent rear-driving crank machine called the "Eagle."

Fig. 4 shows the American Star, as commonly seen, with a fifty-two-inch rear driver and the saddle directly over the driving axle. This curve shows no elevation of the saddle as the front wheel mounts the obstacle, but a radical check to the momentum is shown; observe the curve (*F*), and note that the saddle is forced back in the order of the small numerals, advancing to 1, going back to 2, then on to 3 and 4, which shows that the momentum is not deviated up or down, but is directly reversed in its course.

Fig. 5 shows a new machine of the Star pattern, with twenty-four-inch front steerer, *F*, and a thirty-nine-inch rear driver, *R*. The check in the momentum is not so radical as that shown in Fig. 4, as the front wheel mounts the obstacle. The one short line below the curve shows the backward thrust.

The sudden check in striking an obstacle, with the machines last referred to, shows the necessity and enormous advantage of a forward give to the saddle support adopted in some of those patterns. This arrangement is not so necessary in the Ordinary, yet it would do no harm, for it will be seen that the large front wheel of the latter strikes the obstacle with quite a sudden upward curve and check in the momentum sufficient to justify its use.

In the Star, Eagle, and such other types the man is raised upon the obstacle entirely by the large rear wheel, which carries nearly all of the weight, as shown by the height of the curve; it raises beautifully upon the obstruction with little or no check in the momentum, the diverging lines showing about the same distance apart as at the base. It has been thought to be an advantage to reduce the weight upon the front wheel, but the importance is very much exaggerated; it will reduce the impact in dropping down from an obstruction, and will thus cause less annoyance in rough-road riding;

still this does not alter the fact that the momentum in the man and part of the machine is not only stopped, but reversed backward, as shown in the diagrams. If the wheel were lifted entirely free from the ground before advancing upon the obstruction, it is obvious, then, that no harmful result would ensue, not so much because the jolt and impact in dropping off is obviated, but for the reason that the momentum forward is not interfered with. If the rider should run full force against a wall with his forward wheel, it would be of little consequence to him whether there was any weight upon it or not; it is not always a question of vertical disturbance or of the action of gravity that is of annoyance to the bicycle rider; it is sometimes better to have a heavy weight upon a wheel if it can be kept in contact with the obstruction, as, for instance, upon the front wheel of the Ordinary when it rolls off, as it will be seen that the curve shows a splendid contour by which to give a good pull on the machine.

Fig. 6 shows the Kangaroo type, with a forty-inch front driver and an eighteen-inch rear wheel; this curve presents very little change from that of the Ordinary.

Fig. 7 illustrates the Rover type, having two thirty-inch wheels with their centres forty-one inches apart, the saddle forty inches high and twelve inches in front of the vertical through the rear axle. The mere contour of the curve in the last figure mentioned would be somewhat misleading did the diverging lines not show that in the rolling off of the rear wheel the momentum is considerably checked,—that is, the saddle moves more slowly forward than the normal forward pace of the wheels, though there is no direct reversion of the momentum, as occurs in the Ordinary and some others.

In this connection let me call particular attention to a cardinal distinction with reference to the action in rolling upon and from an obstruction. If the wheels in descending hold the man back in order to remain in contact and thus roll off, it will, of course, result in a check of momentum exactly equal to that which would occur in such advance upon an obstacle, as would be shown by a similar curve in the opposite direction; but, as a matter of fact, the momentum being a certain amount, the effect is to cause the wheel to leave the obstruction entirely and not roll, but jump off, which result causes a great loss of energy and is sure to occur in rapid running. In this case the forward momentum gets no benefit from the potential energy acquired in mounting the obstacle, which shows the great necessity of proper springs such as will enable a man to swing forward slightly without rigidly drawing the machine after him. The object of the springs in this connection should be to hold the wheel in contact and permit it to roll instead of forcing it to jump off; if it rolls and is not carried off by the force of momentum, the energy will be given out in driving the machine forward instead of being lost in the vibration caused by impact when the machine strikes the common level. That is to say, the machine should roll off, but not hold the man back in order to do so; by proper springs the wheels remain in contact, while the man goes on at the regular pace of momentum. The liability of the rear wheel to jump off is a serious difficulty in the present Rover type of rear-driver; there is no reversion of the momentum, nor such a tendency to drop perpendicularly, as in the Ordinary, yet it drops a greater distance and is charged with more weight. This objection cannot be entirely remedied by any springs we now have in use; it requires a lively vertical as well as a horizontal amplitude in the motion of the springs, and they should be placed at the hub of the rear wheel in a manner similar to those used of late in connection with the front wheel. It will be seen from the diagrams that the curves shown by the front wheels leaving the obstructions are never such as would show any liability to jump off; advancing *upon* the obstruction must, in them, be mostly provided for.

In Fig. 8 we have a machine provided with a thirty-inch front and twenty-four-inch rear driving-wheel. This is a modification of the Rover type recently favored by some English makers. The drop of the rear wheel is more radical than that of a full thirty-inch.

In Fig. 9 appears a Dennis Johnson machine, with two wheels of the same size, having the seat low down and exactly midway between them. This is perhaps the easiest riding contrivance in so far as vibration, jolt, and shock are concerned. Observe the equable motion it displays. This machine was patented in England, as spoken of in an early chapter, seventy years ago.

It will be seen, from a general observation and study of all of the diagrams, that the best and most gradual curves are made by the front wheel in descending from, and by the rear wheel in advancing upon, the obstacle; hence it follows that the front wheel works against momentum more in ascending and the rear wheel more in descending.

CHAPTER IX.

SPRINGS IN RELATION TO THE CURVES OF TRANSLATION, MOMENTUM, AND CONCUSSION.

It was a pet scheme of the writer's to treat of the matter of the annoyance to the rider resulting from a shock or jolt and change in momentum in the various styles of bicycles in a purely mathematical form, and to some extent it can be done; but it is found that so many considerations enter that the question becomes almost interminable. The aim was to find a formula with the sizes of wheels, distances between centres, and position of saddle as variables, which would, when applied, give us a result representing the sum total of annoyance felt by the rider in passing over an obstacle or any depression, rut, or ditch of given height or depth on any combination of wheels likely to be used in one machine. The difficulty in the question is in determining just what that annoyance results from or consists in; no doubt the initial impact, change of direction, and sudden reduction of momentum, and also the duration of the shock, all enter into the grand total.

From a theoretical stand-point there need be no loss of power and consequently no annoyance in running over an obstacle, since all the momentum lost in a forward direction ought to be transmitted vertically in mounting the obstacle, thereby establishing a potential energy which would again be transformed into momentum forward as the wheel rolls down from the elevation. Neither should a rut have to be avoided, since by running into it we gain a momentum that should carry us out; hence, as per theory, the cycler should not worry about riding over rough roads, for in mounting each obstacle he only loans a bit of power in going up, which will be returned to him in going down, and in running down into a rut momentum will be loaned to him sufficient to bring him out. But, alas! he does not fancy the thing; somehow he has a like prejudice against rough roads that he has to hills, and as this prejudice cannot arise from purely theoretical considerations, we must look for some violation of nature's laws, or some cause why such laws are not directly applicable. In my judgment there is a reasonably definite connection between the annoyance felt by the cycler in riding over a rough road and the actual loss of energy, though not a similar one in all respects to that which applies in regard to hills. A shock produced by a sudden check or deviation of the momentum is not only hurtful in causing a direct loss of kinetic energy, which the rider has stored up and to regain which he must afterwards do work, but also in contusing and jarring the muscular system, which makes him less able to do the work. In so far as the machine is concerned, the loss of energy goes into vibration and into extra friction of the machine; we cannot see any other means by which it can escape; but as to the rider, while energy is of course similarly lost, the motive power is also interfered with. Now, the application I wish to make of this fact, *i.e.*, that the annoyance or shock felt by the rider in wheeling over rough roads is comparable to an actual loss of kinetic energy, as well as in addition thereto, is that the nearer we can approach to an even rolling motion affecting the rider least disastrously, the nearer we will come to a perfect road bicycle without loss of momentnm. In other words, the dynamical and physiological considerations lead us to the same end,—to relieve the annoyance by means of proper springs, and to so distribute the inequalities of the momentum and modify the change in direction thereof as to minimize the loss of energy. From experiments tried with properly-constructed springs, I find that momentum can be diverted in striking the obstacle into its required new course, upward and forward, with very slight loss indeed, and that much waste of power in rolling off the obstacle can also be saved, the desired conditions and effect being as follows:

The wheel strikes the obstacle, springs back a little, and begins to rise upon it; at the same time an upward thrust is given, additionally compressing the vertical components of the springs, the man going on forward at the usual pace of momentum and being gradually raised. When the top is reached and the wheel starts down, the weight of man and machine causes the wheel to spring forward a little at first, and then, when the weight would drop too slowly and the momentum would otherwise pull the wheel bodily off, the vertical spring, being compressed, will, by its quick action, together with the pressure backward of the horizontal spring against the obstruction, hold the wheel in contact and make it roll off. This action is reversed in the case of a rut, and is quite similar in either fore or hind wheel.

The principle is to avoid a too sudden attack upon the inertia, to change the course of momentum gradually, and to avoid concussion against inelastic parts.

The direct vertical amplitude in the springs of a cycle is of most benefit in regard to momentum in giving the vertical power time to act; that is, if the wheels are raised quickly the momentum is transmitted to and stored up in the springs and allowed to act gradually in raising all the parts without violent concussion or vibration and consequent loss of power. When the machine drops suddenly in descending from an obstacle the springs will act more quickly than gravity can overcome the inertia of the system, and the wheel will then remain in contact with the obstacle; that is to say, sufficient spring acting horizontally in the direction of the acquired momentum, together with the necessary amount of vertical spring, will store the energy otherwise lost in riding suddenly upon an obstacle; said energy will then be given time to act and be utilized in raising the rider and such parts of the system which the springs control to a certain height, establishing a potential, which will be given out in increasing the forward momentum as the wheel rolls down to the common level.

Springs having a horizontal movement relieving only the saddle can prevent loss of momentum in the man, but cannot prevent the weight of the machine from being thrown dead against the obstacle. This can only be remedied by elastic connections of a kind that prevent the shock from ever reaching the heavier parts, which condition would save almost the entire work lost against the obstacle.

We see, then, that the subject of springs comprehends not only the question of comfort in regard to the shock sustained by the body, but also the most serious and interesting factor in relation to the economy of power; nor is this a theme at all confined to cycles; it has been egregiously overlooked by makers and riders of many other vehicles. No better illustration can be had of man's selfishness, as against the brute creation, than the fact that now, in machines in which we have to pull our own load, we are just beginning to contrive and apply all possible means to prevent a loss of momentum, whereas in all our carriages drawn by horses we looked only to the ease and comfort of our bodies, and provided good springs with a vertical give for that especial purpose, having little care for any loss of power, to avoid which loss we should also use horizontal springs so placed as to relieve the entire weight of the heavy running gear, as well as that of the man, from forward concussion. I know full well, even then, that a horizontal spring has still some little to do with the ease of riding, but with a heavy conveyance the advantage to the rider is slight as compared with the advantage that it would be to the horse which furnishes the power. The time will come when the evil will be remedied in general carriages, if only for the gain it will be to the comfort of the man. There would be little hope, indeed, if the poor horse were the only party interested, but when man is directly concerned we can expect more rapid development.

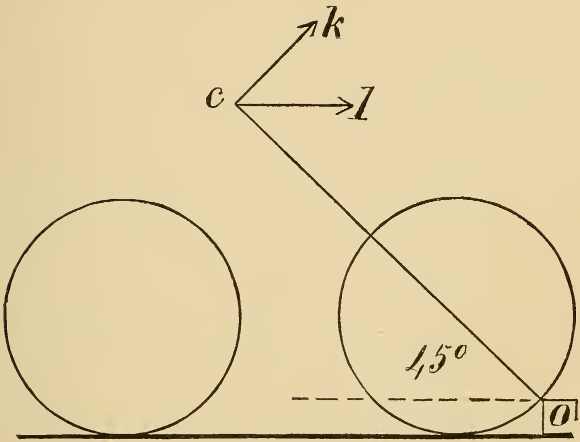
When we start our machines for a run it is considerable work to get up an initial velocity or momentum; however, after that there should be only the friction of the machine within itself and upon the road to be overcome, together with the friction against the air; that is to say, if inequalities in the road could be run over without a loss of momentum being caused thereby, there would not be nearly so much work in travelling upon the cycle as is now necessarily required.

The principal parts of the cycle should be as rigid and firm as possible, so as not to respond at random in vibration to every little shock they should chance to receive, for the spring or elasticity wants to be such as can be controlled,—that is, made to store energy in the right way and give it out at the proper time with a desired effect upon the momentum.

It must be remembered in this connection that useful energy can be stored in the machine only in the plane of horizontal motion and gravity; in other words, vertically and horizontally. Any elasticity at an angle to this plane can only be of use in reducing the concussion upon the rider in a lateral direction; and since, upon a single-track machine, but little if any shock can occur in such direction, it should be seen to that no undue side motion is permitted.

In order to fully comprehend the loss of power that it is possible to save by proper springs, observe as a particular case the annexed diagram showing two thirty-inch wheels arranged substantially as in the present rear-driving Safety.

Let *c* be the centre of gravity, and let the line *c o*, drawn to the obstacle, pass through the centre of the front wheel and make an angle of forty-five degrees with the horizontal.



Rover momentum.

The momentum $c\,l$ is split up into two equal components, one acting in the direction $c\,o$, and the other in the direction $c\,k$ perpendicular to $c\,o$, tending to turn the system about o as a centre. The numerical value of the $c\,k$ component, calling m the momentum, is $\frac{m}{\sqrt{2}}$, and its value in the forward direction $c\,o$ is $\frac{m}{\sqrt{2}} \cos 45° = \frac{m}{\sqrt{2}} \frac{1}{\sqrt{2}} = \frac{m}{2}$, which is the forward momentum retained, showing that in this case one-half of the forward momentum is saved and the other half lost.

It is scarcely necessary to say that the use of an imaginary four-inch obstruction, in our study of momentum and concussion, is entirely arbitrary. Of course obstructions of all heights will evolve proportional results. This proportion would not, however, be linear; the nearest we can come to it is to say that the annoyance begins with an obstruction of zero height, and increases about as a trigonometrical sine increases when the angle grows larger.

It is evident that all this theory applied to one obstruction is simply repeated in a number of them, and a number of them make up a rough road, bearing in mind that a rut is but one form of an obstacle.

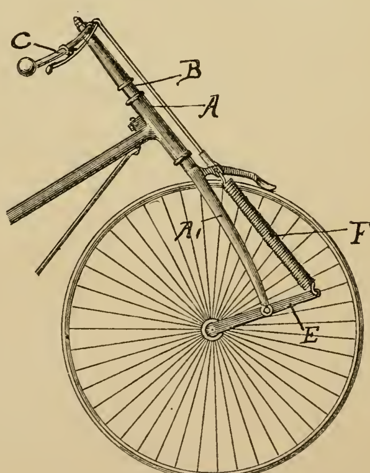
Some makers of late seem to realize the importance of springs which will allow of a horizontal as well as a vertical motion, and have in them not only provided against the loss of momentum in the man, but also in the entire machine exclusive of the front wheel. This has apparently been done with another object in view, —*i.e.*, that of relieving the annoyance to the hands and arms by reducing the vibration in the handle-bar. This object, though worthy, is far short of the ideal. Such springs might properly be called storage springs or power economizers; they are, however, generally nominated Anti-Vibrators and Spring Forks.

CHAPTER X.

ANTI-VIBRATORS AND SPRING FORKS.

THE abstract terms of the heading have, so far, generally been applied to certain devices constituting an elastic connection between the standards of the wheels (1), or, more precisely, between the front fork and backbone. The more recent forms of anti-vibrators are (2) the spring hinge about midway in the rear frame, or backbone, of the machine; (3) the spring joints at the extremity of the front fork connecting with the forward wheel axle; (4) the spring fork proper, in which the extensions are either wholly or in part elastic. The last two are, to my mind, the most deserving of praise. In the first named above, the shock is mainly confined to the front half of the machine,—that is, to the front wheel, its fork, and handle-bar,—while in the last two the front wheel alone receives the concussion to the full extent, an intervening spring preventing the transmission of the shock to other parts of the system. When it comes to be fully appreciated by the fraternity that the shock sustained by the machine and rider is not only to be treated as a matter of comfort or discomfort, but that it has other very important claims to our consideration, we may expect it to be more fully discussed. Not that we care so much about the vibration loosening every joint, screw, and pin in the entire contrivance, which makes it worn out, so called, when it has scarcely begun to wear,—of course, in the general march of progress, we expect to remedy that also,—but it is the momentum we are most after. The writer has always been one who has had a constitutional aversion to working up a speed and then having it all knocked out by a stray stone.

The difficulty experienced by inventors in the line of anti-vibrators appears to be, that while acquiring the desired elasticity in the proper direction an elasticity in other directions has followed, making the machine feel unsteady and capricious, especially in the steering. This undoubtedly valid difficulty in the way is worthy of careful consideration before accepting an anti-vibrator; in fact, the very end desired can easily be missed in an imperfect device, as it might, while holding momentum in one direction, lose it in another. I cannot better express my opinion as to the general requirement of a good anti-vibrator than to say, get plenty of spring, but acting in the plane of momentum and gravity, and get it as quickly as possible; that is,



Recent American anti-vibrator.

at the connection of the wheels with the forks, or at the outer end of the spokes if it can be done without interfering with the rigid transmission of power to the driving-rim.

It is always difficult to apply any attachment to the driving-wheel of a machine; in the Ordinary it would be beneficial to attach an anti-vibrator to the forward wheel, but as a matter of construction it would be about as difficult to do this as it would be to attach it to the rear wheel of the Safety.

We hope to see and may expect a number of devices to be offered by makers which will fulfil all requirements. Appended find a cut of one recently patented, of which I can speak with some confidence from having used a similar contrivance in experiments in this connection.

The figure here, as in the patent, shows the connecting-rod swinging through an almost useless arc of action, but the general plan is good; not, however, as neat as some others.

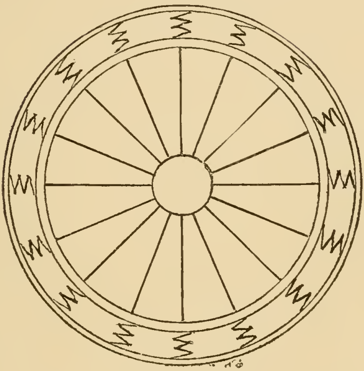
A great maker has of late, however, adopted a device which, to my mind, does *not* fulfil all of the requirements; it is still confined too much to a vertical action, and has really no horizontal amplitude unless the machine is ridden by a very heavy man, in which case the spring will assume a very abnormal position.

Other makers have adopted the joint to the centre of the frame or backbone of the Safety type (No. 2 above), so constructed that the pedals are also provided with a vertical motion; this certainly helps to isolate the man from vertical concussion, and it is good; yet the horizontal give is lacking in these machines, and the front fork, together with the handle-bar, still receives a shock and loses in vibration. Later, an inventor has shown a new pedal in which, apparently, the rubber works upon a spring and has a vertical motion under the pressure of the foot. This is a deserving though a misguided effort. The connection of the man with the apparatus through which the power is transmitted to the machine should be as direct and rigid as possible: all springs should be beyond this point. An elastic pedal is quite a different device from that named in the last preceding paragraph, in which the crank-shaft has a vertical motion and the "connecting-link," together with the source of power (the man), are all rigidly and inelastically connected together, the whole, as a system, swinging vertically by a spring.

An English firm has for several years had upon the market a machine which, from its external appearance, is all springs; the inventor thereof deserves greater credit than the success of the venture has awarded him. If in the early samples put upon the market the parts had not been so frail and the appearance so exceedingly homely, he might have fared better.

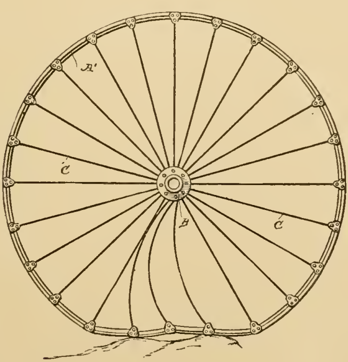
Several premature freaks of advancement in this matter of springs have occurred, but the general progress has been quite logical. First, we had the saddle provided with a very feeble amount of elasticity, then an increased amount, until makers vied with each other in producing the best spring for the old Ordinary; then we had the spring connection between the front fork and backbone in the Safety, confining the shock to the forward half of the machine; and then came the spring fork isolating the entire system except the front wheel from the shock. So far the inventions have been practical and are in use. Next we have a worthy, but I fear impractical, inventor, who proposes springs between two outer rims of the wheel or substantially at the ends of the spokes, thereby confining the concussion to one rim of the front wheel in the manner shown in cut. (See English spring rim.)

This appeared to be the ultimatum, but a shrewd American inventor has "gone him one better" and proposes to confine the shock and vertical thrust to a mere part of the rim. This invention was patented in the United States in 1889, and, if practical, would simply cause the wheel to roll over the obstruction almost as a man would step over in walking,—an ideal state of affairs, to be sure! Such a wheel would not only aid man in his transmigration over smooth roads,



English spring rim.

as claimed for the solid wheel in the fore part of this book, but would be available on the cross-ties of the



American patent flexible rim.

poorly-ballasted railroad; and let the wheel be but tall enough, and he may yet go over that old-time impediment to cross-country locomotion, the rail fence, as unwittingly as though it had not been there at all.

One of the grandest ideas in the way of anti-vibration is suggested by the following from the *American Athlete:*

"An inventor of Belfast, Ireland, has made what he calls a 'Pneumatic Safety,' the tires of which are two inches in diameter, and of *hollow* rubber, so that they contain air, which vastly increases their elasticity. The result is most favorably regarded by Irish wheelmen, and at the recent races at Belfast a rider on a 'Pneumatic' won all the four first prizes, the hollow rubber being described as phenomenally successful on the rough grass track."

If the liability of cutting and collapsing were not so apparent in this device, I would be inclined to think it would have a great future.

By way of conclusion of the foregoing chapters on curves, momentum, and springs, permit me to again call attention to the remarkable fact that a rear-driving Safety of absolutely rigid construction, striking an obstacle four inches high, loses one-half of its entire momentum and that of the rider. Think of it! Not that we often strike a four-inch obstruction, but that it does not take very many smaller to make one. Thus we are continually wasting strength when there is really no substantial necessity or occasion for it, and the writer, for one, feels ready to maintain that even double the weight (harmful as extra weight always is) in a machine is justifiable if in so increasing the weight we can do away with this most potent source of loss of energy. The bicycle, or single-track machine, too, affords an unusual chance for proper manipulation of momentum, and the rear-driver a special opportunity for the attachment of proper springs. In a two-track machine, on the other hand, we are compelled to supply springs with lateral motion as a necessary appliance for the comfort of the rider, which lateral motion results in loss of momentum and kinetic energy, whereas in the bicycle our comfort and energy are all confined to one plane; so that all we want now is to have our springs adroitly and amply applied to operate in this plane and no other, and we shall then find that we invariably save our momentum, preserve our comfort, and retain our strength. It will be a long time before we can expect to realize our dream of perfection in easy riding, or to find cyclers hunting for the rough roads; nor do we expect to see them peering eagerly forward through the misty morning, greeting the dawning obstacle as glad tidings of "Land ho!" but we do expect very soon to see the discomfort and loss of power now encountered in a great measure overcome. If some one will only get us over the sandy places as nicely as we can reasonably expect, in the future, to glide over the rough places, then we will all be happy.

CHAPTER XI.

SADDLES AND SPRINGS IN RELATION TO ANATOMY AND HEALTH.

The problem of saddles in cycles is really one of the greatest moment, and will continue to be, so long as any pain or discomfort is felt upon the bicycle sufficient to discriminate against it in contradistinction to that of sitting on a buggy-seat and being carried over a comparable distance.

Too little attention has been paid to this subject in the past, especially during the "Ordinary" *régime*. The general build of the Ordinary is such as to make it quite difficult to attach comfortable springs and saddles: many and various have been the attempts at improvement, but all have been marked by only a comparative degree of success. Were it not, however, for this success, small as it may be, in making saddles comfortable, the cycling fraternity would have had the entire medical profession down upon them, as some of them are anyhow.

Though a layman himself, the writer met a prominent medical man from the West at the International Medical Congress, who stated that unless these saddles were improved, he would order off all the young men in any way under his charge, as he had already been compelled to do in several individual cases. It is needless to dwell upon proofs of these evils; they are within the knowledge of every bicyclist of experience. Almost every rider knows of some special case of complaint, if not one of real injury.

In an examination on one occasion, made by the writer, of some forty or fifty wheels at a club house, fully two out of three were found that would have been condemned as unridable by any good physician who had given the matter careful attention.

The famous Kirkpatrick style of suspension saddle is a great advance on most of the old short patterns, yet the necessary amount of free elasticity is sadly lacking in the early patterns, and to some extent the deficiency still exists. It is questionable whether the Kirkpatrick is much better than some of the English types which, though shorter, have a large amount of vertical play by means of good springs. The old Harrington cradle spring was a marked advance on the Ordinary, yet it was objected to as having "too much motion." It is little encouragement to inventors, when they have, after considerable labor, improved upon an old device, to hear riders, who are more anxious to vent their opinions than to give honest experience, make an objection to the very point so long striven for and finally attained.

With the Rover pattern, where the room for springs is much more ample, harmful results are rapidly vanishing. It is quite a novelty to watch the body of a rider upon a well-sprung rear-driver Safety swinging through a vertical distance of several inches, when we have been used to riding upon a spring of a half or three-quarters of an inch of amplitude.

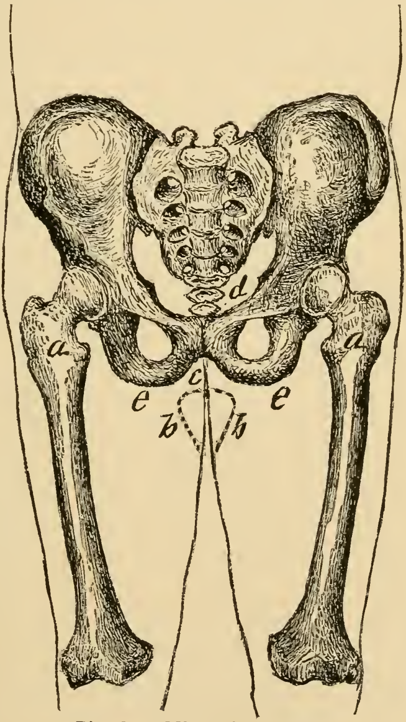
The writer has examined machines where the saddle leather was down upon the sheet-iron frame, and in which the entire motion of the spring would not amount to a half-inch. If such devices do not breed mischief, it will be for the reason that the riders are simply and absolutely impervious to any attack upon their systems, and are possessed of spines in their bodies more invulnerable than those in the machines.

Injury to the spine and other parts naturally showed itself more among American than English riders, for the reason that the general average of the road surface is much in favor of the latter, but complaint has not been unknown even among our English brethren. It is a satisfaction to know that many have awakened to this question, and it is a common and gratifying sight to see prospective buyers testing the saddle and springs of a new mount, as a matter of preliminary inspection, before other points are considered at all. It is to be sadly feared that some old Ordinary riders suffered greater injury than is commonly supposed to have been incurred, but we hope that, since they have come to ignore the supposed danger of being "thrown off" by a too lively spring, there will be less trouble in the future.

The worst feature in the bicycle saddle is that nature did not intend man to sit astride of anything, and this strikes me as the greatest oversight in the general plan of our physical make up as pertaining to cycle riding. Nature only provided three convenient ways of supporting the body,—to wit, first, on the feet; second, sitting down, with the body bent at the thigh joints; and third, lying down. Yet advancing civilization desires something a little different from any of these. In riding a cycle we find it best to stand erect upon the feet and yet get a partial support for the body at the middle,—a condition nature has not exactly provided for.

I have had prepared a cut of that part of the bony structure of the body immediately concerned in this question and sufficient in detail to enable us to understand the matter with the help of facts known to all.

It will be seen that the femurs, *a, a,* would have to swing forward to a right angle with the trunk of the body—that is, perpendicular to the plane of the paper —before we could sit upon the bones nature intended,— to wit, on the tuberosities of the ischia, *e, e,* or promontories of the pelvis. This position can be partially obtained in horseback riding by the spread of the legs over the saddle. When sitting upon a chair or buggy-seat, our weight is entirely upon the right bones in the right way, but upon the bicycle this posture cannot be attained except, possibly, in the act of coasting on the Ordinary with the legs over the handle-bar. It must be observed, in working the bicycle, that the legs are



Bicycle saddle and anatomy.

nearly straight down and the feet almost as close together as when walking; hence, unless a man is enormously bow-legged, he cannot obtain a rest upon the proper bones, as will be seen from the drawing, which shows the position of the body while working the pedals. The coaster on the Ordinary can sit back upon the broad part of the saddle, and how keenly he appreciates the relief immediately felt when he throws his legs over the handles! It will be noticed that in the action of the bicycle saddle, shown by the dotted lines *b*, *b*, the narrow part of the saddle rests in an angle, *c*, formed by the pubic bones, which are joined together at the apex of the angle by a tissue the doctors call the pubic symphysis. The saddle forms a wedge between these bones and tends to spread them; and though this wedging action can be modified to some extent, it is still vicious. The broad part of the saddle catches a small proportion of the downward pressure upon the tuberosities of the ischia directly, but this is only attained by severely distorting the fleshy parts, as shown by the dotted lines *b*, *b*. The body must evidently be supported by the bones somewhere; we cannot hang upon mere flesh; and it is doubtful if ever a saddle can be devised that will be entirely natural and hygienic; hence it is all-important to rest the weight as much as possible on the only other available support, the feet. This can be done by keeping well over the work and resting upon the pedals, and, above all by using good lively springs in connection with the saddle-support. Here again we come upon the question of proper springs, and find it has an element of health connected therewith as well as one of momentum, as hereinbefore treated of.

Objection might be raised that the body is less bent at the thigh when over the work than it was when we used to kick out forward in the old velocipede, and that for this reason we are retrograding. This view will not hold, however, for in any practical machine we have to get so nearly straight up anyhow that we had better go a little farther, thus taking a perfect position for work, and then attack the difficulty of support by means of proper saddle-springs and by resting upon the feet as much as possible.

In horseback riding there is no question of self-propulsion; hence we can bend our bodies sufficiently to sit upon a good wide seat; therefore the difficulty experienced in bicycle saddles does not apply in the equestrian art, as would naturally be supposed.

Upon inquiry as to just what the deleterious results are of riding poorly-sprung machines and improper saddles, and the cause thereof, I find that "doctors differ" slightly. Some have expressed their opinion that the trouble is in the irritation of the pubic symphysis resulting from the wedging action before spoken of; others say it is the bending and irritation of the coccyx, *d*, shown in the cut, owing to the pressure sustained by it instead of by the ischia; others assert it is the constant concussion upon the spine. I am inclined to think that the entire field is pretty well covered by a letter from Dr. Entriken, of Ohio, which will be found below.

"R. P. Scott:

"Dear Sir,—I do not agree with you in the idea as to the cause of the trouble with the bicycle saddle. It is not the strain upon the ligaments, muscles, or bones, nor the injury to the pubic symphysis or adjacent parts, of which physicians complain. It is the bruising and irritation of the urethra where it passes under the pubic symphysis, and of the prostate gland, etc.; also the necessity of muscular action in the lower limbs while the parts are so jostled, bruised, and irritated. This muscular action pumps more blood into the parts, increasing congestion and the tendency to cause disease of the parts I have mentioned. . . .

"Please note the usual narrow saddle fits close to the parts of the pubic bones, and does not run back wide enough to allow the weight of the body to fall upon the tuberosities of the ischia, as in the Mexican and Spanish saddles, but bears upon the soft parts between. You will note also that the ordinarily-shaped bicycle saddle turns up so as to allow some weight to fall upon the os coccyx, or end of the backbone, which brings in another factor in producing what has been not inaptly called the 'bicycle disease.' We have pressure where pressure should never be made, and this pressure, aggravated by the jolting motion, causing a series of rapid concussions to fall upon the spinal column at the point where it is not intended to make resistance,—to wit, the extreme end. If a saddle could be constructed that would lift the soft parts of the perineum comparatively free and cause the weight to rest on the promontories of the ischia, thus protecting the soft parts and communicating a less direct shock to the spine, the trouble would be substantially overcome. I know the difficulty of accomplishing this when the legs must be down and in motion, but some genius will probably solve the problem.

"Yours truly.

"F. W. ENTRIKEN."

Another opinion on the subject of health is as follows, from *The Cyclist*, by Dr. Jennings:

"'It is perhaps inevitable that persons who have no practical experience should accuse the exercise, on theoretical grounds, of producing various evils, such as varicose veins, hernia, hemorrhoids, urethral stricture, and various forms of cardiac and nervous diseases. As to varicose veins, it seems to be clearly established that in those cases in which this condition is due to chronic local causes, to constipation, and a sedentary life, *actual benefit* is derived from cycling, and that even in those cases which are due to organic visceral disease no harm is done. . . . As to cardiac and nervous disease, the case is different. Race-meetings and the silly craze to "break the record" have much to answer for. It is not difficult to understand how such exercises may cause permanent injury to the heart, neurasthenia, or even organic nervous disease.' We presume the writer refers to such exertions on the part of wholly or partially trained men, for we have Dr. Turner's word for it, and that is also the word of a practical athlete, that to men in condition harm does not result."

The importance of some care and knowledge on any subject connected with spirited exercise should always be borne in mind; not only should we give attention to the matter of saddles, but also to any other point which may seem to be important. I append an article from the *Bicycling World*, on another branch of the subject of health in cycling, which explains itself.

"A SOURCE OF DANGER TO WHEELMEN.

"I would most earnestly call the attention of all wheelmen to that most dangerous custom of wearing belts drawn tightly about the waist to support the pants, or even where they are laced tightly or where there is any constriction about the waist whatever.

"Many wheelmen are leading sedentary lives, especially the older riders, and are not physically in a proper condition to put forth the very severe muscular exertions which all wheelmen are called upon to do, and one of the dangers which I wish to particularly call attention to is that of causing hernia or rupture.

"I know of two cases of hernia caused directly by the severe exertions put forth in climbing steep hills. One of them was a particularly strong, healthy, and robust young man, and I am quite confident that the indirect cause of those herniæ was the wearing of tight belts. The young man alluded to above has always been very active in out-door sports, very fond of lifting, and made it a common custom to put forth his utmost strength whenever opportunity offered, and he never had any tendency towards such a result until he began bicycling, which brought about an entire change in form of dress.

"When any person puts forth his strength in lifting—'hill-climbing is merely a form of lifting'—the abdominal muscles are called strongly into play, and if by belting or other means they are prevented from expanding and increasing the circumference of the waist, their force is then directed towards forcing the abdominal contents downward, and thereby greatly increasing the chances of causing hernia.

"The clothing should always be loose about the waist. As suspenders are inconvenient to wear and very uncomfortable in hot weather, I would suggest that the simplest, and I think the best, way of holding up the trousers is by means of a band sewed around the inside of the flannel shirt, with buttons sewed through the shirt and band and then the button-holes made on an extra band on the inside of band of trousers, the same as little boys' waists and trousers are joined.

"I sincerely trust that no one will misconstrue this article as condemning wheeling; no one believes in it more thoroughly than your humble servant. I am writing from experience, not hearsay, and I would desire all wheelmen to give heed to my warning, and so avoid a source of danger.

"L. A. W., 18,954."

["The above is written by a physician who has made a special study of hernia.—Ed."]

There are some strong opinions on the other side of this belt question, if the belts are of proper kind and rightly worn. Very few agree unconditionally with L. A. W. However, it is hoped that no alarm will be taken from the discussion of these subjects. They are not so serious as might appear, except in cases of gross negligence. But whatever danger there may be, it is best to be fully aware of it, and thus be forearmed. As to saddles and springs, let riders show the makers that they are alive to all improvements which will in any way eliminate causes for anxiety in this as well as in other respects, and thereby show that the fact of making a mile in a little shorter space of time, or that of getting one inch farther up a stiff hill, is not all that the modern cyclist proposes to consider.

CHAPTER XII.

HEADERS OR CROPPERS.

"TAKING headers," or, in the parlance of our brethren of England, "coming croppers," is perhaps a trivial heading for any article outside of newspaper or wheel periodical gossip, but it has a popular twang, and to the fraternity means a great deal. Every rider of the old Ordinary can give us personal experiences on this subject; among them will be found mishaps too serious to be chronicled in any jesting mood, a few so serious that we would fain forget them were not this forbidden by our sympathy and respect for the sufferers as fellows of our craft. From this sombre side of our story how joyfully we turn to the many humorous anecdotes which have been related in every club-room, in some of which "we ourselves were part of what we told!"

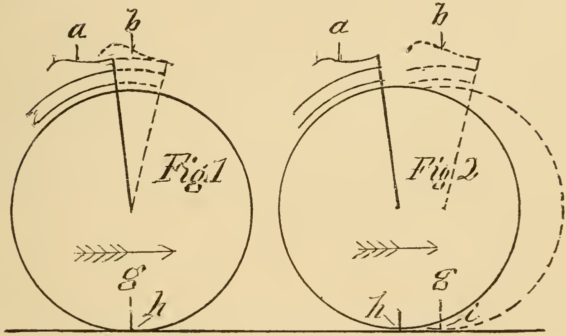
The subject would ere this have been obsolete were it not for a large number who still maintain the supremacy of the "Ordinary," and those others who, forming an intermediate class between the old and new, have unfurled their banner as doughty champions of the "Rational."

A header is the act of "going down on the other side," spoken of in a former chapter, or, more definitely, it is the projection of the rider over the handle-bar to the ground in advance of his machine. It is a simple process, being a mere application of the physical forces of gravity and momentum. A moving body tends to keep moving in a line until stopped or deviated by some counteracting force. In riding a cycle a certain momentum is acquired and kept up against the resisting forces of friction, impact of air, road resistance, etc. Headers are a result of a counteracting force, generally caused by sudden impact against a stationary obstacle on the road, or by the forward wheel becoming suddenly locked through a failure in the axle-bearings to work, or by some clog in the wheel preventing it from revolving freely through the fork in which it is hung. There are modifications of the header action even in machines of the same sizes of wheels and same rake,—rake being a term recognized to express the angle of the front fork from the vertical. This rake has to do with the liability to headers only in so far as it regulates the centre of gravity of the system, "more rake" generally meaning that the rider is farther behind the vertical line through the front wheel axle.

In order to take a header, a certain centre of gravity must get beyond a certain line. This centre of gravity will vary in position in different machines, and the modifications spoken of cause the line to move in a way which is, I think, sometimes overlooked.

If we discuss the crank Ordinary, it will be noticed that when the front wheel is stopped in its forward progress, the frame of the machine together with the rider and all other parts of the system revolve about the centre of the wheel and cause an action within the system, the same as that of the forward wheel revolving backward through the fork. Now, it is just when such backward motion is prevented, that the gravity line moves and alters the conditions, decreasing the liability to headers. If the forward wheel can revolve backward through the fork, then, in taking a header, the system, exclusive of the forward wheel, will revolve about a point in the wheel centre; but if it cannot so revolve, then the entire system, including the forward wheel, must all tend to revolve about the point of contact of the wheel with the ground. Now, it will be seen in the latter case, or anti-header machine as we shall call it, that as the system tends to revolve about the point of contact, such point will constantly change;

in other words, the wheel must roll onward, and the point of contact will therefore advance.

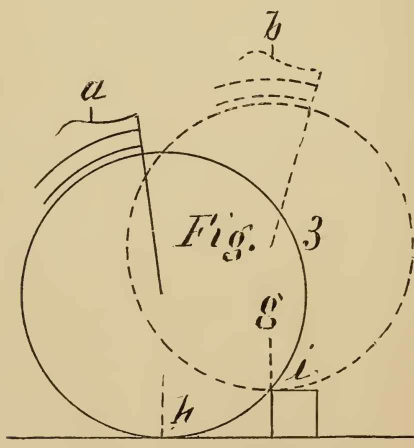


Header action, smooth road.

In Fig. 1, in the annexed diagram, we show the distance forward and upward, *a* to *b*, the rider must be thrown before he gets beyond the gravity line, *g*, in the Ordinary; Fig. 2 shows the distance when the wheel will not revolve backward through the fork. In either case, the header is supposed to be taken on a smooth road and not against an obstruction; this can easily occur in vaulting into the saddle or in leaning too far forward. It will be noticed that the distance the rider is elevated, or, in other words, the amount of work done against gravity, is in both cases the same, but the distance forward he must be thrown is considerably greater in Fig. 2. This is for the reason that while the point of contact, *h*, with the ground remains the same in Fig. 1, in Fig. 2 the point rolls on to *i*. For more accurate illustration of the work to be done against gravity, and the distance forward the rider must be thrown, see the header curves in Figs. 4 and 5, farther on.

We see, then, that the advantage which the anti-header

(No. 2) has over the Ordinary machine (No. 1) is not so very great when in both cases a smooth road is considered; when, however, we consider the element of an obstacle in the path, the difference is much more in favor of No. 2. Let us compare the action of both classes of machines against a four-inch obstruction. In all cases the action of No. 1 machine will be the same,—that is, the wheel will remain in contact at *h*, Fig. 1, and the saddle will go on over, just as it does in the case of no obstruction at all. But in No. 2 the very act of taking the header must raise the entire weight and roll the system upon the obstacle, as shown in Fig. 3.

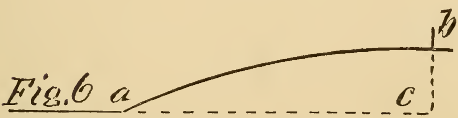


Anti-header wheel action on obstruction.

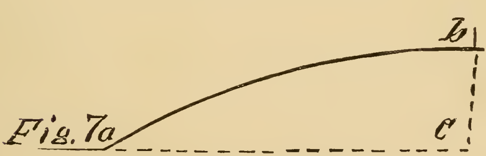
The point of contact, *h*, over and beyond which the centre of gravity must be thrown, will not only move forward, as shown in Fig. 2, but will move to the top of the obstacle *i*, Fig. 3. Or, if the question is one of a rut or indentation in the surface of the roadway, No. 2 will be caused to roll partially or altogether out of the rut. Now, since the rider, by the action of his momentum and that of the machine, is rolled upon the obstacle or out of the rut, it is easily seen that if he is attending strictly to his work and is at all a skilful rider, he can, by a lively thrust upon the pedal at the opportune time, right himself and keep the drive-wheel rolling on, in which case the rear part of the machine will, in all ordinary cases, drop back upon the ground, from which, of course, it will have raised.

Ordinary header curve, any obstruction.

Anti-header attachment, smooth road.



Anti-header, four-inch obstruction.



Anti-header, eight-inch obstruction.

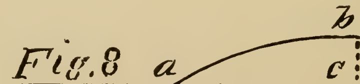
In the diagrams herewith annexed, Fig. 4 shows the curve of the saddle of a No. 1 (Ordinary) machine on a level road, and which would be the same against any obstruction. Scale, one-sixteenth.

Remark how the rider must be lifted from the level c to *b* and be thrown forward from *a* to *b*.

Fig. 5 shows the curve of a No. 2 machine, with the anti-header device, on a level road. The elevation and forward throw are represented by the same letters as in Fig. 4; it will be noticed that the distance from *a* to *b* is very much increased.

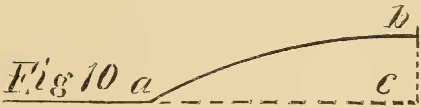
Figs. 6. and 7 show the curves or necessary projection, forward and upward, of the saddle in the header act of a No. 2 machine upon four- and eight-inch obstructions respectively.

The feature of a non-backward revolution of the drive-wheel through the fork is a natural consequence in some lever and clutch machines. This element of anti-header has been the subject of an invention in the way of an attachment to the Ordinary, contrived with a view to reaching the same result, but it cannot be said to be a successful venture in the market, the probable reasons being, first, that it interferes, to a slight extent, in managing the dismounted wheel, the operator being unable to run it backward, as is sometimes desirable; second, that the anti-header element has not been really understood or appreciated among the fraternity, as it does not appeal to the judgment of the casual observer that any such element results from the fact "that a wheel won't run back." In the lever and clutch machine a third objection is raised,—the rider cannot back-pedal, but must depend entirely on the brake in descending hills.

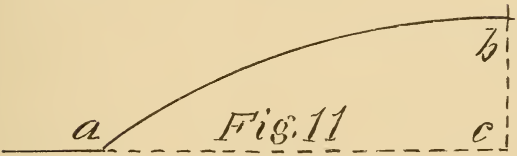


Header Rational Ordinary.

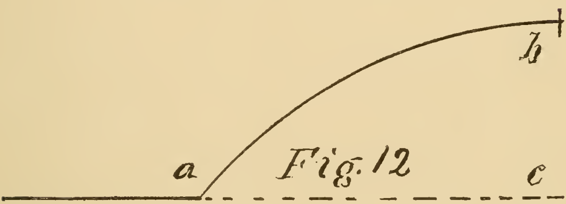
Header Kangaroo.



Kangaroo anti-header, four-inch obstruction.



Header Star rear-driver lever machine.



Header Rover rear-driver type of machine.

Fig. 8 shows the Rational Ordinary curve;
Fig. 9, the curve made by the well-known Kangaroo;
Fig. 10, the Kangaroo with clutch or anti-header attachment;
Fig. 11, the American Star combination of wheels;
Fig. 12, the curve of the regular crank Rover machine.

The Rover type of safety machine is practically free from the liability to direct headers, for the reason that the centre of gravity of the system has to be raised to such a height that the rider swerves around sideways before he can go over; nevertheless, a modified form of the same might be possible through some remote concatenation of circumstances causing the machine to stop and throw the rider bodily over the handle-bar without keeping him company on the trip as usual, in which case he, at least, escapes the usual subsequent annoyance of being pounded by the rear wheel.

A header cannot result from stopping the rotation of the rear wheel, as generally supposed, because the point of contact of the same being in the rear of the rider and centre of gravity, the system cannot revolve about the said point in a forward direction, or direction of momentum. It will be seen, then, that if from any cause the rear wheel leaves the ground, which it can do from a rebound against some obstruction, the instant it does so the system will be simply carried forward by the rolling of the front wheel.

Headers have been said to result from the above cause in the ordinary bicycle, but the writer after several experiments has been unable to attain such a result. Yet it is quite possible that it might occur from the rebound of the rear wheel in striking an object with great force, though it is altogether improbable if the drive-wheel were kept fully in motion. An obstruction so great as to bodily raise the wheel sufficiently high to throw the centre of gravity over never gets a chance to act, since the forward wheel must surmount it first, and this is where the header occurs. It can be easily seen that when the rear wheel, from any cause, is raised from the ground, there can be no action within the system to make it raise any higher or to prevent the forward wheel from rolling onward as usual; hence it is evident that as soon as the former leaves the ground it will simply drop back and rebound again at will. But in the other case, if the front wheel is locked, the rear wheel cannot go on in a straight line and it must therefore go on over the top.

In the writer's experiments on the rear wheel, he had an attendant throw a stick between the spokes while in motion; it was not tried at very high speed, however, for the reason, perhaps, that any failure in the theory above provided might end rather disastrously to the experimenter and thereby cause an act of ingratitude to be perpetrated upon the prospective patron of this book, through an inability to ever finish it.

If some ambitious cyclist will kindly complete these experiments, the writer will gladly incorporate an account of them in future editions of this work, together with an appropriate obituary notice in large type.

CHAPTER XIII.

GEARING UP AND DOWN.

THIS familiar phrase means simply that the number of revolutions made by the drive-wheel in proportion to the number made by the cranks is greater or less. Broadly, it varies the relative amount of motion of the pedals, and consequently of the feet of the rider in travelling over a given distance. In the simple crank device no change can be made in this respect except in the length of the cranks, but in all of the sprocket-chain devices it is also possible to change the amount of motion in the pedals by altering the size of one or the other of the sprocket-wheels. In lever machines and in those which have the sun and planet connection, either with an oscillating lever or full revolving crank, it is generally possible, by some alteration, to produce the same effect as that of changing a sprocket-wheel as mentioned. The variation in the length of crank produces an effect comparable to the change of gearing in so far as the distance through which the feet travel in covering a certain distance is concerned, but the difference lies in this, that altering the crank means a given number of revolutions in a circle of varying radius, while altering the gearing means a variable number of revolutions in a circle of given radius, in order to cover a given length of road.

In popular language, if a rider wishes more power, he must lengthen the crank or decrease the size of the sprocket-wheel on the crank-axle; *vice versa*, if he desires greater speed and less power, he must shorten the crank or enlarge the sprocket-wheel connected therewith. It is needless to say that enlarging the gear-wheel on the crank-axle produces the same effect as decreasing the size of that on the drive-wheel.

In a sprocket-crank machine the real question of gearing is whether to change the length of crank or proportion of the sizes of the gear-wheels; but you can't by any combination get power and speed both with the same amount of work done by the rider.

Simple as all this matter of gearing is, it is probable that there is no feature in cycles so indefinitely understood, or, we might say, so persistently distorted. The only trouble is that riders will not stop to apply a most fundamental law of nature. If we gain speed, we lose power; if we gain power, we must lose speed. To apply this particularly to cycles, if you gear up for speed, you must push harder; if we gear down, we need not push so hard, but must kick faster or go more slowly, provided in each case the length of crank is the same. We cannot go fast and push easy unless we increase the strength of the man. To go over the same distance of given road, the same amount of work is required, no matter how the machine is arranged through which it is done.

This subject was better understood when no element but the length of the crank was to be considered; but now, since bicycles have appeared that are capable of being changed to a high or low gear, some riders persist in treating it as an entirely new problem. It has in one respect a new feature in that greater or less speed can be had without decreasing or increasing the length of the crank; that is, since the comparative speed of the pedal and rim of the wheel in space can be varied either by the length of the crank or the number of revolutions of the same, we can make one turn of a six-inch crank do the same work at the same foot-pressure as two turns of a three-inch crank at the same pressure. Now, this is a valuable feature, because it allows us to increase the vertical amplitude through which to transmit power without change in the velocity of the pedal through space.

A convenient standard has been adopted in gearing cycles by comparing the speed of the driver to that of a wheel and crank connected and revolving together, as in the Ordinary; that is to say, a thirty-inch wheel geared to sixty means that one turn of the crank will drive the thirty-inch wheel twice around, as it must do in order to cover the same distance as one turn of a sixty-inch wheel. To find how high the machine is geared, divide the number of teeth in the sprocket-wheel on the crank by the number in the sprocket-wheel on the driver, then multiply the result by the diameter in inches of the drive-wheel. In short, the speed indicated by the size of the drive-wheel of the geared machine is to the real speed as the number of teeth in the gear upon the wheel is to the number of teeth in the gear on the crank-axle.

When tricycles first appeared in which the power was transmitted through sprocket-wheels and chain, there was quite a cry for "high-geared" machines; but the mistake was soon discovered, and buyers eventually found that moderate gearing was best, and in fact many adopted a level gearing (equal-sized sprocket-wheels) with thirty-six- to forty-two-inch drivers. Notwithstanding this experience, when the geared bicycles came in there was still a great cry for fancied high speed. An English maker in 1885 complained to the writer that it was the bane of his existence,—this howl for high gears,—when it was well known to him that buyers would eventually be dissatisfied. It was of no use to make, said he, what is really needed; customers will not even try the machines, so sure are they that by their scheme "they can fly through the air with the greatest of ease," which expression, when used by the ordinary man, means something like pulling a ten-horse load with one mule.

In the early days of gearing, few riders could be more easily offended than by intimating that they wanted a low-geared machine, say fifty to fifty-two; no less than sixty or seventy would satisfy their cravings for great speed, and in fact the writer has been asked seriously, " Why not gear her up to about a hundred?" But now that the idol of so many riders has been shattered, they will too complacently accept the word of the maker as to what they need, and hence there is a real substantial reason for investigating this matter. The advent of the gearing process has developed a new point, as a result of conditions spoken of, which is to make the machine suit the rider's strength and physical peculiarities as well as to fit him in the length of leg,—a point to which insufficient attention has been paid. If one man wants a machine geared to fifty-six or sixty, there is no conceivable reason why another who happens to have the same length of inseam of his trousers should want the same; nor is it a matter simply of strength: if two men can make the same number of miles in a day, it is fair to presume that they are of nearly equal riding capacity, yet each may accomplish the work most easily on machines geared quite differently. An instance of this kind has occurred to the writer, in riding day after day on a machine geared to about forty-eight, with a man who preferred and could do his best work on a sixty. This difference held good on smooth or rough roads, and as a matter of my own experience it is a pleasure to ride a low gear, and distressing toil to use a higher. There are others whose experience is just the reverse, and it is useless to try to guess at what is wanted; it is best not to go to either extreme in buying unless you have proved the necessity by extended experience on the road. It would be well for all riders to avail themselves of any good opportunity to make a thorough trial of machines geared differently from each other, for it is possible to be unsuited and never know it. Even if you have been able to lead the van when you have been out on a run, you do not know but that you could have led it much easier on something else than that which you rode. The physical system in man may easily become adapted to a wheel which at first was not suitable, but there are those to whom certain gearing will always be wrong. It is safe to say that the prevailing mistake in the past has been the use of too high gears, though this has been much improved of late by the use of long cranks.

There is one subject which should be touched upon with great caution, since the prospects of some very worthy inventors might be unjustly interfered with; it is that of multiple or two speed-gears. I have tried to impress upon the reader the importance of gearing to suit his strength, yet when once suited it is extremely doubtful if he should ever change it; at least it is doubtful if he should do so on the same trip or even during the same season. When a rider transfers his base of operations from a level to a hilly country permanently, a change in his gear may not be out of the way; but to fix the machine for more or less power alternately as hills and levels are met with is, in the light of my experience, more tiresome than the necessary variation in the effort of the man.

CHAPTER XIV.

THE MODERN ROVER, OR REAR-DRIVING SAFETY.

As machines of this general type bid fair to engage the attention of cyclists to a marked degree, it seems in place to give them more than a passing notice in the general discussion. It is fair to presume that more than one-half of all the machines sold in the immediate future will be more or less after this general pattern.

The introduction of the Rover has afforded us one of the most amusing incidents in cycling history. The writer of these pages happened to be in Coventry during the summer of '85, and he had a fortuitous opportunity, fondly accepted, of inventing fun at the expense of the "Crocodile" and of joining in the general laugh at the (alleged) ridiculous attempt of a Coventry firm to "foist" (*sic*) this most extraordinary freak of cycling inventive genius, under a new name, upon the market.

In the fall of the same year a notable Washington agent, allured by the attractive notices of a great prize for a hundred-mile race, imported one of these selfsame incongruous specimens into this country. After a few weeks of hilarious humor, followed by a sullen contempt for the thing, this Washingtonian shipped it to a great American manufacturer, who made sport over it for a year or two before we all began to scramble around and make ready to prove that each one of us individually "saw it all the time." It has been a hard pull, however, and it is still uncertain on whom it did first begin to dawn that somebody had been guilty of colossal stupidity.

One thing the Rover accomplishes, previously touched upon, is the location of the rider as nearly over the work as he chooses to be; which has been the end and aim of all our efforts in that direction. Had this machine been offered to the public, in good shape, at the end of the old bone-shaker *régime,* it is questionable if the Ordinary would ever have acquired the prominence it did. In early times, when learning to ride a tall machine was considered quite a feat of gymnastic exercise, such as only the young and sprightly could ever perform, many, who afterwards by force of circumstances did accomplish the feat, would never have tried it if there had been anything else, such as the present Safety, to learn upon. Every accident on the Ordinary would have told heavily against it in the market, and every severe casualty would have made a new Safety rider; as it was, however, there was only one of three things to do,—take to a three-track machine, stop riding, or try the old mount again. It is needless to say that, almost to a man, the last condition was accepted, and the result is that now we have a class of men who can handle an Ordinary with such dexterity that many of them conscientiously aver that there can be nothing safer. However, among those most devoted to it at the present time there are few, if any, of the close observers who would have stood sponsor for their favorite machine had the rear-driver made its appearance in its present form prior to the advent of the Ordinary. To say that the latter would ever have obtained a footing above the level of a fad or a curiosity, would be equal to denying that the Safety will now ever hold an enviable place among us.

In the minds of many the sprocket-wheels and chain stood much against the introduction of the rear-driver; true, many good tricycles were implanted firmly on the market with such devices for conveying power to its necessary locality, but there was always such a vast chasm lying between the single- and double-track machines that riders did not care to get down to minute details of differences. To an Ordinary rider the idea of sprocket-wheels was, and is yet, for that matter, an abomination, only second to that of being dropped down from his elevated position to the humble plane in which his fellow on the Safety is wont to revel; but nothing in the way of change in the cycle art is unbearable after we become accustomed to it.

No doubt the old Kangaroo, as bad a failure as it was, led us up to endure more complacently the rear-driver in respect to the sprocket-chain; yet in no type of machine could the subject have been brought to our notice in a worse form. The tricycles using a single chain did away with one of the great evils which appertain to this system as found in the Kangaroo, in which we have two chains working entirely independently. The evil of such an arrangement is easily seen: no old Kangaroo rider, or rider of any other double-chain device, is ignorant of the annoyance caused by reversing the slack in each at every half-revolution of the pedal. Keep the chains ever so tight, this slack will be felt as the pedal crosses the dead-centre line at the top and the bottom. In spite of all this, some reputable makers persist in constructing rear-drivers having the double chain, and as a matter of course justly fail to meet with much approval from the riders thereof.

A word in regard to the nature of sprocket-wheels and chain. It is perhaps not generally understood how important it is that they should be well made, with especial view to resist stretching and alteration of pitch, any tightening device, no matter how deftly made, being an inconsistency in mechanics. To be sure, the spreading of the wheel-centres cannot do much harm, and it saves some annoyance, but it does not cure the real evil, nor is it any better to take a link out; it is the length of each and every link that is wrong, and it can only be cured by either changing each link or by altering the sizes of the sprocket wheels.

Two gear-wheels cannot run properly together unless they are proportional in size to the number of teeth. Now, the stretching of a sprocket-chain alters the pitch in a manner similar to that of retaining the same number of teeth in each of two intermeshing wheels, and then altering the size of one. A sprocket-chain acts substantially as an idle wheel; when it stretches we have, as it were, this idle wheel made larger while the size of the others and the number of teeth in each remain the same. Increasing the distance between the centres does not affect the size of the wheels, and when a sprocket-chain stretches or becomes longer by wear the wheels should either be larger or else the number of teeth diminished. It is a general idea among mechanics that chain gearing is about the most undesirable of all means of transmitting power we have. This is perhaps an exaggeration, and I think the cycle art has proved it to be so; but the idea no doubt is fostered by this constant tendency of the chain to stretch, and when this stretch takes place a very considerable amount of friction must result. There is another annoyance felt by patrons of the small wheel: the chains being low down and well oiled, as they should be, especially if once they become stretched, have a superlative capacity for accumulating and holding dirt, causing a grinding second only to that of a finely-set quartz-crusher. This feature is not so much to be deplored if the dirt can be kept out of the chain-link bearings, since it is not the wear of the link against the tooth of the wheel, but that within the link, which makes it longer, alters the pitch, and causes great friction.

We shall, however, have to accept this chain arrangement for the present in Safeties, as it cannot be helped. Some ingenious inventor will no doubt ere long come to our assistance; but until then we can tolerate it with a good grace, since it is a necessary concomitant of so valuable an acquisition to our assortment of mounts.

There is apparently little difference in the construction of the crank Rover Safeties, yet there is more than a cursory glance would lead us to suspect. To begin with, there is quite a variation in the slant of the neck or front fork, many makers giving a considerable curve to the fork, thus throwing the neck much straighter up. Then we have the telescope head, where the front fork revolves inside the tubular front extension of the main frame; and lastly, the swing-joint or Stanley head.

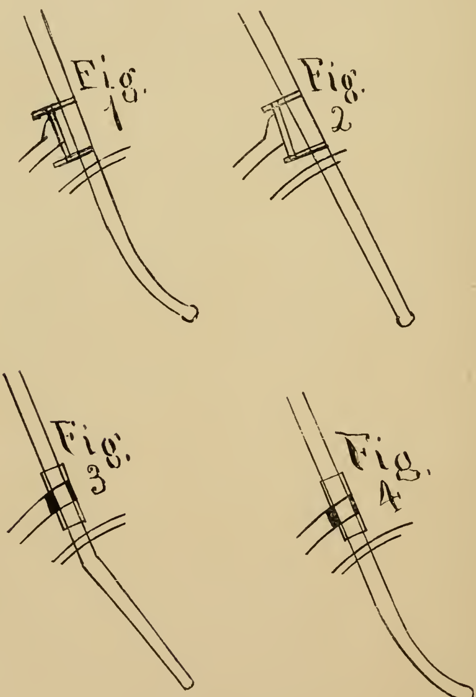
No very startling difference in the durability of these two heads has as yet developed itself. The telescope is often hung in balls, which makes it work as freely as the Stanley, if not more so; it has also a little advantage in appearance; still, a large majority of the makers have adopted the Stanley, probably because it is a little cheaper and quite as efficient. There seems to be less disadvantage in the slant of the front fork than might have been expected. According to an old theory in the Ordinary, the more nearly vertical the head, the less "sensitive" the steering; but experience demonstrates that by practice all machines are so easily steered that the point is really not so vital.

The original Rover machine as put upon the market has everything combined to give it a full slant in the neck; that is to say, it has a large thirty-six-inch front wheel and no curve to the fork, while in other machines of the same general pattern a thirty-inch front wheel is used with considerable curve to the fork, which taken together make the neck almost vertical; riders, however, are equally satisfied with either style.

It will be well to notice here that though I speak of the curve of the fork in relation to steering, it really has necessarily nothing to do with it, since a perfectly straight fork could have a more vertical head bearing than one much curved.

The slant of the pivotal line is the important feature, and this may be varied in either by bending the fork or, in the Stanley, by setting back the lower bearing.

The four drawings below show necks of equal slant and considerable variation in the curve or shape of the forks.

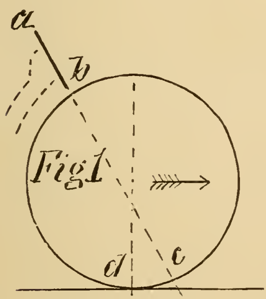


Rear-driver front forks.

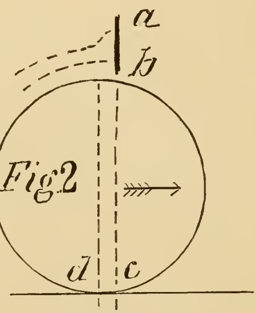
Any of the four patterns above work exactly the same in the hands of the rider.

So much for the manner of obtaining slant of the head or pivotal connection, as we shall call it; but as to the amount of this slant it is desirable to obtain much more can be said.

The great system of castering, so knowingly discussed by some expounders of cycling faith, has in it really something of substantial importance. It is asserted that if the machine is so constructed that the line of pivotal connection strikes the ground in front of the point of contact of the wheel (see Fig. 1), a castering element comes into play which will cause the machine to retain its forward course, and enables the rider to go "hands off." Note that the line *a b* strikes at *c* in front of *d*.



Supposed caster.



Real caster.

I have observed many rear-drivers, and cannot see that this makes much difference; the various kinds seem to be equally well ridden, with respect to easy steering, if only the riders happen to be thorough experts; of course all sorts of theories in regard to the action of the steering have been advanced.

I take it that there is only one truly tenable theory of castering; this when applied will obviate "sensitiveness" completely and under all circumstances; it is as follows: The pivotal connection must be such that the line *a b* strikes in front of the point of support, as before spoken of, and it must also be so constructed and placed in such a position that no motion of the handle-bar will cause the machine to lower its centre of gravity. If by turning the handles any weight is lowered, you can depend upon it that the force of gravity, always tending to lower this weight, will inversely cause the handle-bar to turn. It will be noticed that when the machine stands upright the steering apparatus is not in a state of stable equilibrium; that is to say, the weight of the machine tends to shift the wheel, and it can hardly keep straight by means of such castering element as results simply from the line of the pivotal connection striking in front of the point of contact.

The necessary conditions are as follows (see Fig. 2): The pivotal line *a b* must strike at *c* in front of *d*, and the line *a b c* must be vertical in order that no motion on its axis can lower any weight when the machine stands upright. Now, it follows from these conditions that the head must be vertical and no part of the pivotal line in the rear of a vertical through the centre of the wheel.*

The automatic steering devices do not work as successfully on a bicycle as on the leading wheel of a tricycle. There are two principal plans which have been in use; in one of which a spring forces the steering-bar into a position for running straight ahead; the other plan for the same purpose consists in a V slot and pin. In the latter the weight of the rider keeps the wheel straight by forcing the pin into the bottom of the V slot, and it will rest there until forced out by the action of the handle-bar. Either of the above devices is objectionable in a bicycle, because the constant working of the steering-bar for the purpose of balancing is so continuous, as compared with that of steering pure and simple, that any force tending to hold it in any one position will soon tire the arms and make riding more laborious.

A new form of the rear-driving Safety was shown

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* Since the subject of a patent.

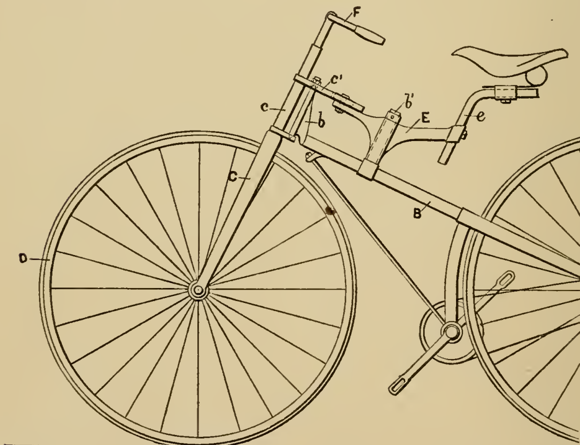
in the season of 1887, invented by a German. I give herewith a cut of the same, citing what he claims.

The "Rothigiesser" principle.

"Can be ridden any distance and on any road without using the handle-bar. The new principle—pedals on the rear wheel and saddle on the front wheel—is just the reverse of the construction of the ordinary bicycle, and is the only true principle for a Safety; the fault of the common rear-driving Safeties being that both saddle and pedals are fixed on the rear wheel, so that the front wheel must be controlled by the arms of the rider."

I have tried the principle, but could not get much out of it. If there is anything in it at all it would be quite valuable; but I am inclined to the opinion that the inventor relied rather too much on his theory and not enough on actual practice. Notice that the handle-bar, trunk of the body, arms, and saddle are all within one system, there being no power to steer except in the action between the trunk and feet, instead of between the arms and trunk, as in other machines.

A new machine has been favorably noticed of late which strikes me as a modification of the German's principle, or rather as a combination of that with the old plan of steering. In this device there is some motion between the saddle and the handles, as of old, and in addition thereto we find a motion between the saddle and the pedals, which is intended possibly to combine all of the good elements. The cut explains itself.



The "Rothigiesser" modification.

But to return to our mutton. The important features which have compelled us to recognize with favor this most homely and awkward-looking machine —the modern rear-driving Safety—are, first, the safety element, and, secondly, the advantage of being more nearly over the work, these two features including many minor characteristics. Then there are a number of independent peculiarities which can hardly be said to necessarily belong to this type of machine, but which are still adopted in it, such, for instance, as gearing up and down, foot-rests for coasting, etc. Until recently there did not seem to be any great fault in the machine except its looks, but a controversy has arisen which is not only extremely important but is so far unsettled; I refer to the discussion of the *side-slip*, which, in showing the number of explanations that different observers will give for the same set of facts, has been not unmixed with an element of the humorous.

CHAPTER XV.

THE SIDE-SLIP OF THE SAFETY.

THE question of side-slip is not entirely new; it was first mooted in connection with the Safety of the Kangaroo type, which had a driver of from thirty-six to forty inches in front of a rear wheel of eighteen or twenty inches, as will be noticed in the cut of this machine given hereinafter. Now, to come to the specific features supposed to account for the side-slip, note that, in order to make room for the sprocket-wheels, the cranks had to be unusually wide apart and, by the necessary construction of the machine, also very low down; in other words, the machine had a very wide tread, swinging very close to the ground. The slip of this wheel was something fearful to behold, and its cause was supposed to be fully explained by the peculiarities of construction just noted, in accordance with a theory which, though religiously believed in at the time, has of late been somewhat shaken, and which we now proceed to develop.

In order to compare the different machines in respect to this theory, suppose we take, first, the Ordinary with a fifty-inch wheel and cranks, say, eight inches apart, or four inches from the centre of the wheel to either crank. Now, if the pedal *b* (Fig. 1) is four inches long, the distance from the centre of the pedal to the centre of the axle of the drive-wheel is six inches, and the diameter of the wheel fifty inches; then, when the crank is extended horizontally out in front, this being the position when it is supposed to be subjected to the greatest strain, we have the following conditions (see Fig. 2):

Let *a b* represent the distance of the centre of the wheel from the centre of the pedal, $a\,c$ the vertical height of the pedal from the ground, and W the weight of the man. Then W applied vertically downward at

FIG. 1.

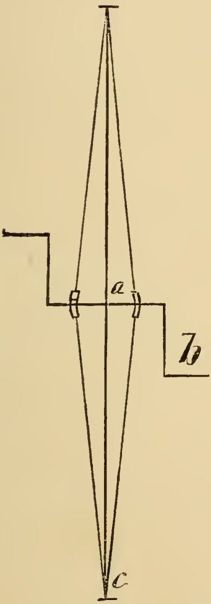
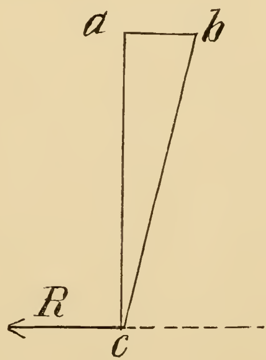


FIG. 2.



Side-slip diagrams.

b will create a horizontal side-slip pressure, R at c, in the direction of the arrow, such that $R = W\frac{ab}{ac}$. If, then, $W = 150$ pounds and $a\,b$ and $a\,c = 6$ and 25 inches respectively, we have $R = 150 \times \frac{6}{25} = 36$ pounds. Supposing the theory to be correct, the above may be said to represent the side-slip resultant in the fifty-inch Ordinary. In the Kangaroo the cranks, being below the centre of the wheel, average about twelve inches from the ground when power is applied. The pedals are about a foot apart, so that $ab = 8$, $ac = 12$, and $W = 150$, whence R by the same formula equals one hundred pounds. The above, though perhaps slightly exaggerated in its application to some of the Kangaroo patterns, is substantially correct, showing the difference to be sixty pounds against it. According to this theory, then, the greater the tread and the less the distance of the pedals from the ground, the greater should be the side-slip.

Appertaining to this matter, I have used a machine with the same sizes of wheels as those found in the Kangaroo, but in which the power devices were very close together, and I have found it comparatively free from slip; and I am also informed by riders of the machine called the Facile, in which the pedals are closer together, that it is remarkably free from the same difficulty. But these facts cannot be taken as a proof of the theory under consideration, for the reason that the application of the formula $R = W\frac{ab}{ac}$ to the two machines just spoken of, at best, still gives, as a result, a large amount of side pressure, which in actual practice does not exist. What difference it may make in the Facile or other treadle machines that the point of application of power is in the rear of the driving axle, I cannot say, or what difference a lever motion would show as compared with the simple crank is also not apparent; in fact, there is very little of established data from which to draw a conclusion, and a good reason which would now deter any cautious man from offering much experience or any theory in the matter will be readily surmised after reading the following extracts from the *Cyclist* on the subject.

"SIDE-SLIPPING ON SAFETIES.

"One of the principal causes of the falling out of favor of the 'Kangaroo' type of Safety was the great proneness it had to side-slipping upon greasy roads, and it was confidently and freely asserted when the rear-driver was introduced that this defect was, in its construction, overcome. That this is not the case every one who has had any extensive experience with this class of machine will admit; indeed, the side-slipping of the Safety is its one great fault. As our readers know, the forks of a Safety of this type are considerably sloped,—some more so than others. It matters not whether the forks are straight or curved, so far as the point we are dealing with now is concerned. The sloping of the fork places the wheel, unless travelling in an absolutely straight line, more or less on its side. The result is manifest. There is a strong force behind pushing it forward. So long as the ground gives enough frictional resistance to the wheel, well and good; but so soon as the surface is lubricated, as it is, by the slippery mud, then the tendency is at once to push the machine over. This tendency is increased, as with the side-slipping upon other forms of machines, by a sloping road surface, the side of a rut, or the cant of the machine in turning a corner; and, moreover, the harder the rider pushes the more chance there is of the machine slipping. Having, then, pointed out the cause of side-slipping, it remains for those who devote their time and talents to invention to overcome it. So far as we can see, a vertical steering-fork should do that which is needed."*

"[1113].—Your leader in last week's issue *re* the side-slipping of rear-driving Safety bicycles is, in my opinion, somewhat calculated to mislead. I cannot for one moment think you are right in stating that the cause of side-slipping in this class of machine is the sloping fork of the steering-wheel. You conclude with the following remark: 'So far as we can see, a vertical steering-fork should do that which is needed.' Here again I must say I emphatically disagree with you. *Had you tried one of the old* '*B.S.A.*' Safeties, you would not say this. These machines were far worse than any sloping-forked machine. *I gave one an extensive trial*, and found that the side-slipping was one of its worst features. Further, you have only to take one of the old 'Humber' Safeties, for example, with the perpendicular fork. Was side-slipping impossible on these?

"In my humble opinion, sir, you have entirely overlooked the real cause of side-slipping on rear-driving Safeties, which is *the absence of sufficient weight on the driving-wheel.* My argument is still further proved by the fact that the 'Scout' Safety (two-chain rear-driver), on which machine the weight of the rider is

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* Mr. Sturmey should have broached this subject in its relation to castering.

thrown as near as possible over the centre of the axle, will not slip sideways on the most greasy surface; and again, the American 'Star,' I am told by experienced riders of this machine, possesses a like good quality. Here, again, the weight is almost entirely on the driver.

"The subject of side-slipping on the most popular machine of the day—viz., the rear-driving Safety—is so serious a one that I am sure you will see your way to open your columns to a discussion on the same. SYDNEY LEE."

["The position of the weight doubtless forms an important factor in the question of side-slipping, and the thanks of the community are due to Mr. Lee for his experiments in that direction. We are bound to say, however, that our experience, so far as the question as to which wheel slips first, and also as to the stability of the tandem Safety on greasy roads, and on the point of safety at high speed, is exactly the reverse of that found by Mr. Lee.—ED."]

"[1114].—I have read with great interest your article on side-slipping in Safeties, and, being a Safety rider myself, should be indeed thankful to see this very serious fault overcome. I am very much inclined to your opinion as to the cause,—viz., the canting over of the steering-wheel in turning,—which can only be obviated, as you suggest, by having a vertical steering-post.

"SIDE-SLIP."

"[1131].—The 'side-slip' of the Safety seems to be the argument of to-day, and probably it is the great and all-important question to winter riders, as well as the members of clubs, near large towns, who attend the Saturday runs, and have to endure the double dose from our friend the 'water-cart.' Undoubtedly, the argument of *The Cyclist* is correct. J. NICHOLSON."

"[1132].—I have been trying experiments on the greasy wood and asphalt roads these last few days, and I have come to the conclusion *that the nearer the rider can get* to a vertical position over the centre of the driving-wheel the less liability to side-slip.

"C. LENI."

The above quotations explain themselves, and many other such, "from experience" (*sic*), might be given. The *Cyclist* editor and Mr. Lee are justly considered to be authorities in such matters. It is beyond all question that all of these writers are strictly honest and speak the truth so far as they know it, but we may well ask, under these circumstances, what is any individual experience worth? Certainly nothing, until it becomes verified and definitely settled by the general verdict of all sides. For such reasons the writer is loath to offer his own observations on this subject as of much value. It is a peculiar fact, and one worthy of notice by all who desire to form an accurate opinion in the matter of cycling or of any other art, that the experience of an interested party is generally as one-sided as his desires. A machine will do an enormous amount in the mind of the user, if he wants it to; and this is not said in a spirit of criticism or deprecation, for the writer has found himself just as liable to the same error as others. In being interested, I do not mean that it is necessary to be financially interested; all a man has to do is to *take a side*, and he is deeply enough interested for all practical purposes: let him set up an opinion and ten to one his experience will bear him out, not in the way of villanous, premeditated misrepresentation, but results will honestly appear to justify him. It does not appear that we must contend with this vicious tendency to any greater extent in connection with the cycle than in any other art. Almost every rider is prone to consider himself an expert in our pet subject, and it very often happens that he is; yet he may not be an observer capable of defending himself against himself in the delusions of experience.

Having probably confused the reader's mind sufficiently by this time to go on with the subject, I may say that another fact why the reasoning and formula in regard to the side-slip are not correct is that the same rule applied to the Rover does not in any way justify the results we find by experience. The slipping of the Rover is much more than it should be, in the light of any conclusion based on our formula; in fact, I believe the entire theory is, and always has been, an unmitigated blunder. A well-known correspondent, Mr. Gerald Stoney, has thrown a little light on the subject by an article in the *Irish Cyclist*, which, though death to one theory, sets up another still of dubious tenability.

"SIDE-SLIPPING OF BICYCLES.

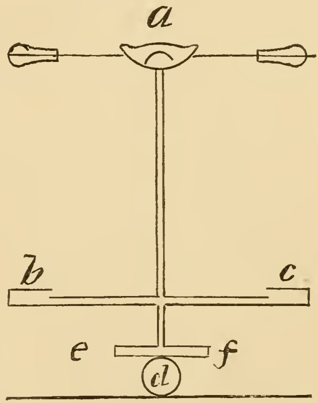
"Mr. Gerald Stoney, in last week's *Irish Cyclist*, adds the following to this interesting and important discussion. It will be noticed his deductions differ both from those of Mr. Lee and ourselves.

"'In a leader in *The Cyclist* of November 28, the reason that low machines of the Kangaroo type slip more than the high Ordinary is referred to the pressure of the foot being low down, pushing the bottom of the wheel to one side more than in a high machine when it is high up. We should wish to point out that no such effect can take place so long as the pressure of the foot does not cause the machine to wabble; since, so long as there is no change in the velocity or direction of motion of the machine, the position, direction, or amount of internal forces, such as the pressure of the foot, do not affect the position, direction, or amount of external forces, such as the pressure of the wheel on the ground. This is one of the first great elementary principles of mechanics. The reason why a small bicycle has, in general, more tendency to slip sideways than one in which the rider is seated high up is, that if the wheel slips off a stone or down the side of a rut, the distance sideways to which the wheel will slip is independent of the size of the wheel, and depends on the size of the stone or rut, the state of the road, the speed the machine is going at, etc. But the amount by which the machine is inclined to the vertical from a given side-slip will depend on how high the centre of gravity is, and, therefore, on how high the rider is seated, and accordingly it will be less the higher the saddle is. Now, it is a theorem in mechanics, which we will ask the reader to assume, that the greater this inclination the greater the tendency of the wheel to go on slipping, when it has hopped off the rut, stone, etc., and, therefore, the higher the saddle the less side-slipping there will be in *similar machines*.'"

I think the above sufficiently exposes the sophistry of the wide-tread theory, but lest some of the old adherents to the idea should not be willing to accept Mr. Stoney's mechanical reasoning, I have had made a device to test the matter in this way (see Fig. 3).

We have an upright frame provided with two cross pieces, *b c* and *e f*, a saddle at *a*, rests for the feet at *b* and *c*, and a roller, *d*, placed under *e f*. Sitting upon the saddle *a*, I was totally unable to move the roller *d* by any pressure upon either pedal *b* or *c*. The above I consider conclusive proof and the result unbiased by prejudice in trying the experiment, because I tested the matter before looking carefully into Mr. Stoney's article and becoming convinced that in this he is right. The laws applying to internal forces or forces within a system are very often disregarded, and especially are internal confounded with external forces, as in this case. In any machine where the rider throws his weight on and vertically over the pedal, the formula given for the side-slip does represent a force acting to swing the machine out of perpendicular and to cause it to "wabble," as Mr. Stoney calls it, but not to slip it on the surface of the roadway, as many would suppose. The rider rarely, however, throws his weight directly over the pedal sideways, as he does in raising upon it in a forward direction in order to get over the work. The lateral or wabbling strain in a cycle of the foot-pressure in one direction is balanced by the pull on the handle-bars and pressure of the leg against the saddle. The only feasible connection the formula theory can possibly have in this matter is that the thrust on the pedal is so sharp and violent that the inertia of the man and other heavy parts of the system are not perceptibly affected sideways; hence we might get an action against the slight weight in the lower part of the wheel. I cannot, however, detect any slipping action of this or any other kind in the roller experiment.

Fig. 3.



Roller experiment.

The futility of an effort to slip the machine sideways by a force upon the crank might be illustrated in this manner: Suppose the drive-wheel of an Ordinary is made rigidly fast to the front fork. Now, it would be impossible for the rider to slip the tire on the road-bed by pressure on the crank, as he can when the wheel is free to revolve in its bearings, no matter how long the crank may be; if the rider leans out over it, the machine could be rolled forward, but not slipped on the surface. Loosen the wheel so that it can revolve as usual, then it can be slipped, as every good rider well knows. Suppose now that the drive-wheel is rigidly fixed in the frame of the bicycle so far as any lateral motion is concerned, and the wheel cannot revolve within the system about any horizontal line at right angles to the axle of the wheel, as it would have to do in order to make it slip in the manner it would in the other case, then it is easy to see that the machine and rider might be rolled over sideways by throwing the weight on one crank; but it cannot be slipped: the only slipping that can occur is when the machine is allowed to get out of perpendicular, but the angle at which it would begin to slip would be the same regardless of width of tread. If the wide tread does affect the slipping, it is the result of other forces than those generally supposed.

I do not believe that the extra weight on the drive-wheel will relieve the trouble. I have a Rover pattern machine in which the weight is almost entirely in the rear, and I can conscientiously aver that it is the worst slipper I was ever on. Now, this is in spite of the fact that there was every reason to believe, and to desire, that it should not slip at all.

One of the *Cyclist* correspondents mentions the American Star, and justly says that it does not slip; yet that fact could be explained by our formula, since it is a tall machine with narrow tread. I cannot see, after all, that any theory of wide or narrow tread could be applied to the Rover type, even if it were found to be valid in other cases, because there seems to be complaint, and I have found it so in practice, that the machine will slip more than the old Ordinary, even when not pushing on the cranks at all. It seems to slip worse than any other in making a curve or in descending hills and upon cobble-stones, whether there is any pressure on the crank or not. This will apply against the *Cyclist* idea that the slanting fork breeds the mischief, since, if it slips in running a straight line, the slant of the fork could not possibly have anything to do with it.

In answer to the idea advanced that the fault is due to the mere size of the wheel,—that a large one has more surface exposed to contact, etc., and will hold better,—the writer has noticed very little difference in his thirty-eight-inch narrow-tread front-driving pattern as compared with a fifty-two-inch Ordinary; if there is any difference caused by the size of the wheel, this fourteen inches ought to have shown itself more than it did.

If the small wheel in a bicycle is a cause for slipping, we could naturally ask why it does not show itself more in the rear wheel of the Ordinary. It may be said, in answer to this, that there is but little weight on it, and that, not being a driver, whatever capers it might choose to cut are ignored by its regal, imperturbable leader; hence, if the rear wheel slips, it is immediately drawn up in line again. Another plea is that the lack of weight on the front wheel of the Safety makes it slip, and then it carries the rear wheel with it. To the last I can simply reply, as I would to the *Cyclist's* notion of the slanting fork, that it is the rear wheel which slips first, last, and all the time, or else a large majority of riders are very much misled, and really can't tell what is going on under them. Certainly we must say that if appearances and sensations of the riders are worth anything, the doctrine of the front wheel slipping first must go to the wall and carry several ingenious solutions with it. Still another bright speculation is, that the unusual bumping of the front wheel holds it back, and the rear pushing on, for the nonce, cannot go forward, hence it must go sideways.

If we admit that the American Star does not slip, then the theories of small weight on the front wheel, the slanting fork, and front bumper must all go for naught. There are some other qualifications, however, which would modify or exclude the Star as a reference. The fork is slanting to a greater extent than in any other machine, but the small front steerer is swung from a point directly above the centre, which, it is said, gives the wheel a better chance to caster. To our ingenious front-bumper friend, I would also suggest the trial of a first-class anti-vibrator to the fork, which will let it spring back a good way.

And again, it has been stated, in regard to the Rover slip, that the large rear wheel swings from side to side, or wabbles, humorously likened by some to the wagging of a duck's tail. This feeling of disturbance in the rear part of the machine is felt in the Ordinary when supplied with the large rear wheel advocated by some, and it may have something to do with the slip, though it is hardly possible that it would in the well-built, steady machines of the present time.

As to the high-up saddle or centre of gravity, true, an inch side-slip at the ground, of a machine with a low-down centre of gravity, will cause it to assume a greater slant or angle from the vertical than a higher; hence our friend could well say that when the Safety starts to slip it will be more certain to go on down. It is to be noted, however, as against this idea, that other machines with low-down saddles do not slip.

Taking all the theories and experiences, *pro* and *con*, into consideration, I am inclined to believe that no one cause can account for the entire difficulty; it is probably a combination of smaller elements partly belonging to several of the theories advanced. The elements which have been most strongly urged are, first, the driver being small; second, the driver being in the rear; third, the weight being in the rear; fourth, the work being done between the wheels. All these seem to work to the same end. Again, any drive-wheel will slip worse than a non-driver, since a sliding force in any direction will tend to loosen the hold of the rubber tire from the surface of the road more than any rolling action. A short slide from a stone is felt more when the weight is upon the wheel, and the drop in rolling off so distinctly felt in connection with the small wheel is much sharper than a similar action of a large one. A rider can certainly manage himself better and more surely when he drives, steers, and leads with the same wheel and has his weight upon it. This is what he *does* on the Ordinary and just what he *does not* do on the rear-driver.

The deepest and most profound explanation of all side-slip was recently proposed to the writer by a mathematician of great ability; but it is so complex that he has not worked it out himself yet, though expecting daily to hand in the solution. He says it is all from the relation of the points, first, of the centre of gravity, second, of the centre of oscillation, and third, of the transmission of power, to each other. Just where and how they ought to be is, as yet, not fully determined.

To remedy the evil of the side-slip in the most obvious ways would be to make the rear-driving Safety no longer the same machine; it would ruin, to a great extent, the very qualities for which it is prized, and therefore, if any such theories as before enumerated should prove tenable, the only clear way out of the difficulty would be in the use of non-slipping tires, if such can be produced.

In regard to the angle at which any machine will slip in rounding a corner, some, who have advanced the idea that the Safety slipped because it had to lean more, do not appear to be aware of, or take into account, the fact that the angle at which the cycle, or any other machine, must lean under such circumstances is entirely independent of the height of the centre of gravity. The angle is a function of the speed and radius of curvature only.

CHAPTER XVI.

THE LADIES' BICYCLE.

PROBABLY the most daring innovation the ladies have made in the domain of sports and pastime within the past decade consists in their riding the bicycle. There is no earthly reason why they should not ride a bicycle if they wish to; that is to say, those bicycles of the modern type especially made for them. At least no objection can be urged that would not equally apply to tandem and single tricycles.

Notwithstanding the above fact, there is and has been a reluctance on the part of the ladies to take up the two-wheeler, and probably a greater reluctance on the part of the community at large to countenance the step. It is needless to discuss the propriety of ladies riding tricycles; the question has been settled by themselves by simply riding; and there is the end of it,—they came, saw, rode, and conquered.

Granted that a woman may ride a tricycle with propriety, it would seem a shame to deny her the right to the less cumbersome and much neater mount. The ladies' bicycle certainly is the more modest appearing, if we were used to both, and it takes much less work to run it; if it does not thrive, it will mean simply that the entire system of ladies' cycle riding must go. Common prejudice cannot long sustain such a senseless discrimination as to keep her on the "trike." Tandems, of course, have an advantage in that the spectators can imagine that the man is doing all the work, which is generally about as true as that he does all the work when the family cook-stove is to be moved. No better illustration of the change of public opinion in the matter of ladies' cycle riding can be had, than in the little story told of Mr. James K. Starley, relating an event which is said to have occurred some years back on the streets of Coventry.

This indefatigable genius of modern cycle art was pumping one of his early tricycles about the nooks and corners of Smithford, Hereford, Jordan Well, Little and Much Park, in the ancient city, amid the jeers and contemptuous sneers of the lusty silk weavers and cynical watchmakers; whereupon, being goaded to desperation by their taunts, he rose and exclaimed, "Why, the time will come when *ladies* will ride these things through your streets." And ladies have long since ridden them through the streets of Coventry, as well as through the streets of many other towns, without compromising themselves or exciting undue comment, while the noble city of its birth has become the centre of modern cycledom.

Social forms stick, often in spite of reason, and it may be a long time before it will be generally conceded that woman is in her legitimate sphere when perched upon the saddle of either a tricycle or bicycle, and if the lack of physical development continues to be one of the chief angelic characteristics of womankind in the mind of man, the time will be very remote indeed. But should it be discovered that less seraphic and more muscular tissue tends to make us all happier, then perhaps the time and doctors' bills will be shorter.

It is scarcely necessary to explain the construction of the bicycle intended for ladies' use; suffice it to say, that a modern Rover Safety is used in which the backbone drops down to a level with the cranks, and the rider can step between the wheels and rise into the saddle by the pedal mount; not a difficult task, to judge from the grace and ease with which women accomplish the feat every day. It is not within the province of this book to pass encomiums upon any tribe, class, or individual, nor to compliment any sex, but it would be heinous selfishness not to give the ladies some credit when it is so justly their due, as in this matter of the "bike." When, on the streets of Washington, I see apparently timid girls make the pedal mount and move off so naturally and adroitly, the feeling of comparative superior physical dexterity, generally accredited to our sex, suffers a tremendous blow within me. In meeting these fair riders at their homes it is quite evident that they still retain the old-time graces and accomplishments common to the sex which men delight to honor. All this proves once for all and conclusively that some of the ideas entertained by mankind about womankind approach very nearly to the sphere of unmitigated humbug. Below will be found an energetic opinion of one of the ladies, as chronicled in the *Bicycling World*.

"WOMEN, BICYCLES, AND DOCTORS.

"Being a member of the L. A. W., I naturally see the *World*, and I have beside me a copy of your paper, in which I notice an article on 'Why a woman should ride.' I agree with the writer in that the ladies should ride, and from my own experience I have found it improves my 'health and complexion' very much. I have only been riding since last June, but I am stronger now, and enjoy living much better than I ever did before that time. The pains and the doctors have both gone, where, I don't know and care less, so long as they *have* gone and so long as I still have my bicycle and can take my ride every day. It seems to give me life, and I feel the life-giving exhilaration born of this splendid exercise after I take a five-mile run around the city, or, perchance, the country. It is such sport to leave far behind fast-trotting horses, and men and women who are obliged to take the street-car every place they go. And what could be more amusing than to see some or all in a car rush to that side to see a 'lady riding a bicycle.' I sometimes get just a trifle angry when I hear some old feminine fuss and feathers say, 'Oh, isn't that *disgraceful* to see a *woman* riding a *man's* bicycle!' They, I suppose, never read the papers, as they would scarcely ever have time after working, worrying, and scolding their husbands (if they are lucky enough to have one). If they could just for an hour have the pleasure of riding as I do, I think the cross, fretful, and worrying fits would be few and far between. I could not do without my bicycle now. Sometimes when I have been out I come home laughing, and as I trot my five-year-old baby on my knee, she sometimes says, 'What's happened that's so funny? tell me.' And as I take her little hands and we fly around the room together, I feel that no woman on earth is as happy as I. Even after riding ten miles I do not feel tired, but come home feeling better than when I started. My husband is very much pleased that I ride, and here I will mention that the advantage in having a lady's Safety is that either can ride. I actually think sometimes that my bicycle is keeping me too young in actions, and that I am not growing old gracefully as I ought to.

"Now I don't want any one to infer from this that I am one of those strong-minded women that want to vote, and keep the men in petticoats. Oh, no, indeed! I am very well satisfied to let the men run this government as it is, or as it will be after March next.

"GRACE E. S."

CHAPTER XVII.

TANDEMS AND THE RATIONAL.

The Tandem is a cycle in which two riders are mounted, one in front of the other, upon the same machine. We have the tandem tricycle, which is a two- or three-track machine on the tricycle principle, and the tandem bicycle, or single-track machine with two wheels.

Of the tandem tricycle I shall have little to say, as my experience does not justify the attempt; also of the single tricycle I cannot give much of an account. This book does not pretend to treat of man-motor carriages so generally as to include all of the two- or three-track devices, nor of the three- or four-in-hand. Latterly remarkable records have been made on a "triplet," and we hope this machine is all that is claimed for it. But there is too great a step from a single-track machine to the double or triple to treat of them all, so for the present I shall confine myself principally to that class in which the rider is maintained in an upright position by means of steering.

The only single-track tandem which now bids fair to attain any conspicuous position is that built upon the Rover Safety principle, where two low wheels support two saddles and the rear wheel is made the driver by means of a series of sprocket-chains and cranks. No lever-motion machine, for two, of any pattern, has as yet made an appearance in the market. It is quite probable that the rear-driving tandem will acquire an enviable place in the sphere of cycling, and it certainly deserves to be enthusiastically welcomed among us. Very few cyclers care to take a spin all alone, and it takes two riders at least to make company: why not then mount them sociably upon one vehicle? Surely the tandem method must steadily gain favor, and when it is finally and securely launched in our midst, we shall derive much pleasure from its use, and for touring it must become invaluable. No doubt a very little increase of weight of parts and cost can and will finally serve two happy cyclists. When this is accomplished it will take but little palaver to sell to touring parties at once, since one machine, even if of double weight, can be handled, in many cases, by two men much more easily than each can handle a light one alone. The Tandem takes up less space in a railroad car than two separate machines, and any store-room can be made to accommodate an increased number of saddles. The machines will mostly be made for each to accommodate both a lady and gentleman or two gentlemen, as may be preferred, and on this account they will, at some not far distant time, partially supplant single mounts. Some will also be made convertible; that is, capable of being divided into two single cycles. It is hardly probable that machines for more than two will ever become general, at least not for social riding; no better reason can be given than the old saw, "two's company and three's a crowd." We do not, however, venture to prophesy positively about multiple riding (that is, more than double), since it has a start now, and there is no telling where it will end.

In experimenting on tandem bicycles, I have found one difficulty which, so far, has been very serious; it is the tendency of switching between the riders; that is to say, the twist of the machine. It is difficult to make a frame strong enough to prevent this, since the rear end has to be kept perpendicular by means of a direct twist on a long backbone. Both riders cannot be uprighted as the same weight can be when it is all centred in one spot. It is the distribution of the weight more than the amount of it that causes the trouble. It is well known that a man of two hundred and fifty pounds avoirdupois can ride without much trouble, but two men of one hundred and twenty-five pounds each, sitting two feet apart, will strain a single-track machine tremendously; this annoyance will not be finally escaped by means of mere strength of parts. Some novel arrangement of the wheels, saddles, or other mechanism will have to be called into play to modify the unsightly length of the present tandem bicycles, though it is not right to disparage them on account of it. Much objection has been raised to the "shape of the thing," but since the advent of the Safety bicycles, appearance must take a second place to that which it held when we sat perched upon the noble old Ordinaries. If we must slip along the ground like beetles, let us not be too fastidious as to just how we look.

Let the Tandem come on; and be received with open arms. Those of us who are a little weak want to make a combination with some flyers, to make up our deficiencies in scorching runs. If we can get on the rear seat and eat doughnuts part of the time, so much the better.

THE RATIONAL ORDINARY.

As the above term seems to be indigenous to England, and emanates indirectly from the fertile brain of the distinguished editor of the *Cyclist*, I append below a quotation from that journal by way of introduction to this subject.

"THE FUTURE OF THE ORDINARY.

"'The Ordinary is doomed,' we very frequently hear people say, but we are not of that opinion. True, it has 'had its nose put out of joint' by the Safety lately, but this only shows us the correctness of the opinions we have always held, and proves to us that, if the makers will only look after the safety and comfort of Ordinary riders a little more, the old love for the high wheel will return, and good business will result. In the introduction to the 'Indispensable Bicyclists' Hand-Book' this year we say; 'The Ordinary bicycle, for the young and active, is the most delightful form of cycle to possess, and the youth of England

and other active nations will ever select it in preference to its perhaps safer, yet more cumbrous rival. To retain its hold as a touring machine, however, I feel certain that more attention must be paid to the comfort and comparative safety of the rider, and I hope to see in the near future a gradual inclination towards larger back wheels, more rake, longer cranks, and the addition of foot-rests, when the ordinary and original machine will, with common care, be equal in safety to any form of cycle extant.' . . .

"This being so, we ask makers, in their own interests and in the interests of the Ordinary as a type, to deal with the matter and give attention to the points enumerated above. We are sure it would pay any maker, who has the proper facilities for doing so, to place a machine built as described vigorously on the market, and we hope next season to see it done, when we feel assured the rationally-built Ordinary will gradually work its way back into the public estimation."

In spite of the laudatory notices of subsequent writers in the *Cyclist*, I am not disposed to treat this subject seriously. If not already consigned to oblivion, no doubt the ideas advanced in the foregoing quotation will be by the time this book reaches the reader; something must be said about it, however, since the importance of the question is now quite generally felt. To long cranks little objection can be made, but as to increased rake and large rear wheels, this is a thrust at the heart of all we have to admire in the Ordinary. We are willing to take the old mount with all its dangers, for the sake of its neat appearance and ease of running, but when we get back nearly off the large wheel; when we reach out to the end of a longer crank; when we get over and drag along after us a great ungainly rear wheel to wag about over the road; and lastly, when we strike at the life of easy steering, pray what have we left? Why not go back to the old bone-shaker, curl up like a sleeping chimpanzee and kick up in the air as we used to do, and be done with it? No! If we propose to stick to the old high perch, let us be men and take it as it has been perfected, neat and comfortable, with the rider upon the front wheel and within a reasonable distance of the point over his work. If not that, then let us gracefully accept our place down among the dogs, and take the Safety, depending upon having so little else to attend to that we can kick off the festive canines and take up the time we would otherwise spend in patching up our skin with sticking plaster, in wiping off the accumulated dust from our machines.

No man can edit a journal without making mistakes, and I shall probably find that books cannot be written without incurring the same liability, but for all this we cannot excuse the *Rational.* The more generally correct an editor is the more keenly we feel his freaks; so let this be my defence in noticing this little idiosyncratic perturbation of Mr. Sturmey's otherwise infallible intellect.

CHAPTER XVIII.

WORKMANSHIP IN CYCLES—ENGLISH AND AMERICAN MAKERS.

Unfortunately, it is next to impossible to practically test the durability and general excellence of a wheel before purchasing. The buyer therefore has to depend upon his skill in judging of workmanship. It is impossible to give many set rules that would be of much assistance to a prospective buyer, but of one thing he can be reasonably certain,—if he finds a single poorly made or undeniably botched part, it is a valid cause for a rigid examination into all others. A first-class manufacturer is not liable to botch a single part, but if you find that he has done so, it is well to be very cautious in patronizing him. It is generally a safe plan to examine a machine that has been in use in order to judge of the durability of a maker's work, though durability will generally accompany good workmanship and finish when new. A cheap quality of nickel-plating often gives the appearance of a good job, but it will peel and rust; and to prevent this good platers put on a coat of copper under the nickel as a base upon which to plate. It is difficult to determine in a new machine the amount of the nickel deposit, or whether it is upon a copper base; hence it will be seen that the maker's work in the past is the only standard from which such matters can be judged. With enamel and paint it is much more easy to determine the quality, though a glossy surface is not necessarily a true gauge of good work. It is the finish of the under surfaces that takes the labor. A good job of painting is to my mind superior to enamel or japan, but it is attended with considerable labor. In olden times, when paint was more common, a maker could be identified by the finish and striping of his machines; there was such a difference in the quality of the work. Now, however, since the dead-black japan rules the day, it is more difficult to judge between makers by the outward finish of their wares. There cannot be much difference in the amount of labor put upon the work by the various manufacturers, for the reason that a certain process has to be gone through before it can be done at all. *À propos* of striping, it may be considered gaudy, but an artistic job sets off a machine as compared with a plain black now in vogue.

The quality of rubber in the tire of a bicycle affords a splendid field for an expert; only those who have to use rubber in other connections realize the great differences in its quality. Rubber can be made absolutely useless by adulteration; and when we see how easily some tires cut, we cannot doubt that makers often sacrifice quality for the sake of price. Buyers should notice carefully the old tires of different makers, and see how they have stood the test.

In the matter of quality of tubing of which machines are made there is little difficulty at present, as nearly all of the firms buy from one or the other of two great English factories, but when the industry of weldless tube-making becomes more disseminated, and small concerns with inadequate facilities enter the field, we can expect more trouble. About the brazing of the tubes it is utterly impossible to tell anything except from the way it stands.

The screws and nuts about a machine should be provided with sharp, deep threads, and work easily though not loosely. A maker can almost always be judged by the kind of screws he cuts. The nuts and screw-heads should be case-hardened and be neat and square on the corners, and not rounded by the nickel polisher. In all cases where it is practicable some device for preventing the nuts from coming loose, or being entirely lost, is a great boon; this point will have to be looked after now since complicated machines are becoming more popular. The device generally used on the outer end of pedals should become more common, especially on tricycles, tandems, and chain Safeties, where there are so many parts. A good practical jam-nut has never yet been invented, and the cycle-builders are therefore not to blame for not having provided some means against loose nuts generally.

In the matter of saddle and other springs, we are somewhat at a loss for a guide; there is not so much carelessness in quality of the steel used as in the tempering, and in this the buyer has again to rely on reputation and observance of other machines of the same make. The quality of leather often used in saddles is simply an insult to the judgment of the fraternity, and if we will go on in blindly taking any and everything that is offered, the imposition will continue. If buyers scrutinize closely, the makers will be proportionately careful, thus making it harder for unscrupulous tradesmen to foist poor work upon the market, an evil which has existed and will increase as the industry advances.

ABOUT ENGLISH AND AMERICAN MAKERS.

One of the most frequent questions asked by the would-be purchaser of either a two- or three-wheeler is, "What make shall I buy?" And before he settles down to a matter of comparison between individual firms he must first settle whether he will buy an English or American mount. This difficulty is, however, of less importance than he is apt to imagine, because, beyond all question, there are wheels good enough for any one made in either country. The chief trouble will lie in choosing between the different makers, especially if he conclude to try an English wheel. This, as regards the English builders, arises from no general lack of capability among them, but it is simply due to the fact that the industry is so much more widely disseminated there than here. That is to say, there are so many more factories already established and new ones starting there, that, as a natural consequence, some incompetent people, with inadequate plant and machinery, will be certain to creep into the field. This is a temporary condition of affairs as between the two countries, for it will not be long until the same conditions will apply here in America. Now, the reader might infer that we condemn new and small makers, but by no means is this so. There are many small shops that turn out the best of work, some of them do not make the entire machine, but purchase many parts from manufacturers of specialties; but, as a general rule, it is a little safer to buy of a larger concern, that makes, as nearly as possible, the entire machine. This will apply in any line of business, especially if the buyer is not an expert in judging of the goods. On the other hand, there is this fact to contend against with the larger manufacturers,—when they make a mistake at all it is almost sure to be one comparable to the size of their business. In the small shops an error will be discovered more quickly, and, as a rule, will be rectified before many machines go on the market.

In America the larger concerns are so vastly predominant over the small that the buyer has only to decide between articles of established reputation; the American factories do not seem to have ever been small. In a large majority of cases there are certain peculiarities about the machines which not only settle the matter *nationally*, but as to individual makers. Some little point at once takes the eye or the heart of the buyer, and that settles it all; and perhaps it is best it should be so. Nationally considered, the English have had much larger and more varied experience in the cycle industry than we have had; they have more experts in the line and are nearer to the fountain head of supplies, particularly in regard to tubing, and no matter how soon we on this side may have tube-works, it will be some time before we can depend upon them. The English have taken advantage of their good fortune, and, together with the natural precedence in this art which we all agree has been allotted to them, they have gone ahead without the erroneous veneration generally felt in favor of their grandfather's method, which has blinded them so often in their advancement in other arts. It was a marvellous sight to the writer to see a bicycle firm, flush with the times in all their work, in a factory almost nestling against other places devoted to making fusee watches with "Granddaddy winding-apparatuses," making watch-cases by gradually punching them into a conical cast-iron cavity, cutting alleged screw bezels with a chaser in a lathe pulled back by a hickory spring, and such eocenic appliances.

In Coventry there stood, wet and rusting in an old botanical conservatory, one of the finest of American watch-case tools, which some ambitious English watchmaker, in a fit of sanity, had taken over; but his men could not, or probably would not, use it. Yet a great cycle firm had just bought, and was using, one of the very finest Brown & Sharp lathes, merely, I suppose, to make sure that no Yankee should get the better of them in tools. This is not an admission on their part that all English tools are immature affairs; they need not admit anything of the kind, for among the number of tons of cast iron in a twelve-inch screw lathe which you see in every cycle shop, a small part of one ton, at least, is fixed to do some work, and accurate work at that. It was a fortunate thing for our mother country in the cycle business that it was clogged by no fettering precedents or mediæval rules of mechanics. The English cycle-makers are abreast of the times in their line, and there is no better illustration of the total absence of all effect of surroundings upon this great industry than the fact that the lightest cycles in the world are made with such ponderous tools. It must have been a great feat, in view of their proclivities for substantial machinery, to shave off the last superfluous ounce in a bicycle. In short, it has been impressed very forcibly on the writer's mind that the famous Yankee ingenuity is simply unchained English genius. In our heated discussions as to whether the American manufacturer, with a higher rate of wages, could hold his own against the English without a discriminating tariff duty, there may be two sides in regard to watch-making and some other industries, but when applied to cycles it is nonsense to suppose that we could compete.

As to American machines, that which would strike us as remarkable in the English would be, to a large extent, natural to our institutions; that all machine parts should be accurately made and be interchangeable would be taken for granted when coming from one of our factories, but it is a little odd to find it approached by others. The absolute regularity and similarity with which work is turned out by us is sometimes an objection; if a part is too hard or brittle, or in any way bad in its construction and form, a part for the same purpose, from the same factory, will be sure to be just like the one you want to replace; in fact, if you have one bad part, depend upon it there have been thousands made just like it, and you will be pretty certain to get one of them. It is generally conceded that the American maker is more careful to test his new plans before placing the product upon the market; anyhow, since the customer in this country is able to get to head-quarters more easily with his complaint, he generally favors buying at home, though it is often a very close contest in his mind just what to do.

However a cyclist may feel in regard to this question of English or American machines, it would be best in the long run to settle the question entirely upon the merits and quality of the work. It is a bad plan to implicitly take the word of a salesman regardless of one's own judgment. The variety of machines has become so great that it is more than likely the customer will generally have to buy from the maker who has adopted the special style of machine the buyer is determined to have. But let this not deter him from insisting on a high grade of workmanship and excellence of material.

CHAPTER XIX.

CRANKS AND LEVERS AND TANGENT SPOKES.

THE subject of cranks and levers has been touched upon from a philosophical stand-point, but an ingenious squib in a maker's catalogue on the subject has suggested the propriety of treating its mechanical features more fully. The squib referred to runs as follows:

"CRANKS VS. LEVERS.

"The question of a motive power for cycles is as old as the first idea of wheel riding. Inventors, after having persistently tried and abandoned every other known motor,—steam, electricity, etc.,—have made every effort to discover the best way of applying leg-power.

"While nine-tenths of the cycles have always been driven by cranks, in a few cases the attempt has been made to show that power could absolutely be created by the use of levers, and that if the power could be applied on one side only of the axle, avoiding the return stroke of a crank, the result would equal a man's lifting himself over a fence by his boot-straps.

"In their eager pursuit of this one idea its advocates have lost sight of the fact that the question is of the economical use of the power we have, and that it is as impossible to *create* a power as to overcome the laws of gravitation. For hundreds of years the machinery of the world, practically speaking, has been driven by cranks. In this fact we have the testimony of the highest mechanical genius the world has known.

"Engineers agree that the crank is the only economical method of applying power—that it transmits to the driving shaft ninety-nine per cent. of the power applied. In no class of machinery except cycles is the attempt made to use levers where cranks could be used.

"Careful experiments have shown that the use of a lever is misleading, in that, while power can be converted into speed and speed into power, the development of either is at the expense of the other. It is at once evident that with levers we have more friction, more weight, and more complication than with cranks, and that absolutely more power is required, as the springs which are used to return the levers must be forced down at the expenditure of power which should be applied to the propulsion of the machine. Several years ago lever-power was tried in England on bicycles and tricycles and extensively introduced, but has been so generally abandoned that there is to-day no machine of importance so driven. The worst feature of the lever action, however, is that the movement of the foot does not become automatic, as is the case in the use of the crank. There is absence of regularity, and a consequent loss of momentum. A rotary motion is more natural to the feet, being more like walking, while a lever motion is like treading water while swimming, or like constantly climbing up stairs. Not only does the mechanical use of the legs require a regular movement, but it is better to use always the same length of crank, never varying the throw.

"A special set of muscles can be trained to such work as the use of the lever action; but such development is abnormal and at the expense of other parts of the body."

There is little doubt in the minds of reasonable people that a good machine can be made either with cranks or levers; and this possibility makes it an interesting point in cycle discussion. It is hardly fair, however, to hold a maker responsible for matter written for the purpose of advertising his wares, nor do I wish to do so. The article above quoted puts, in unique form, the opinions of a large class of observers, and for that reason it is given here. I take up the lever side of the question simply because there is more to talk about on that side, and also perhaps for the reason that I have had large experience at considerable cost in experimenting on different forms of levers.

Some of the remarks about "creating power" are true, but might be applied equally well to some of our crank theorists.

To say that the machinery of the world is driven by cranks, is hardly tenable; even though the engine generally has a crank. But now, since we must reduce our comparisons down to the human motor, in combination with the crank of a bicycle, let us say the pitman rod represents the man's leg. This rod has to push and pull, which a man cannot do with one leg; but for this you say he has two legs; admitting, then, that two legs represent the pitman, we are still out a fly-wheel and an evenly-running resistance. (See chapter on "Connecting Link.")

A great deal of the power of machinery is transmitted through pulleys and belts; now I take it that this is much more similar to some of the drum and lever machines than to a simple crank. There is, however, a form of lever and crank combined, of which I have spoken elsewhere, that is really worse than any simple form of either, but we have just as much right to say the crank ought to make it good as to say the lever makes it bad; if the crank is such a great cure for all evils, as the maker quoted seems to imply, it ought not be so bad in any combination.

There is no loss of power in pushing down a spring if it is only just strong enough to lift the leg, since the leg would otherwise have to be lifted by the expenditure of muscular energy. In using a spring we press down with a little more weight than is required to run the machine, so that a storage of power is the result which is given out in lifting the leg. In fact this is done to some extent in the crank machines; the rider not only puts enough power on each crank to turn the wheel, but also enough to lift the other leg; this is true at least when the rider is quite tired. Examples are known wherein a racer on long distances could no longer lift his legs, even with the aid of a spring, though at the same time, he still had strength enough left to propel the machine. In fine, this difference between the crank and spring lever is that in the former, a little extra power is exerted to lift the *other* leg, while, in the latter, energy is stored to be used in raising the *same* leg.

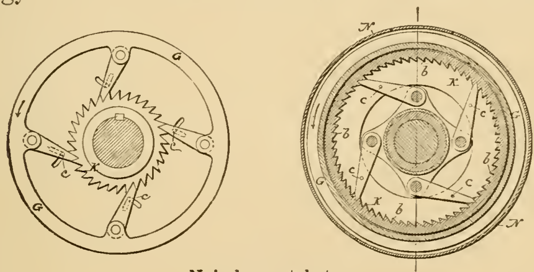
In a perfectly fresh man I have found, by the registers of the cyclograph, that the rider lifts all weight from a returning crank, but this does not happen when he becomes tired. Evidently, if the spring is strong enough to more than lift the leg, a loss of power will result, since the rider would have to hold it in check even in coming up in order to keep it from stopping with a bang, as is sometimes noticed when he jumps from a treadle machine. The winding and unwinding of the spring involves no loss of power except in heat incident to motion and imperfect elasticity, which is quite small. This loss from heat within the molecular structure, I am constrained to think, is not what is popularly meant by loss of power in springs.

Coming back to our quotation, true, in England levers have been tried and expunged. A prominent American, I believe, assisted some little in enlightening our too susceptible English brethren on the subject, yet some attempts have been made with them in this country which no fair person can call unsuccessful.

A little printer's ink will answer the last sentence of our quotation. Simply change the words "lever-action," and substitute "cranks," and you will have the following: "A special set of muscles can be trained to such work as the use of cranks, but such development is abnormal and at the expense of other parts of the body." So the reader can see how a little slip in the type would have changed the whole argument. This discussion could be continued with great interest to both sides if we could only find in some maker's catalogue of lever machines an attempt to "down" the crank machine on general principles. As it is, it must close for lack of antagonism in so far as broad principle goes.

As to the construction of crank machines, the subject is so familiar to every one, and the device is so simple, that it is impossible to write much of an essay on it. With regard to levers, however, the subject is inexhaustible. The most salient features claimed for the clutch machines now in the market are, first, non-dead centre,—that is, even, continuous power; second, entire rest of the legs when power is not required. The objections are chiefly, first, insecurity and entire dependence on the brake found in the absence of all back pedalling; second, non-support of the legs, springs being insufficient to sustain their weight. To the above objections appertaining to the lever and clutch machine, a third may be added,—viz., the complexity of parts, liability to breakage, and danger of accidents therefrom. At one time the advantage of safety was found in the clutch machine almost exclusively, but at the present time we have complete safety elements in certain forms of crank-wheels.

Much difficulty has been experienced by makers of lever cycles in finding a suitable clutching device, a difficulty with which most of the experience the writer has had is concerned. In conducting experiments in this line I have found that the rattle of the old ratchet was annoying, and it was quite a problem in my mind why makers used them; but any one who undertakes to make a bicycle clutch will soon discover the reason, though at what cost "deponent sayeth not." A neophyte in the bicycle experimenting ranks might justly suppose that the matter of clutches is a well-developed art in mechanics; to a certain extent it is, but not in the direction he will need. Clutches may be divided into three classes,—first, the common ratchet and pawl, either spring or gravity; second, the ratchet and friction pawl; third, surface-friction clutches proper. The first two grip on corrugated surfaces, the last on a perfectly plain or smooth surface. The first class rattles according to the pressure on the pawl or the weight of the same, and also to the amount of drop. The second class rattles only under certain conditions; that is, when both ratchet and pawl are in motion in the same direction, one moving a little faster than the other. The third class is entirely noiseless. Let us pass over the first class, as being familiar to everybody. The second class is not so well known and has never been used in any of the arts in this country so far as I know, except as recently applied to bicycles. This clutch is very similar in appearance to a regular ratchet, the difference being that in the former the pawl is held out of contact by friction against some of the moving parts, and when the motion is reversed the friction in a certain direction throws the pawl into action. A good mechanic would have hardly conceded such an arrangement as practicable in any machine, much less in a bicycle, for the reason that when the motion is reversed the pawl plunges into the teeth with so much force that damage would be supposed to result. Several patents are registered in England upon the noiseless ratchet; they are all alike in general principle, but it is due to the energy of an American maker that it has been made a



Noiseless ratchets.

success in cycle construction, and I am inclined to think it is the first time such a ratchet has ever been used to any extent in any kind of machinery.

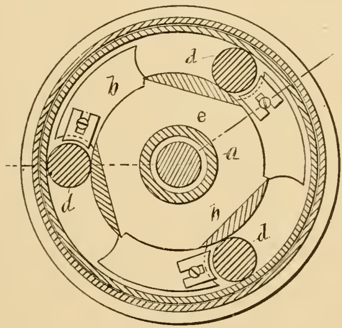
As to the third class of clutches, much of interest can be said for the benefit of those particularly concerned. "A friction clutch" to mechanics is a familiar term, since the name is applied to all pulley clutches, that grip on a smooth surface. Many of these clutches are a success for the purpose for which they are intended. The most common form used on machines where the requirements are similar to those of a cycle, is the "Roller." The cycle experimenter nearly always strikes upon this clutch first, and with sufficiently good reason. It has been adopted in many arts, and is used in England upon tricycles in combination with cranks, with moderate success, but just here allow me to call attention to a cardinal difference in the requirements of a clutch as used on crank tricycles and successfully in the arts heretofore. In the crank-clutch cycles the clutch is used for the purpose of detaching the cranks from the spindle when the machine requires no driving, as in running down grade, but when once the clutch is gripped, it remains so till further power ceases to be required. Now, this is also just the action of all belt-pulley clutches, and between such action and that required in a lever-clutch cycle the difference is exceedingly conspicuous. In the crank-clutch cycle, as in other uses, the immediate solid grip is a matter of little concern; if a half turn of the parts takes place before clutching, it does little harm, since it is so small a fraction of the entire number of revolutions to be made before the grip is released. But if a grip is to be taken at every down stroke of the foot, as in a lever-clutch cycle, the least slip or lost motion is fatal.

This incessant clutching action, together with the great weight the parts have to sustain, and the repeated concussion of one piece upon another under this weight, makes up a combination of disturbing elements which will cause mischief against which it is almost impossible to provide.

In a form of roller-clutch I have tried, the inner frame or carrier is made loose upon a spindle.

In the drawing herewith annexed we have first a spindle in the centre, then a little open space around it, and then the clutch frame *b b*, which is connected loosely, not rigidly, to the drum. By this arrangement the pressure is distributed evenly upon the three rollers *d*, *d*, *d*, outwardly at three points against the casing, and in no event is the work done by a single roller. This device worked as well as any of this class I have tried; but the patterns are for sale at a very reasonable price. The main trouble I found in this contrivance and all other roller clutches was, that the great pressure disintegrated the oil, making a paste that would cause the rollers to slip in spite of everything.

If it were not that another American, a cycle-maker, has apparently made a success of a roller-clutch, I should be tempted to warn all experimenters against it as a thing that "stingeth like a serpent and biteth like an adder."

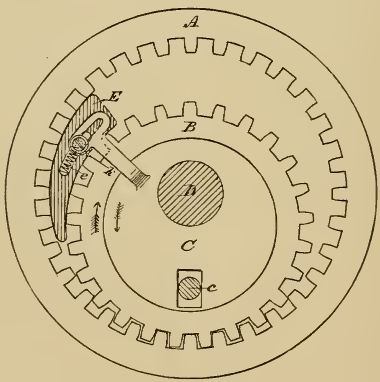


Loose centre roller-clutch.

Under a bench in a shop not far from the geographical centre of England may still be found about a bushel of friction-clutches of various and ingenious forms, which future historians in the art will find very interesting. Should any one wish to enter the arena as a searcher for the true friction-clutch, let him first examine these specimens, and he will start several years ahead. The nearest approach to a success which the writer has fallen upon is illustrated below for the purpose of helping those who may wish to carry on the search, or experiment in clutch-cycles,—if any should think it worth while in view of the alleged success of the American above referred to. The clutch illustrated below was contrived by a fellow-laborer in the field.

The drawing represents the device in a crude form; some improvements having been necessary to complete it.

B is a cog-wheel within another, *A*, the latter fast to the wheel-hub, and the former to the clutch-drum. A wedge, *E*, follows between the wheels, whence it will be seen that they can revolve, in relation to each other, in one direction only.



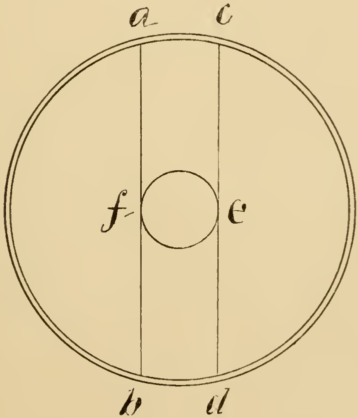
Scott wedge-clutch.

For those who wish to study this question more minutely, Kempe, on link motion, will be found a valuable work in connection with the construction of levers in any art, when it is desired to obtain a motion in a straight line from an oscillating or circular.

In the way of conclusion, reverting to the possibilities of direct application of these remarks to the actual purchase and use of cycles, I wish to say, in regard to the mechanical difficulties in this matter of lever and clutch machines, that so long as the use of oil is necessary, I have very grave doubts if a thoroughly satisfactory, noiseless friction-clutch for use on cycles will ever be invented.

TANGENT VS. DIRECT SPOKES.

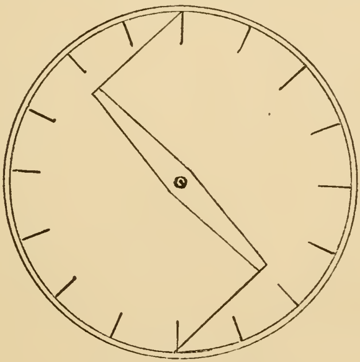
The subject of Tangent *vs.* Direct Spokes, or Direct *vs.* Partial Tangent, is one on which so much has been written and said within the last few years that it is probably well understood in the main by all enthusiastic wheelmen, but a few points may not come amiss to the beginner. In the first place, there is no such thing as partial tangency. A tangent spoke is tangent, and that is all there is about it. A tangent is a defi-



Tangent spokes.

nite thing, and means a line normal to a radius at the circumference; at least, we can accept this definition as well enough suited to the cycle art. And, in speaking of tangency, we ought rather to say tangent hub than tangent wheel, since the spokes are not tangent to the rim of the wheel, but to the hub. All cyclists know very well, nevertheless, what is meant by partial tangency in the cycle art, and I will therefore use the term. If a long spoke went straight from one point in the rim to another nearly opposite, and just touched the outside circumference of the hub in one place, it would make two purely tangent spokes. (See cut.) As, for instance, *a b* and *c d* make all together four spokes, *a f*, *b f*, *d e*, and *c e*. If a spoke runs from any point, *a*, *c*, *b*, or *d*, to any point on the circumference of the hub between *f* and *e*, it will not be a full tangent spoke. The distinctive characteristic of a full tangent spoke is that, when the force tending to revolve the wheel is applied, it pulls from the point on the hub which would recede most rapidly from that point in the rim to which the other end of the spoke is affixed. Hence, the common expression that "a tangent hub gives a direct end-pull on the spokes;" but so does any other hub, if the spoke is swivelled into it. With a direct spoke screwed into the hub, the weight of the man is sustained by a direct end-pull, and a slight power is transmitted to the rim by the resistance to flexure or bending in the spoke tending to revolve the wheel, and it will be found in practice that any hub with a direct spoke will turn independently of the rim far enough to increase the distance slightly between the ends of the spokes so as to really make an end-pull as in the tangent spoke, but evidently the hub must revolve a great way in order to increase the length a very little. Here comes in the advantage of the tangent spoke, for, in order to turn the hub within the rim, the spoke has to stretch an amount equal to the distance a point on the circumference of the hub moves. To represent this in popular terms, if the hub turns one-eighth of an inch, the spoke has to stretch that amount if tangent, whereas the necessary increase in length of the direct spoke is almost imperceptible.

One point must not be forgotten in this matter, which redounds to the credit of the absolute direct spoke. It is that the driving strain passes through every spoke from the hub to the rim, whereas, in a tangent or partial tangent spoke, the strain is resisted by only one-half of the entire number. This defect is partially remedied by the late plan of soldering the spokes together at the points of crossing, this binding together being what really makes the tangent spokes so strong in resisting buckling, to which they were very liable before the soldering process was used. I am inclined to think that the midway or partial tangent hubs are the best, as they seem to combine all of the possible advantages, but the plan of crossing the spokes just once is, in the light of my experience, very bad, as it seems to combine the faults of both with the advantages of neither; they should be more nearly full



Old bone-shaker wheel.

tangent than direct if varied from the midway position at all. The small eighteen- or even thirty-inch wheel is good enough, if well made, with either direct or tangent hubs, especially in the one not used as a driver.

The soldering of the spokes together, and other difficulties in the way of screwing them into tangent hubs, has led makers to adopt the plan of screwing them into the rim; this seems unavoidable, but is not very desirable, if for no other reason than that the wheel getting wet, the screw threads are apt to rust off and strip. With brass, aluminum, or bronze nipples, however, this difficulty can be to a great extent overcome.

Tangent wheels are as old as the industry of cycling. Starley, of Coventry, is said to have experimented and shown, many years ago, that a tangent wheel with silk spokes would resist the revolving strain on the hub equal to a direct wire spoke, and the *Scientific American* gave an illustration of a tangent hub in their issue of September 1, 1877.

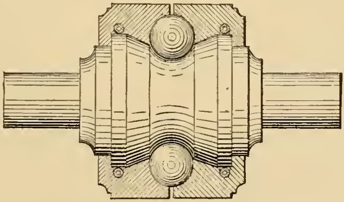
The cross bar in the old bone-shaker made practically two tangent spokes, and pulled from the rim, so to speak, as will be noticed in our essay on hobbies.

CHAPTER XX.

ANTIFRICTION BEARINGS, BALL AND ROLLER.

THE cycle art has developed the use of antifriction, or, we might say, rolling-friction bearings, to an extent never before attained; these bearings are in the form of balls and rollers; the former are made in several styles and the latter in at least two, but all are more or less old in the arts.

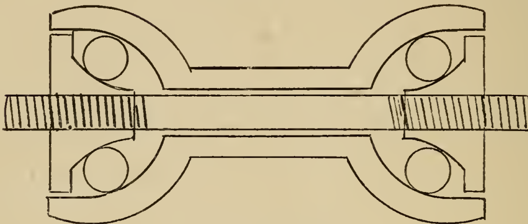
The first prominent patent in the American office, upon balls or rollers, is dated June 18, 1861, No. 32,604. There are some three hundred drawings of



1861. Ball-bearing patent.

roller and ball-bearing patents on file at the United States office; this, however, does not represent the entire number issued. All of the more recent patents are substantially modifications of former patterns, such as No. 29,570, 1860; 37,765, 1863; 58,739, 1866; 63,609, 1867; 82,665, 1868; 113,867, 1871; 202,271, 1878, and Peter's, November 20, 1877, No. 197,289.

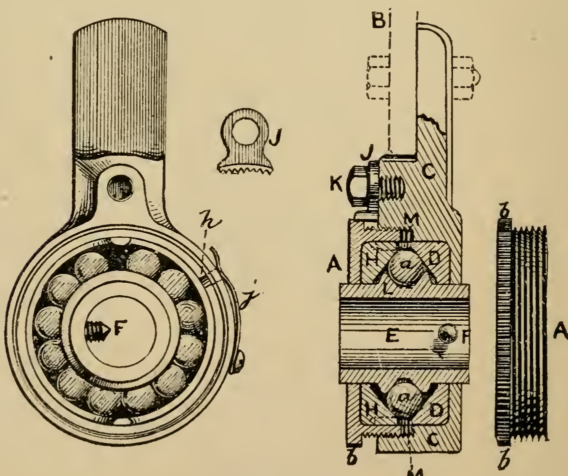
One of the most useful variations and the one best adapted to the cycle art, is the lateral adjusting bearing of this style.



Rear-wheel bearing.

Below find selected figure and claim from a prominent patent over which there has been much contention.

J. H. HUGHES, BEARING FOR WHEELS, NO. 227,632, PATENTED MAY 18, 1880.



Hughes's patent.

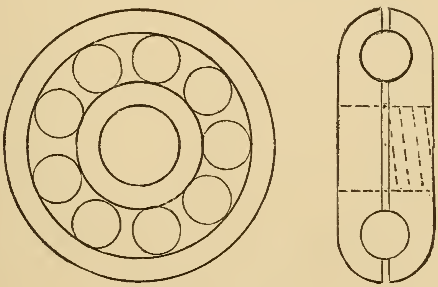
"What I claim, and wish protected by Letters Patent is,—

"In bearings for bicycles, tricycles, or carriages, the combination of hardened conical or curved surfaces, hardened spherical balls, and the means, substantially as shown and described, of adjusting or setting up the parts, for the purposes set forth.

"JOSEPH HENRY HUGHES."

Other forms, such as the disk pattern with an annular groove upon its face, have their special uses.

As to friction, ball-bearings may be said to reduce this to nothing, since in mathematical calculations, rolling friction on hard surfaces is usually neglected, as compared with sliding friction. In actual practice this would not quite hold good, since oil and dirt will make a difference. The balls, in the ordinary bearings in the market, roll upon conical, spherical, or cylindrical surfaces. In either of the last two cases the radius of curvature of the box is so much greater than that of the ball that the effect is the same as upon the cone,

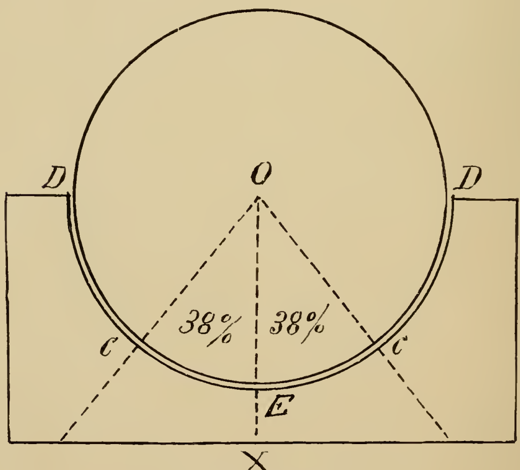


Annular, ball-bearing.

and in all cases where a bearing is well constructed the action is the same as that of a ball rolling upon a flat surface. True, some friction results from the contact of the balls with each other, but as there is no force driving them together, it is very slight.

So long as the bearings are new and properly made, each ball touches and rolls along what may be considered a mathematical line, and there is, in fact, no friction worthy of consideration. Nevertheless there is some, and in time a small groove is worn, or rolled, into the bearing, which groove just fits the ball. The friction is greater now than before, and increases with the deepening groove until, finally, when the depth of the groove equals the radius of the ball, the friction reaches its maximum and would be at that time nearly equal to one-fourth of the amount of friction engendered if the ball actually slid in the groove. The ball would then roll on lines along the groove through points *c, c* thirty-eight and one-fourth degrees around from *E* towards *D*, as shown in the annexed diagram. (Fig. 1.)

FIG. 1.



Rolling Lines, ball-bearing.

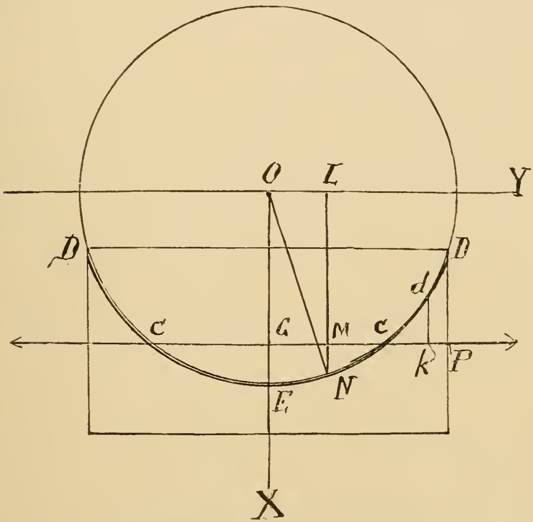
The reader can form a tolerably clear idea of the amount of friction caused by the ball sliding without rolling; let this then be the unit. Also let the radius of the ball be the unit depth of groove. The following table gives roughly in these units the frictions for the groove depths expressed in tenths.

GROOVE DEPTHS . . .	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
FRICTIONS	0	.01	.02	.03	.05	.07	.09	.12	.15	.18	.21

To what is this friction due? Look at this diagram (Fig. 2), representing a transverse section of the groove and ball.

Is it not evident that the ball really rolls on two parallel lines in the groove somewhere between D and E, say the lines through $c\,c$ perpendicular to the plane of the paper? This granted, it follows that points on the ball-surface touching the groove above c are going faster,

FIG. 2.



Transverse section groove and ball.

while those touching below c are going slower than points touching at c. Hence, no wonder there is friction. The position of $c\,c$ is such that the sum of the moments of friction above $c\,c$ balances the sum of the moments of friction below $c\,c$. Take axes $O\,X$, $O\,Y$, as indicated; let the x of $c\,c$ be a, and that of $D\,D$, b; put $d\,s$ for an element of arc, and let A be the angle between the radius to $d\,s$ and $O\,Y$. Then the friction on ds is proportional to $ds \cos A = dy$, and its moment about $c\,c$ is proportional to $dy\,(x - a)$, or, $dy\,(a - x)$, according as ds is above or below $c\,c$.

Therefore, $$\int_{o}^{\sqrt{1-a^2}} (x - a)\,dy = \int_{\sqrt{1-a^2}}^{\sqrt{1-b^2}} (a - x)\,dy$$

The ball's radius being unity, the solution of the above equation is,—

$$a = \tfrac{1}{2}\left(\frac{\text{arc} \cos b}{\sqrt{1-b^2}} + b\sqrt{1-b^2}\right),$$

which determines a for all values of b; that is, determines the points c, c. It was stated above that ds was proportional to the friction upon itself. Of course, we meant that it was proportional so long as a remained constant. In terms of the unit given at the beginning of this discussion, the friction is $\dfrac{ds}{2a\sqrt{1-a^2}}$, and the total friction upon the ball is therefore

$$\frac{4\displaystyle\int_{o}^{\sqrt{1-a^2}} (x - a)\,dy}{2a\sqrt{1-a^2}} = \frac{\text{arc} \cos a}{\sqrt{1-a^2}} = 1,$$

which is the formula used to calculate our table above.

As to the weight balls can safely carry in any bearing, below will be found results of experiments and calculations made by Professor Robinson, of the Ohio State University. This article is the result of careful, exhaustive work, and I am under great obligations for the privilege of introducing it here, as it has never before been in print.

"To find the load which a single hardened steel ball will safely carry in any ball-bearing, either when running between two flat surfaces or between two equally grooved surfaces of hardened steel, in each case the following formula may be applied,—viz.: Load in pounds $= 190\, d^2 \sqrt{1 + \frac{d}{d' - d}}$, where d equals the diameter of the ball in inches and d' equals the diameter of the groove in which the ball runs, either top or bottom. For flat surfaces, for top and bottom bearing of ball $d' = \infty$ and $\frac{d}{d' - d} = o$, so that, for a ball between hardened flat plates, Load $= 190\, d^2$. For n balls in a nest, all in equally fair bearings, the load equals $n\, 190\, d^2 \sqrt{1 + \frac{d}{d' - d}}$; for example, a one-inch ball between flat surfaces will carry one hundred and ninety pounds safely.

"Again a one-half-inch ball will carry $\frac{190}{4} = 47.5$ pounds; and again a one-inch ball in a groove of one and one-eighth-inch diameter top and bottom will carry $190 \sqrt{1 + \frac{1}{1'\,(8 - 1)}} = 570$ pounds. So that there is great advantage in supplying grooves for the balls to run in. Again, suppose the ball be one inch and the grooves one and one-eightieth inches in diameter; then the load equals seventeen hundred and ten pounds. Again, if the ball is one-half-inch diameter, and the groove nine-sixteenths-inch diameter, the load equals 142.5 pounds, etc.

"Hundreds of experiments in all were made on this subject, and the above formula deduced by theory was found to agree almost exactly with the experimental results for hardened steel for balls and track for same. When a much greater load than the above is attempted to be carried, the balls will indent a groove of their own until the necessary bearing surface is obtained.

"I am not aware that the coefficient of friction for ball-bearings is definitely known. Experiments made with the Lick telescope, in which the weights of some parts had to be guessed at, gives .00175 for the value of friction coefficient for one-inch balls; but this, though the best I have, is not a reliable figure. It is for hardened steel on hardened steel."

Mr. Robinson here shows an advantage in the groove so far as capacity for resisting strain is concerned, but he would hardly construct a ball-bearing with grooves fitting the balls after a careful perusal of our section on grooves and friction.

As to *ball-heads* to bicycles, they have been highly recommended by a few makers and much admired by some riders. As before said, the balancing of the bicycle is accomplished by means of the steering apparatus, and the easier the head swivels the less work the rider has to do to effect his object. If simple steering —that is, changing the general course of the rider's progress—happened to be all for which the head is swivelled, it would make little difference whether it moved very easily or not; nay, it would be better to have it move a little stiff, since it would then stay in place. But when it comes to balancing, the head is constantly moving, and every resistance is work to be overcome by the rider's muscular exertion. To say that a head cannot swivel too easily, would be a valid axiom in the art of balancing; hence a ball-head could do no harm, and might do some good. In the Rover or Safety pattern, ball-heads are quite common and are rather a valuable acquisition, especially in the telescope. In the Stanley head, however, it is very questionable whether the advantage gained is sufficient to justify the extra complication and weight of the parts. Conical heads can be, and are, made to work so smoothly and the amount of motion is so small that the same question in regard to friction does not apply as in the case of other bearings about the machine. It is the opinion of the writer that every other part about a wheel should be about perfect, and of the very highest grade, before the question of ball-heads should be considered at all.

In regard to the patents on, and general use of, ball-bearings in cycles, I think the necessity of using the prominent lateral adjusting bearings is really not so absolute as many suppose; of course this is the most artistic form and the most easily-made pattern of all, and is in every way adapted to cycle use; but it would not be policy to throw aside any other advantage in a wheel to gain the lateral adjustment in the bearings. There are some other styles of ball-bearing boxes which answer the purpose very well, the chief difficulty being that a greater amount of work is necessary for their adjustment. If the boxes are split in a plane through the geometric axis of the axle, they will be slightly out of round after adjusting, but when it is taken into consideration that the weight is all on one side or, as in a bicycle, on the top, the fault will not be noticeable; it is more serious when the boxes revolve than when they are stationary.

The patents now existing on lateral adjusting bearings have caused many attempts at other methods of taking up the wear. The validity of these patents is questioned by many, and considerable litigation has been the result, though in many cases makers prefer to use other devices to running the chance of a law suit. The happy medium adopted by others is to pay the royalty demanded; this is, perhaps, the best course to pursue if the said royalty is not made burdensome. Every maker, however, should assure himself, by special examination, if his particular bearing really infringes any patent before paying; the fact of it being a ball-bearing with a lateral adjustment is not an incontrovertible reason that it should infringe, since both of these elements are, in themselves, old. It is only a special ball-bearing with a special adjustment that is patented. Unhappily, however, the special adjustment is a screw. How the patent will stand, time alone can tell; its validity is certainly questionable.

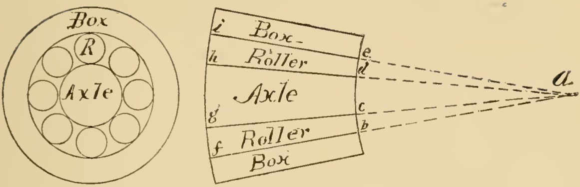
A word here in regard to paying royalties in general. Makers are too scrupulously averse to such payments, even when small, and buyers have the idea that any one who pays a royalty is naturally working at a disadvantage. This is not necessarily the case. Some would save more by the use of an ingenious machine for making the parts than several times the royalty often amounts to. In the manufacturing business there are so many ways of saving and losing money, that unless a careful watch is kept all round the little matter of royalty on some one part will fall into insignificance as compared with other leaks.

The advertisement of a maker that he pays no royalty gives us but little assurance that he can make a better machine for less money. When a patent is evaded by slight changes, such, for instance, as the increase or decrease of an inch in the diameter of a wheel, it shows not so much a great shrewdness on the part of the pirate as a frailty in the patent; this sort of evasion of royalties is considered to be perfectly legitimate, however, and means that either the attorney who took out the patent was incompetent, or that there was but little invention to be claimed.

ROLLERS.

Theoretically there is less friction in roller- than in ball-bearings, as there need be no sliding action whatever in the former if well made. But in actual practice no bearing can be made in which there is no tendency of the rollers to run together; and if we place them in a frame to hold them apart we shall have about as much friction as when they rub against one another. The most perfect plan is to place a small roller between each of the larger; with this arrangement the friction is practically nothing. The action of rollers upon the boxes is always a pure rolling friction, which cannot be the case with balls after the slightest groove is worn in the casing.

One reason for rollers being little used is that they tend to work out of line with the axle and box, which causes some ends to get a little in advance of the others, when they can no longer work perfectly. For an oscillating bearing,—that is, one that goes backward and forward, instead of continually around,—I have found rollers very good, since they cannot get much out of line; even when the bearing is a little imperfect, the rollers cannot multiply the imperfection, as they will in one that keeps going on in the same direction. The other great fault of the roller is its non-adjustability, although this can be rectified in the following way:



Roller construction.

The above cut shows a bearing and the construction lines that must be followed in its manufacture. The taper of the axle, roller, and box must all meet in a point, as at *a;* this arrangement is evident. The roller must be kept in proper position and roll around the large end in the same number of turns as the small end; hence the circumference of the small end of the roller must bear the same relation to the circumference of the larger as the relative ends of the axle and box bear to each other. The geometrical conditions are as follows: π being the relation of circumference to the diameter, referring to the diagram, we have $b\,c : f\,g :: c\,d : g\,h :: b\,e : f\,i$; hence $\pi\, b\,c : \pi\, f\,g :: \pi\, c\,d : \pi\, g\,h :: \pi\, b\,e : \pi\, f\,i$. Now, by virtue of the last formula, when the axle or box is revolved, each end of the roller will travel through exactly the same number of degrees around the axle and in the box, wherefore the axle rollers and box all keep straight.

CHAPTER XXI.

ALUMINUM IN CYCLE CONSTRUCTION—STRENGTH OF TUBES.

"WE really thought that we were going to pass over a period of three months without having to chronicle the discovery (?) of a method of producing aluminum at a cost of not more than that of first-class steel. The periodical inventor has appeared, and this time he hails from Melrose, Mass., and his name is Washburn. Next!!"—*Bicycling World.*

Inventors do little harm in periodically making cheap aluminum or increasing its strength without adding to its gravity, but when a large corporation is started, as was done some months ago, with a lot of money and aluminum medals issued, the same being made out of copper, then the matter becomes serious. Probably, next to the hobby of separating water and creating enormous power thereby, the aluminum hobby holds undisputed sway. But as there really is something of interest to cyclists and cycle makers in the subject, there seems a need to touch upon it. Among the articles in the manufacture of which aluminum can be satisfactorily used we find in the catalogue of a well-known smelting firm mention made of bicycles, tricycles, etc. The idea exists in the minds of many that a bicycle made from pure aluminum would be a practical machine and much lighter than one of steel. This notion arises from the fact that aluminum in the pure state has a specific gravity of only 2.5, or about one-fourth the weight of steel. Below we print a letter from the Cowles Smelting and Aluminum Company on the subject.

"LOCKPORT, N. Y., U. S. A., August 20, 1888.

"R. P. SCOTT, ESQ., Baltimore Md.:

DEAR SIR,—Replying to your favor of August 16, you can obtain the book on Aluminum, by Richards, from Philadelphia. Aluminum has a great many uses in its commercial state, but a simple pure aluminum casting has not sufficient strength to make it desirable for small parts. If you could have it rolled or hammered to shape, so as to make it rigid, it would become much more tenacious, but to secure strength desired in bicycle parts, your castings would necessarily be so large as to be ungainly, and we doubt if you would attain the most desirable end,—viz., light weight. The alloys of copper and aluminum are much better adapted to your requirements than the pure metal could possibly be.

"Yours very truly,

"THE COWLES E. S. AND AL. CO.

"*Tucker.*"

It will be seen that the metal in its pure state lacks strength, and can only be used in the arts to any extent when alloyed with copper about in the proportion of nine of copper to one of aluminum. When alloyed as above, it is about as heavy as steel.

AVERAGE ULTIMATE TENSILE STRENGTH OF METALS AND ALLOYS.

(*From Trautwine's Engineer's Pocket Book*, 1885.)

	Pounds per square inch.
Cast brass	23,000
Annealed brass wire	49,000
Cast copper	24,000
Annealed copper wire	32,000
Gun bronze of copper and tin cast	39,000
Average American cast iron	16,000
Good wrought iron	50,000
Best American wrought iron (exceptional)	76,100
Iron wire ropes	38,000
Malleable iron castings	48,000
Steel plates (rolled)	81,000
Cast steel average Bessemer ingots	63,000

ALUMINUM BRONZE.				
Per cent. of aluminum.	Grade.	Tensile strength per square inch.	Elongation.	Ingots per pound.
	A 1	90,000 lbs. and over.	0 to 5 per cent.	$0.45
	A 2	75,000 to 90,000 lbs.	10 per cent. and over.	.40
10	A 3	65,000 to 75,000 lbs.	25 " "	.37
7½	B	47,500 to 65,000 lbs.	20 " "	.33
5	C	35,000 to 47,500 lbs.	25 " "	.26
2½	D	27,500 to 35,000 lbs.	30 " "	.20
1½	E	20,000 to 27,500 lbs.	15 " "	.16

The specific gravity of the *A* grade is 7.56, that of steel being 7 88. Its coefficient of expansion is small at ordinary temperatures; its electrical conductivity is about 9, and with the lower grades the expansion by heat, specific gravity and heat and electrical conductivity increases the nearer the metal approaches to pure copper. With more than eleven per cent. of aluminum the bronze rapidly becomes brittle. In color, aluminum bronze of the C and D grades is the nearest to gold of any known metal, the higher grades being lighter in hue than the lower. The *A* grade melts at about 1700° F., a little higher than ordinary bronze or brass. Aluminum bronze shrinks about twice as much as brass.

In working aluminum I have found it to be a splendid substitute for malleable iron, especially in many cases where the iron could not be procured in time, or when it came so warped as to be unfit for use. I have never been able, however, to get castings which would come quite up to the strength claimed for it; the most satisfactory grade was that of ten-per-cent. aluminum, which by the way is very hard to work, especially in drilling. There is no doubt, however, that it can be made to take the place of steel in many instances.

A knowledge of aluminum is a great boon to experimenters, as it will probably come into quite general use with the manufacturer. The ten-per-cent. aluminum finishes very handsomely, and in olden times it would have been a splendid substitute for the brass hubs then so common. As an antifriction metal it is unsurpassed by any of the bronzes. It casts bright and sharp, but shrinks amazingly, although not dangerously; at least I have never had a part of the casting drop off, as in malleable it often does, and though the aluminum sometimes leaves a great depression in the heavy part of the casting, it causes no sponginess underneath. It can be readily bronzed or soldered.

Aluminum bronze drawn into wire will make very good spokes, and it has been used for this purpose to some extent in England. All tendency to rust is obviated, and it saves all nickeling; it resists corrosion sufficiently well to dispense with any covering, but it does not look as well as a nickel finish. No better authority on the subject can be had than that of the Cowles Catalogue; useful information also can be gathered from "Richards's Aluminum," and "Thurston's Material of Engineering." The last-named treatise speaks on the subject as follows:

"The alloys of aluminum are very valuable. Its remarkable lightness, combined with its strength, makes it useful as a constituent of those alloys in which strength and lightness are the needed qualities. It has a pleasant metallic ring when struck, and confers a beautiful tone when introduced into bellmetal.

"Aluminum may be added to bronzes and brasses with good results. The alloys (copper ninety per cent., aluminum ten per cent.) may be worked cold or hot like wrought iron, but not welded. Its tenacity is sometimes nearly one hundred thousand pounds per square inch. Its specific gravity is 7.7. In compression this alloy has been found capable of sustaining a little more than in tension,—one hundred and thirty thousand pounds per square inch (nine thousand one hundred and thirty nine kilos per square millimetre),—and its ductility and toughness were such that it did not even crack when distorted by this load. It is so ductile and malleable that it can be drawn down under the hammer to the fineness of a cambric needle.

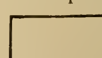
"It works well, casts well, holds a fine surface under the tool and when exposed to the weather, *and it is in every respect considered the best bronze yet known.* Its *high cost alone has prevented its extensive use in the arts.* These alloys are very uniform in character and work regularly and smoothly. Even one per cent. of aluminum added to copper causes a considerable increase in ductility and fusibility, and enables it to be used satisfactorily in making castings. Two per cent. gives a mixture used for castings which are to be worked with a chisel. It is softened by sudden cooling from a red heat. Its coefficient of expansion is small at ordinary temperatures.

"It has great elasticity when made into springs; it has been found useful for watches, and has the decided advantage over steel of being little liable to oxidization. Kettles of aluminum bronze are used in making fruit syrups and preserves. Steel containing but .08 per cent. of aluminum is said to be greatly improved by its presence."

Aluminum bronze, such as would be required for cycle castings, costs from thirty to fifty cents per pound, according to quality and quantity. A valuable alloy of aluminum and iron has recently been made, by which it is maintained that wrought-iron castings are possible. The factory is, I believe, at Worcester, Mass. In our endeavor to learn more upon the subject we have been referred to the United States Mitis Co., No. 26 Broadway, New York, which company has the exclusive right in this country to make Mitis castings, or of granting permission to those who desire to make these castings themselves.

STRENGTH OF TUBES.

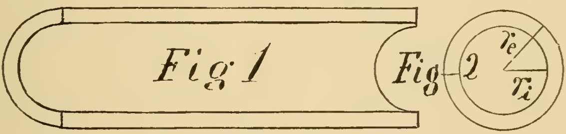
Metal in the form of tubes resists all strain liable to occur in cycle work better than in any other form. In regard to strain of compression, we find, in "Wood's Resistance of Materials," the following summary:

"Experiments heretofore made do not indicate a specific law of resistance to buckling, but the following general facts appear to be established: The resistance of buckling is always less than that of crushing, and is nearly independent of the length. Cylindrical tubes are strongest, and next in order are square tubes, and then the rectangular. Rectangular tubes  are not so strong as tubes of this form ."

There is, however, very little direct crushing strain on the tubes in a cycle; it is almost entirely a strain of flexure or bending; hence this is the only interesting feature pertaining to the subject in cycling work.

Since a tube is stronger than a solid bar, for same weight the intuitive idea is to make the tube as large as possible, and the mathematical demonstration which we append shows this to be correct, generally speaking.

Let R equal the strain per square inch of cross-section of the tube at the point farthest removed from the neutral axis at the instant of rupture.



Tube sections.

Suppose Fig. 1 to represent the half of the tube, and that you are trying to bend it down at the ends. The particles towards the top will be pulled apart, while those at the bottom are crowded together; somewhere between the top and bottom the particles are neither pulled apart nor crowded together. Were the tube solid, the line of these particles would be the neutral axis. In the tube an imaginary line through the centre of the hole does not vary much from said axis. Now the moment of rupture $= \frac{R\pi}{4 r_e}(r_e^4 - r_i^4)$, where r_e and r_i (Fig. 2) are the exterior and interior radii; $\frac{R\pi}{4}$ is a constant, which we will call K, whence we can write moment of rupture $= K(r_e^2 - r_i^2)(r_e^2 + r_i^2) \div r_e$. Here the factor $(r_e^2 - r_i^2)$ is proportional to the area of the annular cross-section and is constant, while the other factor, $(r_e^2 + r_i^2) \div r_e$ or, $r_e + \frac{r_i}{r_e} r_i$, though less than $2\,r_e$, gets nearer and nearer to $2\,r_e$ as r_e gets large and r_i approaches r_e.

Therefore we have, that in resistance to flexure the tube should be as large in diameter as practicable, which means that it must be as thin as possible. This result is only modified in practice by the necessity of guarding against dinging and also against imperfections in the steel. A surface crack will ruin a very thin tube which otherwise may be harmless in a thicker, but it is safe to say that it is best to use reasonably large thin tubes.

Oval tubes are of an advantage only when the direction of the strain is positively known and when it invariably occurs in that direction. Since the tube finds its greatest limit of general resistance in cylindrical form, to alter that form must necessarily weaken it more in one direction than it strengthens it in another.

CHAPTER XXII.

THE CYCLE IN WAR—STEAM AND ELECTRICITY.

No more important and interesting phase in the development of the wheel has recently occurred than the consideration and partial adoption of the cycle in military affairs. Already this subject has engaged the attention of English and continental war departments. At first the tricycle was adjudged the most promising form of man-motor carriage for the army, but latterly authorities have directed their attention to the more sensible and practical plan of adopting the Rover-type Safety. Some advantages could be named favoring the tricycle, but certainly, with the slight effort needful to master the rear-driver, if the cycle ever attains any prominent place in the military field, it will be in the form of a single-track machine. In all countries where reasonable roads can be expected the cycle must succeed in this warlike department of usefulness ; not that we ever expect to hear of the charge of the cycle corps, or of a hand-to-hand sword combat upon the "festive bikes," though such things are within the pale of possibility ; what we do expect to hear of in the next war is the cycle scout and forager and of the cycle corps getting there ahead of the calvary. With a light bicycle that can be lifted over small obstructions, an expert could go almost anywhere that it would be practicable to take a horse, and when you consider how much easier it would be to conceal your cycle, in case a little excursion on foot were necessary, and how much less danger there would be when no provender or shelter is required for the steed, certainly the idea is feasible. It has been said that a horse can go where a cycle cannot ;

while this is sometimes true, on the other hand, there are places where the cycle can be taken when the horse would have to be left behind. For instance, a steep rocky cliff might be surmounted by the man and his bicycle, since the latter could be easily drawn over after him; in fact, he could go with his machine over almost any place which it would be possible to clamber himself, while by no means would this apply to the horse; in short, we feel assured that war cycling promises great development in the armies of all civilized nations, and to this end the most solid, powerful, unbreakable, and at the same time light, wheel must be striven for by any maker who would advance the art in this direction, and reap the consequent substantial returns to his exchequer.

STEAM, ELECTRICITY, SPRINGS, AND COMPRESSED AIR AS MOTORS.

This heading is not entirely german to the subject of man-motor locomotion, but we will take advantage of the fact that in all mechanical motors that will ever be applied to bicycles and tricycles there will have to be an auxiliary apparatus for the feet. This is obvious, since in any break-down the rider will need some means of getting home. As the ocean steamers retain some apologies for sails, so the cycler will have to retain his foot-power mechanism in any machine he might adopt for individual transportation, though the main motor power be steam or electricity, one of which may finally be adopted in cycles. That every rider will care for this extraneous assistance is doubtful, as the element of exercise would be eliminated to a great extent. For practical uses aside from exercise, as in the transaction of business, etc., other motors than that of human energy would be a boon in the present cycle, but they would never be used to the exclusion of the legs. Already many experiments have been made, some quite successful, both in steam and electricity, but the steam I think affords the greater prospect of success, because the necessary conditions are naturally more nearly complete. Whatever motor is used, it will be necessary to have supply-stations at intervals along the road, which would require but little effort to establish for steam, since oil and water can be obtained almost anywhere now, and positive arrangements could easily be made to have the necessary supplies kept at all the cross-roads stores. All that is required is that some one shall put a practical steam bicycle upon the market, with all parts as light as possible and with oil for fuel. The main principles have all been worked out separately, and what we need now is a combination of the most improved methods and a go-ahead man to push the business.

Electricity is as yet too indefinite in its development, in this direction, to encourage the hope that it can, at present, be made available. The only prospective means of utilizing it as a road-motor is by the use of secondary or storage batteries, which would require dynamos scattered along the road for recharging them; but the slightest thought will show that this expensive arrangement is hardly a possibility considering the enormous distances and length of roads, especially in this country.

We have only to mention compressed air and springs, in order to dispose of them; the former does not promise much, and as to the latter, all efforts in that direction which have come under the writer's notice have been quite nonsensical.

CHAPTER XXIII.

CYCLE PATENTS AND INVENTORS.

THE ever ubiquitous Yankee inventor fell upon an inexhaustible mine when he tapped the virgin soil of cycledom, and his English brother has not been much less fortunate; in fact, it is questionable whether Jonathan has been able to keep the start of Brother Bull in this matter, with three thousand patents on record in the American office against three thousand five hundred provisional in the English, thirteen hundred and twenty of the latter being sealed, up to March, 1889. Few fields of invention have ever developed so rapidly and interested so many inventors with as little apparent advance to the casual observer. As I have stated in a former chapter, the advance has been a sort of evolution, creditable to those who work the changes, yet with little chance at any time for what is termed a broad patent. When the saddle was raised up over the cranks and the front wheel enlarged, a great stride forward in the art was made, yet it is questionable whether such changes afforded sufficient ground for strong patent claims; twenty years ago they certainly would not have done so, with the feeling and usual action of the patent authorities and general stupidity of patent attorneys at that time. Mere changes in the sizes of wheels would stand a much better chance of being patentable now than some time ago. We have, in fact, a patent now existing, given out to an Englishman, on the Safety rear-driving pattern of machine, in which the proportional diameter of the wheels is pretty well claimed. How this patent was wedged into the American office is somewhat remarkable; if it could be held valid, makers of rear-drivers with a front wheel as large or larger than the rear would find it warm work to continue. Fitting cranks upon the drive-wheel would, with modern patent attorneys, have afforded a broad field for good claims, but it did not seem to in Lallement's time, seeing the kind he got. The rubber tire, in spite of the fact that it was perhaps the greatest element of all in making a cycle a practical roadster, was so old in other relations that the U. S. patent of Serrel, No. 87,713, afforded no protection to the inventor; but even if it had been used on the wheels of some machines within the knowledge of the Patent Office, which could be used as a reference, a good attorney would now hardly abandon a claim for its use in a cycle on that account. The claim to the hollow or tubular construction of frame,* though ingenious, was laughed at by good patent experts; it was the one thing that was old and by right absolutely unpatentable. Yet the attempt to hold it had at one time better prospects of being successful than any other in connection with the great principles in modern cycles; unless the mud-guard should be considered a great principle. The ball-bearings were broadly old, as shown in the American office; still, very good patents have been obtained upon them, sufficient to cause several famous law-suits. There was some good ground for these patents, but I doubt if any better than was found in the case of the rubber tire, the large drive-wheel, or, particularly, the step for mounting the ordinary bicycle, and possibly no better than was found in the tubular construction.

The American Patent Office and the courts more recently take the view that if a man has really done something in the art they will give him a patent. This is absolutely necessary under existing circumstances, as it is almost impossible, with the enormous number of patents that have been issued, to invent

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* Pickering, March 30, 1869, No. 88507.

anything upon which the Office cannot find some sort of reference, and for this reason it is proper that the evidence of invention should rest largely on the fact of general success and value in the market. The courts are liable to ask, "Why, if a certain invention is so old and obvious and in such great demand, was it not used before?"

The Patent Offices, both in America and in England, have become so utterly clogged with cycle patents that it takes great ingenuity to get in anything that is broadly new. The patents are necessarily on some detail of construction, except perhaps in the open field afforded by the innovation of the rear-driver, just as there has been some attempt to improve upon the "Rothigiesser system," in which a German inventor claims to ride "hands-off, as spoken of elsewhere. There is also a good opening in tandem bicycles and tricycles, and in the anti-vibration element of the rear-driver, but the field is rapidly closing in.

THE CYCLE INVENTOR.

Close upon the question of patents comes the idea of the cycle inventor. It is not my desire to in any way curtail the income of the respective governments of the world, or to embarrass the Patent Offices thereof, by causing a lack of new applications, but the cycle inventor, as well as inventors in other departments, might profit by a little advice from a personal standpoint. A glance at the numerous samples of patents illustrated in this book, and a thought of the total number issued, should be enough to convince any fair-minded reader that many useless fees are yearly dropped into the patent-slot at both the American and English offices. This fact, together with an extended experience in other departments of invention and a limited turn at the gridiron upon which the cycle inventor is grilled, has caused a few facts appertaining to inventors and patents to dawn upon me, which I now propose to inflict upon the reader. These things are not the discovery of a sore-head; they are related by one who has to thank the patent department of his country for all of his wordly financial success.

If you think of a good thing in cycles, don't rush off to the Patent Office all at once; just stop a little, there is no hurry, and do this. Draw off a good sketch of the thing, put a date upon it at once, and explain it to one or two trustworthy friends and have them sign the sketch as witnesses. Get this done, and then breathe a little while. Next, write out this question in large bold letters,—Do I want to go into the cycle business? After cool deliberation, taking into account your capacity, your wealth, your family, present occupation, and prospects, if you can answer in the affirmative, then you may be bolder. If your answer is nay, then go very cautiously. In any case, be sure you do this next. Send the sketch and about ten dollars to a first-class patent-attorney, with instructions to make a five-dollar preliminary examination and to spend the other five dollars in copies of patents nearest allied to your invention, and insist that the attorney sends these copies to you. Either in the English or American office you should be able to get them at twenty-five cents each, and for less if you order a quantity. If you have any knowledge of the art, you ought to be as good a judge as the attorney whether these patents anticipate your own or not; but whatever you do, don't take out a patent simply because one can be had. Study calmly and lucidly whether your thing is of any account or not, and practically try it, if possible. If you conclude to take out a patent, be sure and employ a good attorney, being particularly wary of the low-priced men. Not that I would say to always employ the old attorneys of great reputation, because a young practitioner, if unusually bright, will perhaps make up in extra time spent upon the case what he lacks in astuteness of snap judgment.

Beware of the "no patent, no pay" fellows. It costs just as much to find out that the office will not grant the patent as to find out that it will, unless a careful preliminary settles the case definitely. You can be assured that if the invention is promising it will ultimately, in all probability, have to stand the scrutiny of a court before it will be of any great value. If you do not intend to go into the manufacture of your invention, a good plan is to offer it to a reliable man already in the business before you go into any expense at all; of course, taking the precaution of having your sketch witnessed, as before advised. Very few manufacturers in the cycle or any other line are the notorious patent thieves they are commonly supposed to be; especially are they loath to take advantage of a confiding inventor who has no patent. Of course, if you have taken out a patent, and pretend by virtue thereof to assert that you are protected, you make yourself a legitimate prey if your patent happens to be invalid, which it often is even when the invention deserves the most rigid protection. There are, in all, over five thousand patents in the world in connection with the cycle art, many of which are sound. Think of this before you divert your mind from your legitimate business. It seems hard to the general would-be inventor to say it, but I believe that the proper persons to spend their time and talents in the invention of cycles are the persons employed by the manufacturers for that purpose. In trusting to the judgment of the manufacturer in regard to any idea you may have, if you keep your sketch and a copy of your correspondence, it will be powerful evidence against him if he plays false with you and goes into a fight for priority of invention. Almost any manufacturer will answer a letter about a new idea in his own line, and if he decides against you he will generally give his reasons, from which you can judge whether it will pay you to go ahead or not. This advice may seem to encourage a great risk to the inventor, but I give it from the experience on both sides of the fence. Inventors will say that they get no attention from manufacturers; this, when true, is almost invariably because the alleged invention is absolutely unworthy of any attention at all, though of course all inquiries should receive courteous answers.

The real inventor is a very nice fellow, but the chronic inventor is generally a bore. Take notice, my dear reader, of one fact, how few of the great inventions were the work of chronic inventors. I do not refer to men who have simply taken out a number of patents in their own particular line: one of the best cures for chronic inventorism is to resolve to confine yourself to one line; the next best cure being to firmly conclude never to take out a second patent until the first has paid you something, or has done you some good in some way. The great inventors are those who stick to one thing until success is attained or absolute failure fully demonstrated. Why, now, this anathema against the chronic inventor? It is this: the chronic inventor is lazy; you say he will stay up at night, work all day, and never sleep; well, let him, all except the work; this element is supposititious. It is *not* work, and here is just where the trouble comes in,—the chronic inventor stops just where the work begins. It is fun to invent, and it only takes a little practice to be able to accomplish it; it is as easy as "castle-building," but when you come to build the real castle, out of good hard stone and grimy mortar,—"ay, there's the rub!"

The men who have really done something to the benefit of the world, are those who have reduced their inventions (or those of some one else) to practice and brought them before the people. A great invention which has never gotten beyond the confines of the brain that evolved it might as well never have been evolved at all. Nor is it any better that a pasteboard model lies moulding in the garret; and, strange as it may appear, a record of the same in the Patent Office does not help matters much. See the number of patents, many of which are good, lying in the files at the Patent Office,—neglected and forgotten by everybody except the examiner, who persistently uses them as ammunition against the real benefactor of mankind who, though subsequent, would like to do something with them.

Before my early entrance into the arena of invention, I had a suspicion that some of the work of benefiting mankind, if so high a title be justifiable, consisted in getting an invention into practical and useful form for general use. I also had some premonition that it would require a portion of the ingenuity to get the pay for it at the hands of the populace. In this connection a diverting amusement was discovered in the way of apportioning the ingenuity to the different departments of the required work. My original scale was as follows: One-half of the ingenuity to inventing the thing, one-fourth to getting up the tools and making same, and one-fourth to placing upon the market and gathering in the returns.

After a little experience the schedule was remodelled, making one-third to each section. Later on, the entire schedule underwent a most decided and radical change. It stands now as follows:

Scale of proportional genius required for each department in benefiting mankind (and yourself) by means of invention: Two per cent., inventing; seven per cent., getting into shape; three per cent., getting American patent; one-hundredth of one per cent., getting English patent; ten per cent., getting patent through court; twenty-eight per cent., getting the money; forty-nine and ninety-nine-hundredths per cent, keeping it after you get it.

CHAPTER XXIV.

HOBBIES.

THE cycle hobbyist is one of the quaint characters of the fraternity, and he exists in profusion; turns up at all the meets, and always makes his ubiquitous presence felt.

Only make a wheel big enough, a lever long enough, or a spring strong enough, and he has you foul.

Some of them have pet schemes of storing compressed air in the tubes; others, more practical, make vague hints at a mile a minute with their electrical or steam motors; while others of these embryo inventors would outdo the now notorious Keely with their wonders; and the only surprise is that they would stop to fix the thing to a cycle, when a most diverting amusement could be found in starting the earth around backward or in drawing the poles straight up and thereby making an eternal spring.

Such fundamental principles as that a short lever hung in the middle is just as powerful as a long one hung in the same way; that two turns of a small wheel rolls over as much ground as one turn of another twice the size; that there is no more power in a spring than you put into it, and many other like principles, all seem to be forgotten in the general rush to be the first to make a mile a minute on a dirt road.

Truly we inhabit a wonderful sphere; only just make gravity pull sideways, and we would have no further use for locomotives. Somehow or other, however, the contrary old gravity continues to haul everything just its own way, and that is just the way we do not care to go, either now or in the distant future. Certainly all would-be perpetual-motion makers must feel that something satanic is working against them in this unceasing pull of gravity in the wrong direction.

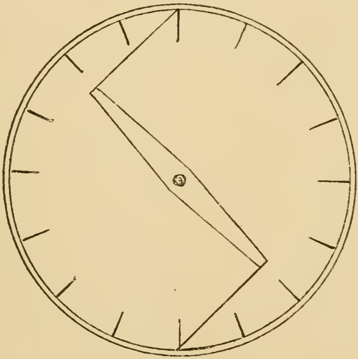
But to revert to our cycle hobbyist in particular. A friend of the writer's, a prominent man, intelligent in all other things, once proposed to pull all the Chicago street-cars by having a man in each, continually winding a spring, said spring to drive the car; and he knit his brow in half offence at the suggestion that there would be less danger of the wheels slipping if the spring-worker would get out and pull by the front platform.

No one can readily believe how common such ideas as the above spring method are till they scour the patent-office records, or talk to the cycle hobbyist. Intelligent men often remark "how powerful" a certain machine must be "with that long lever," when the lever is hung to be worked from the short end; and how often we have heard them condemn the thirty-inch safeties as being slow, on account of the small wheel. Even to cycle-riders not aspiring to the high degree of hobbyists it was a matter of surprise, when the old Kangaroo came out, that it pushed harder when geared to the sixty than others geared to fifty.

"Big wheel, big speed," seems to be indelibly written in the mind of the cycle hobbyist; but we will forgive him all such little inconsistencies if he will only let us continue to believe that there is no innate power in a gear wheel.

I once knew a successful manufacturer who geared up a sausage-cutter to double speed, and then down again to the same, and he believes to this day that it runs easier on account of these four gear wheels. I have often thought that the cycling fraternity would not have cared much whether it did or not, if he had only made it large enough to take in a few cycle hobbyists.

"Pull a bicycle from the rim," and you have power only equalled by the pinch-bar. Did anybody notice the half-page advertisement of a prominent English maker a few years ago, of the tricycle that pulled from the rim (probably not endorsed by the said maker, it being merely contract work for an outsider)? and have any of our American readers ever seen the old bone-shaker wheel with the cross-bar on the hub? (See cut.)



Old bone-shaker wheel.

For years they were used in England with the benighted idea, in the minds of many, that they thereby gained in power. One of these wheels of eight-day size is suspended in front of a building in Coventry (or was a few years ago), used as a sign. This wheel "pulls by the rim," at least so I was quite often informed, not always by reputable English makers, but by riders, who mostly see these great principles (?) first.

The error appertaining to all such ideas is generally the result of confusing external with internal forces. We must have the hub of a wheel connected to the rim in some substantial manner, so that both will revolve rigidly together; further than this the manner of connecting them can matter but little so far as transmission of power is concerned. All that is necessary is that the hub shall not revolve within the rim independently and thereby cause a lack of firmness.

Another sample of the hobbyistic idea is promulgated in the following from the cyclist in a recent issue.

"A NEW BRAKE.

"Mr. ——, of ——, has patented a good idea. On the other side of the forks from the regulation plunger he introduces another spoon connected with the front under the arch of the fork, provision being made for the mud-guard. On moving the lever, both brakes act in unison, thus duplicating the resistance with the same power required to work the brake in its single form."

If it takes a certain pressure to hold the first brake down, and none to hold the second, why not put on two seconds and no first, and thus have a good brake power without any pressure at all?

Since penning the above I have heard further of the new brake in question, and have been tempted to cancel the paragraph, since injustice might be done to an honest inventor; but on second thought concluded to retain it as an example of careless statement, knowing that others were misled by the same. Had the inventor simply remarked that he had made use of his momentum, transmitted through the rim of the wheel, and acting to wedge one of the brakes against the head or the other brake, whereby to increase the brake, or some such explanation, everybody would have acquiesced in it as a reasonable possibility, even if they had not the slightest idea of what the inventor was talking about. It is a satisfaction to know that it is becoming a little dangerous, in the cycle art, to make a statement that savors of getting something for nothing.

A prominent American maker, whose wares now stand high in our market, must have been a hobbyist once too, when he climbed the steps into an English bicycle factory on his lever tricycle. Probably he has reformed, as I hear of no step-climbing now.

Only within a few days I have had an offer to inspect a machine that the inventor assumes will make a mile a minute. "No other machine was ever made to work by hand and foot," says the same inventor. He also assures me that wire wheels are a mistake, and that the old wooden ones are just as good and cheaper. This machine has an ingenious device by which to lock the front wheel of a bicycle, to save the trouble of holding the handle-bars "when you don't want to steer." This much I believe the inventor may be right about. A machine, properly made, run by hand and foot, might make short distances very rapidly, since the entire energy of the man could be quickly used up; but whether such a machine would be of marketable value is a question.

Quite recently a new "hickory wheel" man of more formidable caliber has entered the lists, and again we are called back to bone-shaker days. Well! after the beetle (rear-driver) has been so fondly embraced, let us be prepared for anything that may come. We have dropped down from the cat to the kitten, and can now get out through a pretty small hole if hard pressed; so for the present we will hold the hickory wheel on probation.

A gentleman at Coventry, a few years ago, conceived, and spent a small fortune upon, a plan for overcoming the dead centre in crank tricycles; his method was quite simple: he only had to turn an angle on the crank at the outer extremity like a letter L, so that when the straight or radial part, represented by the stem of the L with the axle through the upper end, stood vertical, the pedal, which is supposed to be attached to the tip of the horizontal extension, would have passed some two inches beyond the dead-centre point.

This same inventor had an enormous steel spring ensconced beneath the seat of his machine, which he wound with his hands as he went along. Whenever the proprietor of the establishment where these experiments were being conducted ran short of work he invariably proposed to the inventor to "go out and try the tricycle."

The writer was a moderate hobbyist himself once, and has perhaps not yet entirely recovered from the spell. Below find a letter written some time ago, while the delusion was still upon him.

"AN AMERICAN HOBBYIST.

"TRIALS AND TRIBULATIONS OF AN AMERICAN ABROAD—HOW PET THEORIES ARE RECEIVED IN THE BICYCLING CENTRE OF THE WORLD.

"EDITOR SPRINGFIELD WHEELMEN'S GAZETTE:

"Some friend has kindly sent me a copy of the *Gazette*, and I make haste to remit you the amount of subscription.

"I will not assume that the bicycling papers of the country of which I am now a guest are not good. In fact, to do so would libel my host; I simply say that, being an American, I like American papers.

"In the letter I first wrote, of which this is in main a copy, I asserted that the papers here were too much taken up by race-course news, but even since then I have received a copy of an English periodical which I find is not open to the objection given; hence I will still speak cautiously, lest I do not know all yet.

"I have no penchant for the race-course; in fact, I never ran but one race, and then I was left so far behind that I have never been interested in racing news since. In one respect my race was a success, for I was loudly cheered by the crowd opposite the starting-point, for by some fortunate error they got the idea that I had been handicapped half a lap, that being about my distance in the rear at the end of the first round. Since that time I have confined myself exclusively to touring, with which object my brother and I came to England this spring.

"I have been admitted to membership in the Cyclists' Touring Club, and must say it is a grand institution, and the official organ thereof is a valuable journal.

"If you and your readers will permit me to speak of my object in making a centre at Coventry without denouncing it as merely a scheme whereby to benefit in a free advertisement, I would say that I have taken the liberty—almost a criminal one it seems here—of having a *hobby* relating to an 'ideal bicycle.' This is from a *tourist's* stand-point; not that of a racer, or it would have been all right.

"My hobby consists in the following hobbies in detail: 1. A bicycle with a large front wheel, because it rides smoother and steers easier than any other. 2. A bicycle in which you are directly over the work and do not have to reach out to do it, or lean over the handle-bar to get your centre of gravity over it. I should think the 'Grasshopper' good in this respect. 3. A bicycle in which the legs are *at rest* on all down grade, or when work is unnecessary, *à la* Star. 4. A bicycle with a treadle motion, as I think power is more economically applied by the same. (This is largely theory, so far.) 5. A bicycle with no dead centre at any time, as I think it is a continual impediment in up-hill or rough roads (also theory). 6. A bicycle where one foot going down lifts the other positively, as in a crank; to lift by springs I consider bad. 7. A bicycle safer from headers than the common large wheel machines, say about comparable with the 'Grasshopper.' I do not aspire to the security of the small wheelers, nor do I like the other known safety devices (probably prejudice). 8. (Ordinary bicyclers' pride suggests No. 8.) A bicycle as neat and trim in appearance as the common large wheel crank-machine without octopus-clawed walking beams, gear wheels, or chains swinging through the air in full view at long range. 9. A bicycle that brakes from the hind wheel, as there is less danger of headers. 10. A bicycle with some good sort of safety handle-bar that will be open to no objections found in those now used. This is to prevent injury in case of a header, and also to store the bicycle in less space.

"You will infer, of course, that I had a plan for combining these hobbies; hence my trip to Coventry with a view to having such a machine made for my own use. When I arrived here and called on some of the bicycle manufacturers and made my purpose known, I cannot say that I was quite so well received as your correspondent C.; in fact, a Yankee inventor does not seem to be such desirable property in Coventry as a foreign agent, and yet I doubt not that a real genius of the former sort might do them much more good. Now, I think I was entitled to the reception of such a character for at least the few minutes it would have taken to expose the error, but there seems to be a sort of suspicious dread of a Yankee inventor, which is all wrong and against their interest. The greatest fault I have to find is in the manner in which they insist that I could not possibly know anything about the bicycle business, or have a right to a hobby and waste some money on it if I wanted to.

"The bad weather has detained us here much longer than we thought to stay, but we do not regret it, as it is the best centre in England from which to make short tours. The attractions of this ancient city are innumerable, and the proximity of Kenilworth, Warwick, and Stratford-on-Avon need only be mentioned to make Coventry all I assert.

"You will pardon me if I say that my new machine is all and more than I expected; but a word to all hobbyists before I close:

Have you a hobby? If so, then 'bend low and with bated breath I will a secret tale unfold.'

"*Have your hobby*, nourish it, talk and write about it, and make everybody believe you can fly; don't let anybody down you, get in the last kick at every man who won't think just as you do, but just as you are going to put it in practice, stop! slip quietly to your escritoire, get out your book, go straight to the bank, and have it accurately footed up; if there is a fat balance, and you are unmarried, with no other care on your mind, and nothing to do for seven years, then go in, and God speed to you.

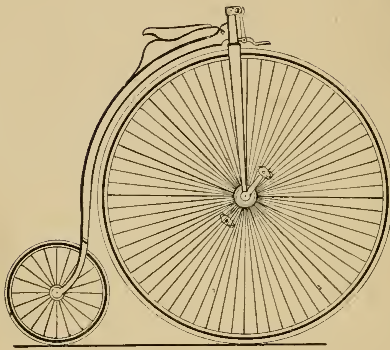
"If the above conditions fail you, go straight home, kiss your wife, and baby if you have any, and thank Providence that you are saved from the lunatic asylum and your family from poverty and want.

"R. P. S.

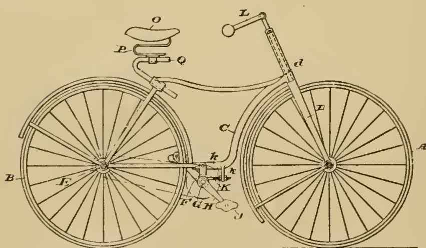
"COVENTRY, ENGLAND, June 11, 1885."

PART II.

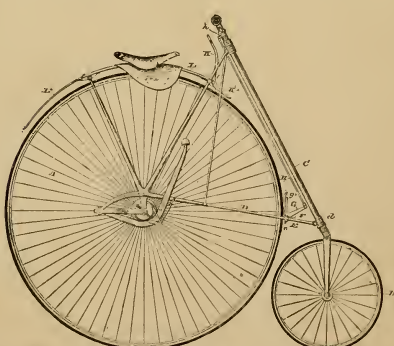
Designed to amuse rather than to instruct the reader, and intended as a reward to those who have struggled through the foregoing pages.



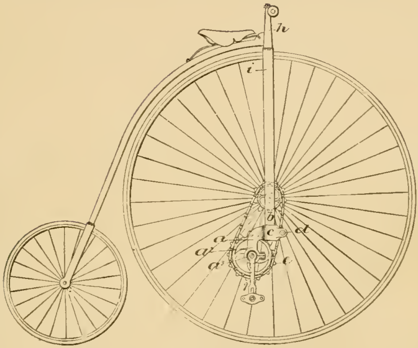
Ordinary, 50-inch front, 18-inch rear wheel.



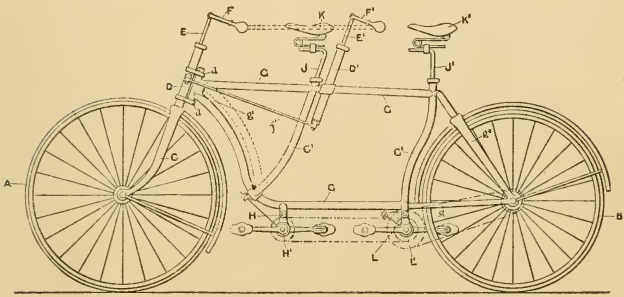
Rover type, rear-driver safety, 30-inch wheels.



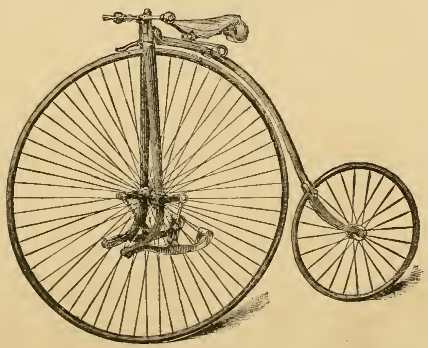
Star type, 20 front, 52 rear.



Kangaroo safety, 40 front, 18 rear.



Rear-driver tandem, 30-inch wheels.



Facile lever-action, 40 front, 18 rear.

REMARKS ON BOLTON U. S. PATENT, SEPTEMBER 29, 1804.

(*See cut, page* 36).

This early inventor, who had the honor of President Jefferson's signature to his patent, was a clever genius in his time. I am constrained to think he was of that school which believes in the inherent power of the gear wheel; at least the four wheels, where there is no demand for more than two, would suggest this idea. According to our present system of gauging, this machine is geared to about fifteen. Mr. Bolton, however, was a pioneer, and as such we must hold him in great veneration.

ENGLISH PATENT, DECEMBER 2, 1818.

(*See cut, page* 35.)

There has been considerable discussion anent the earliest bicycle inventor, but after all his name seems to have been "Dennis," or rather Dennis Johnson. As "Dennis" has been before us in the periodicals for a number of years, we will not dwell upon him; suffice it to say that his name will always hold the high place it deserves, as the first patentee of a single-track balancing machine.

CROFT AMERICAN PATENT.

The inventor, Mr. Croft, a cut of whose machine will be found on page 38, was one, and probably the earliest, of those who have deceived themselves with the idea that power could be increased by means of a solid grip on the ground, forgetting a common principle that, so long as the hold does not give way, one plan is as good as another in this respect. Below find a brief of his specification.

"UNITED STATES PATENT OFFICE.

"MATTHEW E. CROFT, OF HORICON, WISCONSIN.
IMPROVEMENT IN TRICYCLES.

(*See cut, page* 38.)

"The object of this invention is to furnish an improved tricycle, designed for use by mechanics and others for going to and from their places of business, by merchants and others for sending small parcels from one place to another, and by youths and others for amusement and exercise, and which shall be simple in construction and easily operated.

"To the stirrups J are pivoted the rear ends of two rods K, the forward ends of which are pivoted to the forward axle B, near its ends, so that the rider can guide and turn the machine with his feet.

"The rider propels the machine by means of two rods, L, which he holds in his hands, and which he presses against the ground. In starting, the rider presses both rods L against the ground at the same time, but after he has got up enough motion to give momentum to the machine, he can use the rods L alternately.

"If desired, a receptacle may be secured to the bolster E, to contain a lunch or other small parcels."

SOME EXTRACTS FROM VERY OLD ENGLISH PATENTS.

"A.D. 1691 June 12—No 269

GREENE, JOHN

New engines or carryages of certaine shapes and measures to be drawne or driven by man or beast upon one or more wheeles, wherein the lading carryed about with every revolution of the wheele, which for ease of the burthen or draft and labour exceeds all others that were ever yett invented or used, being of great benefit and service to the publique

"A.D. 1693 March 3—No 315

HADLEY, JOHN

Engines moved by wind, useful for drawing severall machines and carryages instead of horses

A.D. 1787 May 12—No 1602

GEORGE WATKIN—Anti-friction axle

The axis is surrounded by a number of rollers or cylinders

A.D. 1791 October 12—No 1829

The principle lies in the interposition of rollers

A.D. 1794 August 12—No 2006

VAUGHAN, PHILIP

The axle is provided with grooves for the reception of balls which serve as anti-friction rollers, the wave of each wheel being provided with grooves corresponding with those in the arms of the axle

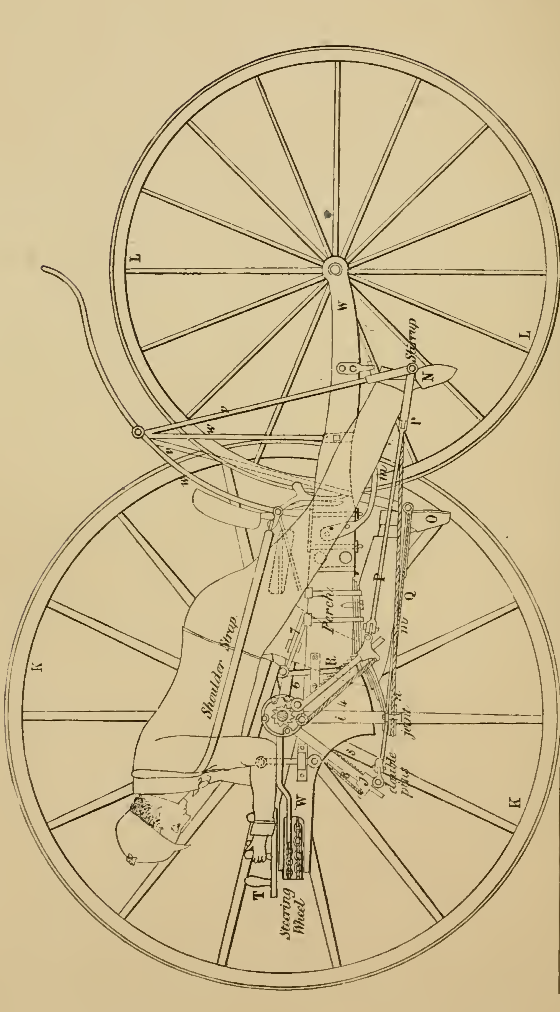
"PROPELLING CARRIAGES, VESSELS, &c.

"BRAMLEY AND PARKER'S SPECIFICATION.

(*One drawing of this patent is used as a frontispiece.*)

"To all to whom these presents shall come, we, Thomas Bramley, Gentleman, and Robert Parker, Lieutenant in the Royal Navy, both of Mousley Priory, in the County of Surrey, send greeting.

"Whereas His present most Excellent Majesty King William the Fourth, by His Letters Patent under the Great Seal of Great Britain, bearing date at Westminster, the Fourth day of November, One thousand eight hundred and thirty, in the first year of His reign, did, for Himself, His heirs and successors, give and grant unto us, the said Thomas Bramley and Robert Parker, . . . a patent for . . . Certain Improvements on Locomotive and other Carriages or Machines applicable to Rail and other Roads, which Improvements, or Part or Parts thereof, are also applicable to Moving Bodies on Water and Working other Machinery."



Side-view locomotion carriage, applicable to common roads. Bramley & Parker. English patent.

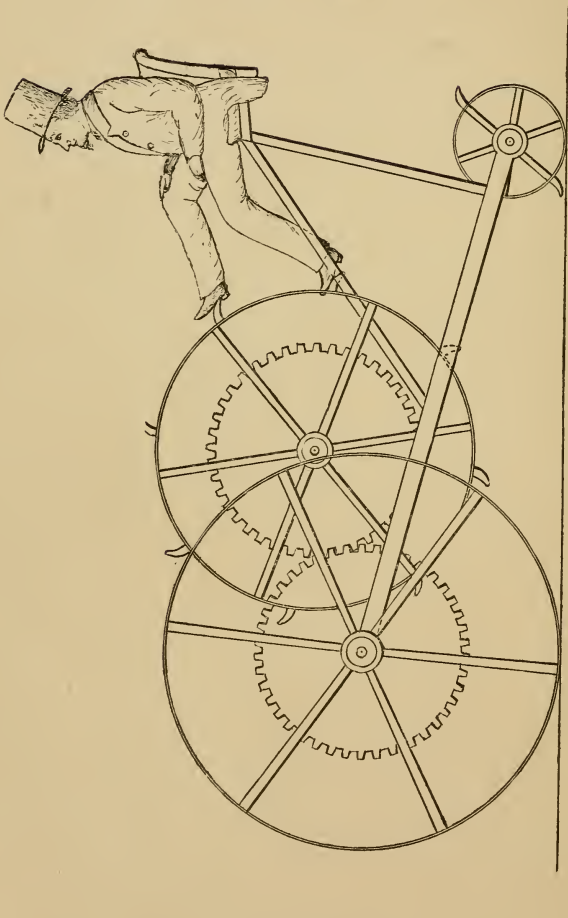
PROPELLING CARRIAGES, VESSELS, &c.

BRAMLEY AND PARKER'S SPECIFICATION.

(*Continued.*)

The cut on opposite page is a part of the Bramley & Parker English patent of 1830. These early inventors were apparently the original tandem makers, and they possibly originated the expression "lay down to the work." If the cuts fairly represent the inventors, truly no one can deny that they were handsome fellows, and that they deserve a greater reward than can be said to have accrued to them after the shades of fifty years have fallen upon this, probably the greatest effort of their lives. Below find another part of their specification, which illustrates the verbosity of legal language found in those, and to some extent in the present English patents.

". . . In which said Letters Patent is contained a proviso that we, the said Thomas Bramley or Robert Parker, or one of us, shall cause a particular description of the nature of my said Invention, and in what manner the same is to be performed, to be inrolled in His said Majesty's High Court of Chancery within six calendar months next and immediately after the date of the said in part recited Letters Patent, as in and by the same, reference being thereunto had, will more fully and at large appear."



A. Julien. French patent. June 30, 1830.

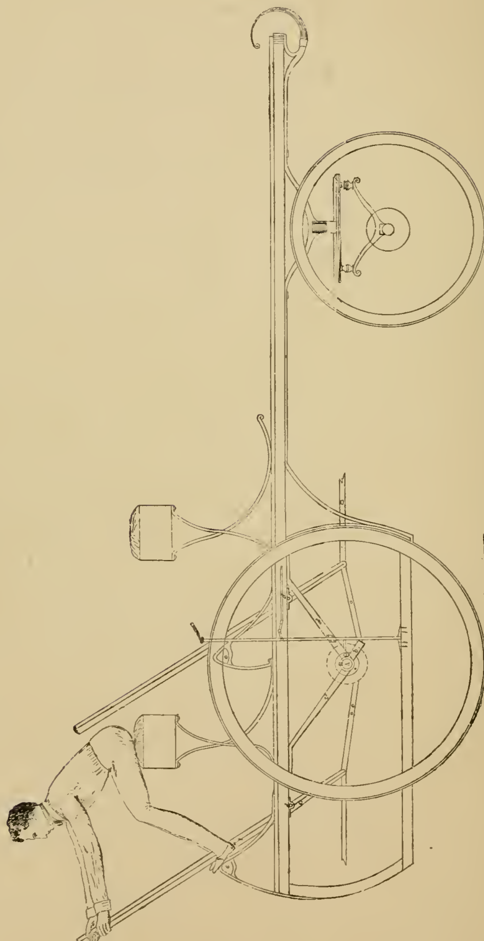
FRENCH PATENT.

M. JULIEN. JUNE 30, 1830.

The French patent to M. Julien, date of June 30, 1830, of whose machine a cut will be found on the opposite page, seems to be for a sort of combination of cycle and plough. It is to be inferred that M. Julien proposes to do up his ploughing, and then mount his cycle and off to town for an airing.

Jeering and contemptuous cyclers will be liable to overlook a novel and invaluable feature of this invention relating to security in descending long and dangerous hills. The rider can, by easy manipulation of certain simple and ingenious devices, lower the plough and thereby bring into operation a brake of great power and unquestionable holding-back proclivities. As to the steering, it does not appear, from the drawing, how this may be accomplished, but so fertile a brain cannot have left this necessary adjunct unprovided for.

That the machine can be worked with little exertion is implied by the skilful introduction, on the part of the draughtsman, of the chimney-pot hat which adorns the brow of the supposed agricultural gentleman upon the box, and also by the general appearance of ease and comfort which pervades the entire picture.



Cochrane. English patent. No. 6150. August 10, 1831.

"PROPELLING CARRIAGES AND VESSELS, DRIVING MACHINERY, &c.

"COCHRANE'S SPECIFICATION.

"TO ALL TO WHOM THESE PRESENTS SHALL COME, I, ALEXANDER COCHRANE, of Norton Street, Great Portland Street, in the county of Middlesex, Esquire, send greeting.

"AND BE IT REMEMBERED, that on the Tenth day of February, in the year of our Lord 1832, the aforesaid Alexander Cochrane came before our said Lord the King in His Chancery, and acknowledged the Specification aforesaid, and all and every thing therein contained and specified, in form above written. And also the Specification aforesaid was stamped according to the tenor of the Statute made for that purpose.

"Inrolled the Tenth day of February, in the year of our Lord One thousand eight hundred and thirty-two."

This rowing-motion carriage has been invented over again several times since 1831.

Dalzell machine, 1845.

"THE ORIGINAL BICYCLE.

" At the late Stanley Show was exhibited the machine which is now generally conceded to be the original bicycle. We present a cut of the machine reproduced from the *Scottish Cyclist*, also a representation of the features of the inventor, one Gavin Dalzell, a merchant of Lesmahgon, Lanarkshire, Scotland. Dalzell was born August 29, 1811, and died June 14, 1863. He possessed decided talent for mechanical inventions. From the written testimony of a letter, and the testimony of J. B. Dalzell, son of the inventor and present owner of the machine, it is proved that it was in use previous to 1846, and there are eye-witnesses who recollect the inventor riding his bicycle over the roads of Lanarkshire.

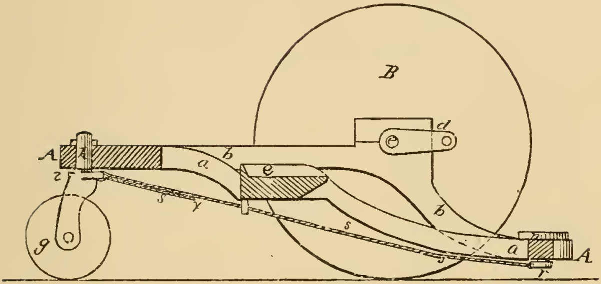
"In construction the Dalzell bicycle is the exact prototype of the now popular rear-driving safety.

"It is constructed chiefly of wood, which, though worm-eaten, is still wonderfully strong, especially in the wheels, these seeming to have stood the ravages of time and rough usage much better than the frame-work. The rear wheel—the driver—is of wood, shod with iron, about forty inches in diameter, and has twelve spokes, each about an inch in diameter. The front wheel is of similar construction, but only of about thirty inches in diameter. From the front wheel hub the fork—straight, and with a rake which some of our modern makers could copy with profit—passes up, and is joined together, through the fore-part of the wooden frame-work. A pair of handles are then attached and bent backward into a V shape to suit the rider, who sits about two feet behind the front-wheel hub. These were commonly termed the 'reins.' The main frame is somewhat like that which is now termed the 'dip' pattern, the design of which is applied in an extended form to ladies' safeties.

"A wooden mud-guard rises from this frame, covering about one-fourth of the circumference of the hind wheel; from this to the back forks, which are horizontal, and of wood, vertical flat stays run down, forming a dress-guard after the manner of those on the latest cycling development,—the ladies' safety. The action thus obtained is not rotary, being a downward and forward thrust with return, the feet describing a small segment of a circle. That the gearing, which constitutes the chief wonder to the critical and historical reader, was actually on the machine while being ridden by Mr. Dalzell, is proved by the receipted accounts of the blacksmith, John Leslie, who made all the iron-work used in its construction."—"Bi News," in *The Wheel.*

E. Landis. Velocipede. No. 29,288. Patented July 24, 1860.

This inventor, a Baltimorean, was probably not aware, at the time, that he was one of the earliest cycle inventors. The cut gives a clear illustration of working parts, the motion being quite like that of horseback riding. This patent might be considered an anticipation of the broad principle of the rear-driver as shown in some later machines.



C. A. Way. Velocipede. No. 71,561. Patented November 26, 1867.

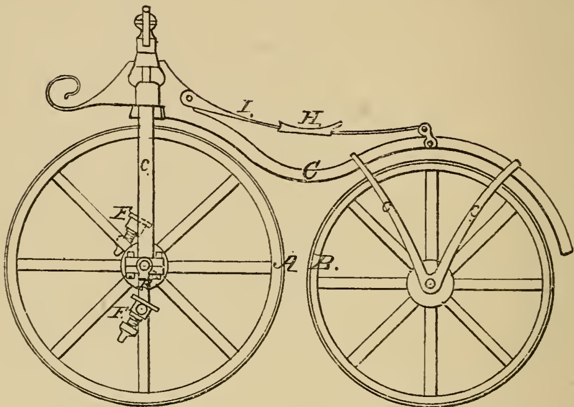
"*To all whom it may concern:*

"Be it known that I, CHARLES A. WAY, of Charlestown, in the county of Sullivan, and State of New Hampshire, have invented certain new and useful Improvements in Velocipedes.

"This invention consists in a novel arrangement of cranks and short axles with reference to the seat, side rails, and supporting-wheels of a velocipede, whereby the wheels may be operated to propel the apparatus with much greater facility than if the cranks were attached directly thereto.

"The invention further consists in so arranging the cords that work the guiding-caster that they shall cross each other in such manner as to act more directly and consequently more efficiently upon the said caster than as hitherto applied."

Not apparently made for anybody to ride; "but in other respects a very good" velocipede.



P. Lallement. Velocipede. No. 59,915. Patented November 20, 1866.

"*To all whom it may concern:*

"Be it known that I, PIERRE LALLEMENT, of Paris, France, temporarily residing at New Haven, in the county of New Haven and State of Connecticut, have invented a new Improvement in Velocipedes; and I do hereby declare the following, when taken in connection with the accompanying drawings, and the letters of reference marked thereon, to be a full, clear, and exact description of the same, and which said drawings constitute part of this specification.

"My invention consists in the arrangement of two wheels, the one directly in front of the other, combined with a mechanism for driving the wheels, and an arrangement for guiding, which arrangement also enables the rider to balance himself upon the two wheels.

"By this construction of a velocipede, after a little practice, the rider is enabled to drive the same at an incredible velocity with the greatest ease.

"Having, therefore, thus fully described my invention, what I claim as new and useful, and desire to secure by Letters Patent, is—

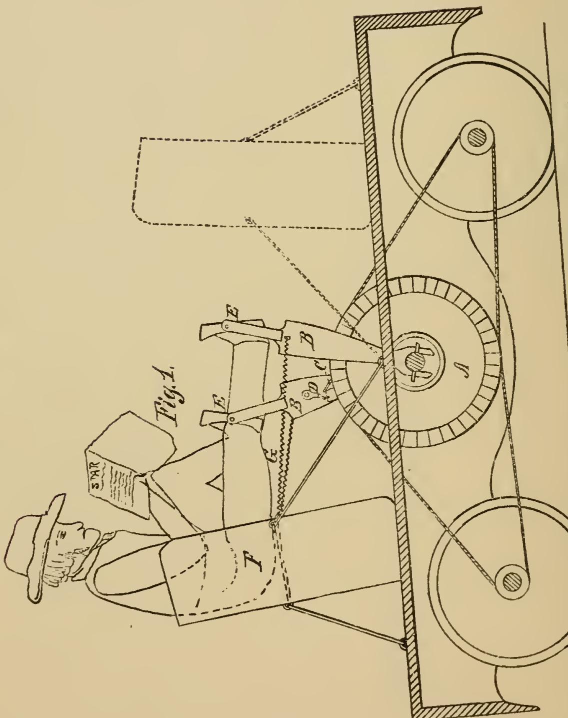
"The combination and arrangement of the two wheels *A* and *B*, provided with the treadles *F* and the guiding-arms *D*, so as to operate substantially as and for the purpose herein set forth.

"PIERRE LALLEMENT."

This inventor has generally been accredited as being the first to apply cranks to the single-track machine; but priority is now claimed by Dalzell. If this claim be valid, Lallement would have to confine himself to the honor of being the first to apply the feet directly to the cranks, and to being the first patentee.

It is stoutly maintained in Coventry that others had applied cranks, in a manner similar to that described in the foregoing specification, some time prior to the date of this patent; it is fair to say, however, that Lallement was the most energetic in pushing his invention, and that he did as much, if not more, than any other man in the great work which has now assumed such mammoth proportions.

Considering the short time it has taken to firmly establish this new and useful mode of locomotion as a recognized necessity to mankind, there is little need to quarrel over the exact division of the honors; there is enough for all, and all will be in time duly credited with their respective claims.



W. C. Moores. Velocipede. No. 42,678. Patented May 10, 1864.

"UNITED STATES PATENT OFFICE.

"WM. C. MOORES, OF BLOOMFIELD, WISCONSIN. IMPROVEMENT IN ECONOMIZING HUMAN POWER.

"The object of this invention is to furnish means whereby the strongest muscles of the human body may be advantageously used in propelling machinery, whether for locomotion or for stationary work, thus cheapening motive power.

"What I claim as my invention is,—

"1. The ratchet-wheel *A*, with its notches cut in each direction and worked by means of the levers *B*, *B*, with the pawls *C*, *C*, and springs *D*, *D*, as described.

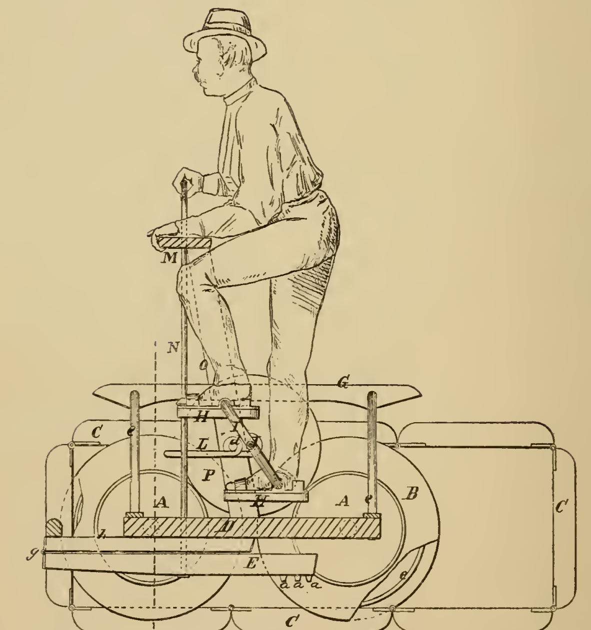
"2. In combination with the above, the treadles *E*, *E*, attached to the ends of the levers *B*, *B*, constructed in box form, as described.

"3. The seat *F*, constructed as described, when used in combination with the ratchet-wheel *A*, levers *B*, *B*, and pawls *C*, *C*, and treadles *E*, *E*, and springs *G*, *G*, all arranged as set forth.

"Wm. C. Moores."

If this lever-motion had been properly claimed, and his tilting pedals adroitly covered by patents, he might have given no end of trouble to future manufacturers; but he lived too soon; his patents would have all expired ere they would have been useful in the art as later developed.

Mr. Moores claims "a machine for economizing human power," which shows that his ideas were broad, or at least those of his attorneys were for him.



O. T. Gleason, of Maine. Velocipede. No. 77,478. Patented May 5, 1868.

GLEASON SPECIFICATION.

"The object of this invention is to obtain locomotion by the direct application of the weight of the operator.

"An endless track, composed of the hinged parts *C, C, C*, as shown, loosely close each of the two wheels on a side, and are kept in proper position by means of the flanges *B* of the rolling wheels as shown.

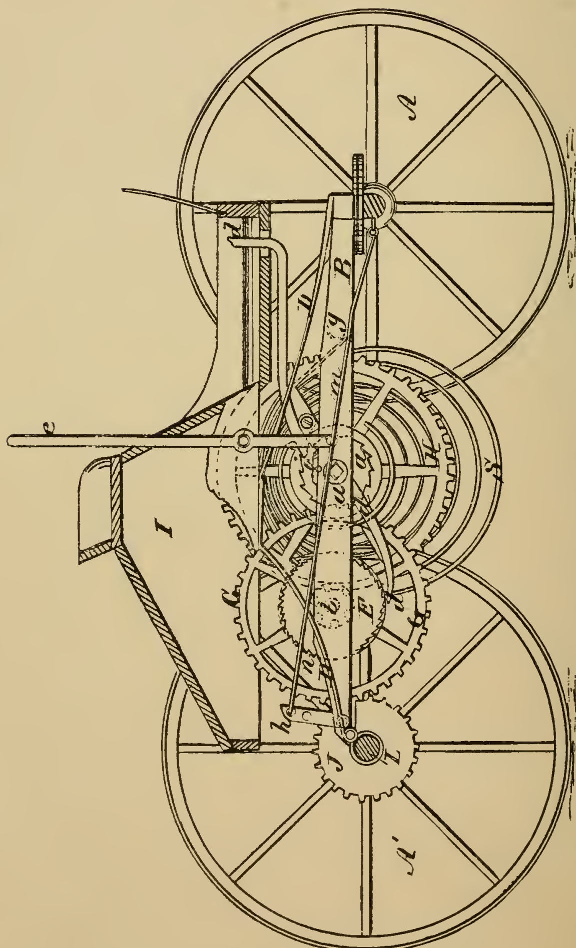
"By this means the track is laid in front of the wheels, and passes over from the rear of the same in an endless belt, as shown.

"The guide-rails *G* are suported above the traction-wheels, by means of arms *e*, as shown, and prevent the jointed track from leaving the flanges.

"When a level pavement is available, or the ordinary road is of sufficient evenness, the jointed track may be dispensed with, and the traction-wheels used directly upon the ground or pavement.

"In this case the flanges *B*, being disks of sheet metal, attached by means of bolts to the traction-wheels, are readily removed."

Mr. Gleason was determined to prevent slipping of the wheels in climbing hills, and probably succeeded. We have not seen any of the machines on the market, but they are, no doubt, all right. The draughtsman did well to show the rider with his coat off; the work would in all probability keep him warm enough.



T. Rhoads. Velocipede. No. 76,814. Patented April 14, 1868.

"UNITED STATES PATENT OFFICE.

"THOMAS RHOADS, OF FISKILWA, ILLINOIS. IMPROVEMENT IN PROPELLING VEHICLES.

"This invention relates to the propelling of vehicles for practical use, and consists of the spring and wheel-work mechanism attached thereto, as will be set forth in the following.

"The propelling power is derived from the spring *S*, which is affixed to a cross-rod in the frame, as indicated at *g*.

"The other end of the spring is attached to the shaft of the wheel *H*, in the usual manner.

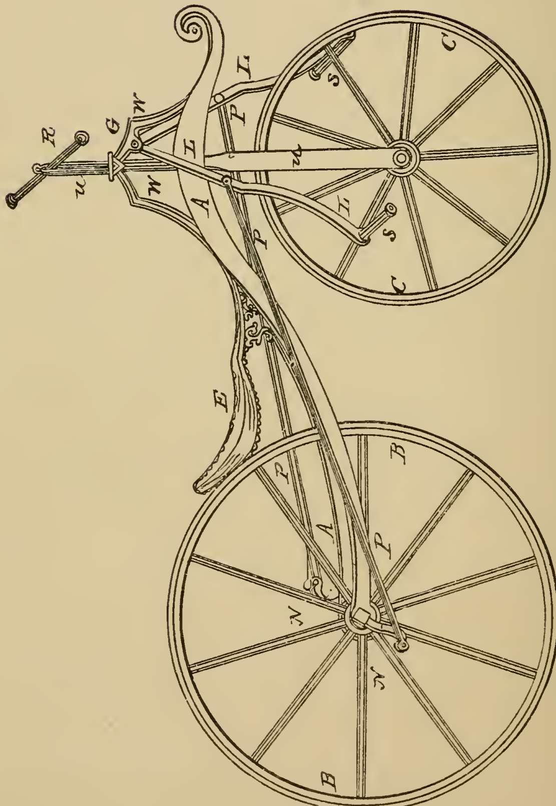
"By this invention, vehicles may be propelled on common roads, with more or less speed, according to the level or uneven character of the road.

"Its advantage, in dispensing with the use of horses, is obvious.

"I claim as new, and desire to secure by Letters Patent,—

"1. The arrangement, with relation to the revolving shaft *L*, carrying the wheels *A′*, of the wheels *G*, *H*, *J*, pinion *b*, and spring *S*, as herein described, for the purpose specified."

This is a fair sample of "deriving power from springs." The poor horse will now have his long-needed rest.



S. F. Estell, of Richmond, Ind. Velocipede. No. 87,033. Patented February 16, 1869.

ESTELL SPECIFICATION.

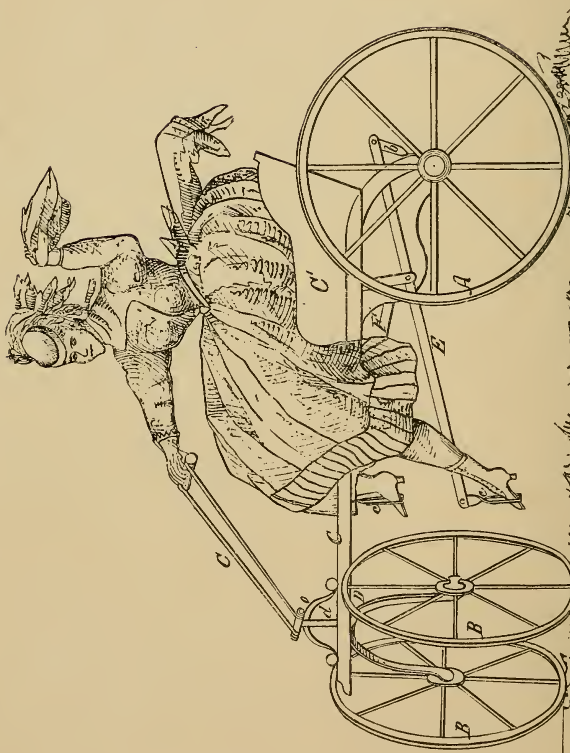
"The nature of my invention relates to an improved method of constructing velocipedes, whereby the propelling-power is communicated to the hind wheel by means of cranks and shafts, or pitman-rods, the latter being connected at their forward ends with levers, that are worked with the feet.

"What I claim, and desire to secure by Letters Patent, is,—

"The velocipede, in which the brace *W* is secured to the front part of the reach forming part of the bearing for the vertical shaft *U*, and supports for the pendent levers *L*, *L*, secured to the brace, one on each side, in combination with rods *P*, *P*, connected with cranks *N*, and attached to the pendent levers *L*, *L*, by means of pivots, all combined as herein shown and described.

"SAMUEL F. ESTELL."

This is almost an exact copy of the Dalzell contrivance, alleged to have been made in 1845–46. The greatest fault in this system consists in the direction of application of power, being a forward thrust instead of a downward. The machine has merit, however; and should have been heard from in the early days of cycling.



"VELOX."

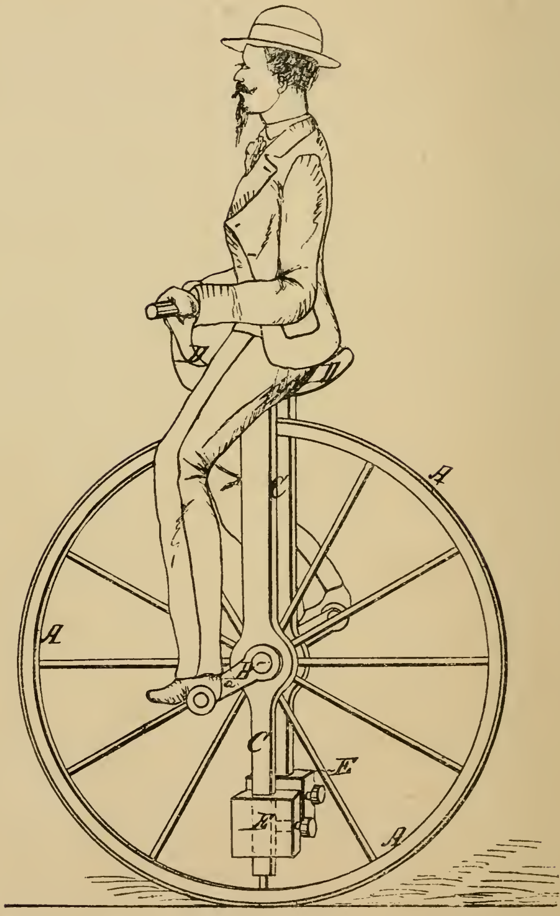
A. Christian and J. Reinhart. Velocipede. No. 87,245. Patented February 23, 1869.

REMARKS ON PATENT TO CHRISTIAN AND REINHART. VELOCIPEDE.

This drawing is a fine illustration of the practice of draughtsmen, in which they essay to impress upon the office and the public, by means of their deft pencils, the miraculous speed and easy locomotion attainable in their clients' devices.

This drawing has always been an amusing one to me, a bright spot in the tedious work of going through the patent files. Some wag of the office, having been similarly struck with the humor of this picture, embossed beneath the principal figure, in a large bold hand, the simple word "VELOX." Now, I never happened to have a lexicon at hand in which to look up the exact meaning of the word, but I did not, for one moment, doubt its appropriateness. There seemed to be something in the word that carried conviction with it; if it did not mean anything pertinent to the subject, there was always a feeling that it ought to. In scanning patent drawings, in this art, I always turned "Velox" down so that when wearied by the toil of research, I could turn over the papers and smile at "Velox."

The modern drop-frame for tricycles and rear-driving bicycles would be a valuable improvement on Messrs. Christian and Reinhart's invention; some of our ladies would object to a free exhibition of quite so much shoe-top.



T. W. Ward, of New York. Velocipede. No. 88,683. Patented April 6, 1869.

"The drawing represents a perspective view of my improved one-wheeled velocipede.

"This invention relates to a certain improvement on that class of one-wheeled velocipedes in which the driver's seat is arranged above the wheel, it being pivoted to the axle of the same.

"The invention has for its object to provide for an easy balancing of the frame, and consists in attaching weights to the lower end of the seat-frame, whereby the same will be retained in a vertical position.

"The balance can, with this weight-attachment, not be so readily lost as without it, and the operation of the one-wheeled velocipede is made easier and more practicable.

"From the lower ends of the frame are suspended, as near to the ground as possible, weights *E*, *E*, which tend to keep the frame in a vertical position, and which are intended to balance the weight of the rider, so that the difficulty of holding the seat in the desired direction, above the axle, will be considerably reduced.

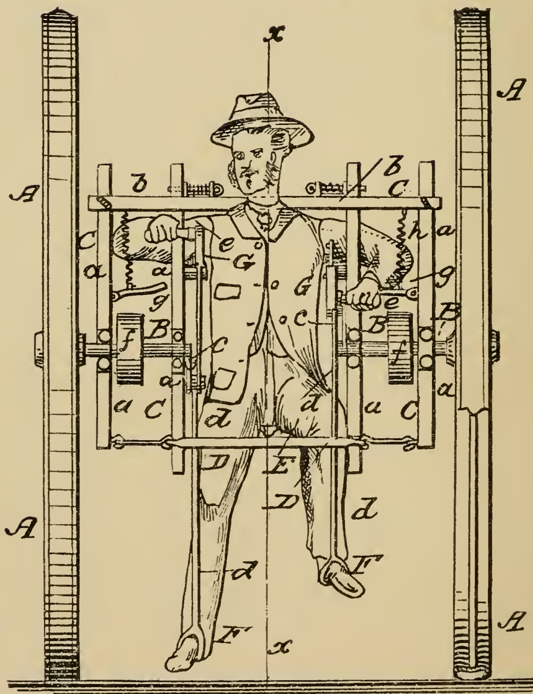
"The velocipede may be propelled by means of foot-cranks *a*, *a*, or by other suitable mechanism.

"Having thus described my invention,

"What I claim as new, and desire to secure by Letters Patent, is,—

"The weights *E*, *E*, suspended from the lower ends of the frame *C* of a one-wheeled velocipede, for the purpose of balancing the frame, substantially as herein shown and described. THOMAS W. WARD."

How Mr. Ward proposed to steer is not made quite plain. The claim is strong, and the invention was really never patented before. Any one wishing to use it can do so now, however, as the patent has expired. I wish to call attention to the fact that the combined weights E, E, as arranged in drawing, need not exceed five hundred pounds in order to balance a hundred-and-sixty-pound man.



J. J. White, of Philadelphia. Velocipede. No. 88,930. Patented April 13, 1869.

WHITE SPECIFICATION.

"*To all whom it may concern:*

"Be it known that I, JOHN J. WHITE, of Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented a new and Improved Velocipede.

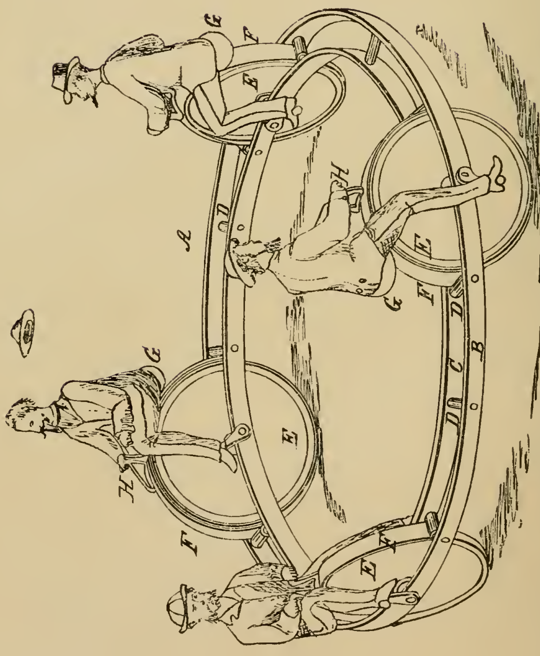
"This invention relates to a new velocipede, which consists entirely of two wheels and their connecting-axles, the axles supporting a frame in which the seat and driving-gear are arranged, so that they can be conveniently operated. The wheels can, with this arrangement, be made very large, to obtain great velocity, and the whole apparatus can be made light and convenient.

"The invention consists in the general arrangement of the apparatus, and, furthermore, in the special arrangement of a hinged seat which can be swung down when on going up-hill the rider desires to leave the seat and walk with the vehicle.

"The invention also consists in the application of convenient brakes, by means of which the instrument can be conveniently stopped and steered.

"The neck of the driver rests against the upper bar, *b*, which is hollowed for its reception, and which can be adjusted up and down on the bars *a*, to be adapted to the size of the rider."

Mr. White has at least provided some way to stop, and also to "walk with the vehicle," if he should so desire, which we think he probably would.



Sturdy & Young, of Providence, R. I. Velocipede. No. 89,700. Patented May 4, 1869.

SOME YOUNG AND STURDY "CHILDREN OF LARGER GROWTH" INVENT A WHIRLIGIG.

"This invention relates to a new and useful improvement in velocipedes, whereby they are better adapted to be employed as a medium of amusement and exercise for children and youth, as well as for '*children of a larger growth.*' It is chiefly designed for use in play-grounds, lawns, gardens, and play-rooms; and

"The invention consists in rotating a large horizontal wheel, formed of two concentric rings, tied together by bars, and supported on vertical wheels, each of which is revolved, by means of cranks, with the feet, after the manner of the common velocipede, thus rotating the main wheel, the construction, arrangement, and operation being as hereinafter more fully described.

"The accompanying drawing is a perspective view of the combined velocipede, showing the manner of its construction and operation.

"*A* represents the double-rimmed wheel, which may be made of any required diameter, and of any suitable material, and in any equivalent manner.

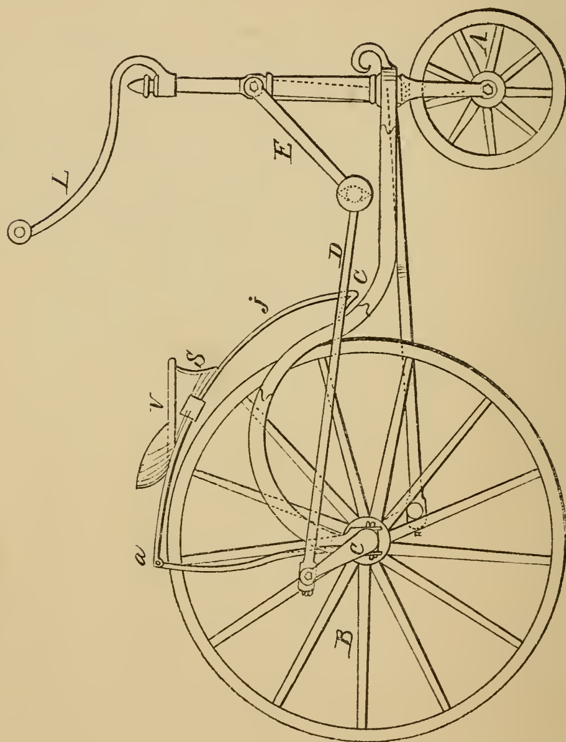
"We do not confine ourselves to propelling by the feet exclusively. The driving-wheels may be rotated by the hands, as in some descriptions of velocipede, or by the feet and the weight of the body combined, as in the rocking-saddle kind.

"Having thus described our invention,

"What we claim as new, and desire to secure by Letters Patent, is,—

2. A velocipede formed of a horizontal wheel or rim, when supported on vertical wheels adapted to be rotated by means of cranks, substantially as set forth.

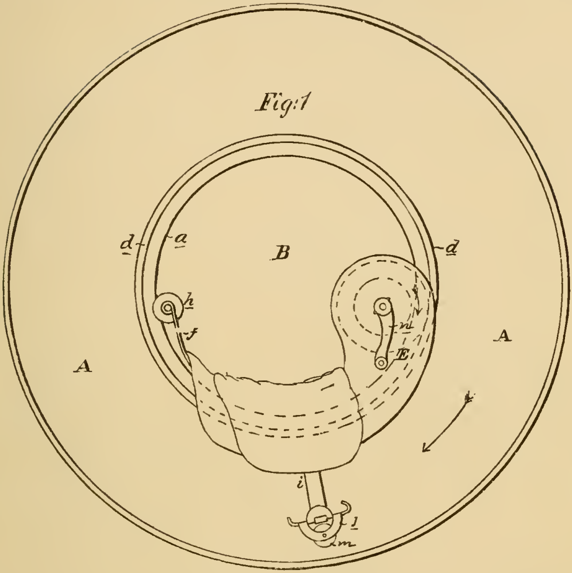
"GEORGE J. STURDY.
"SOLOMON W. YOUNG."



B. S. Lawson. Velocipede. No. 90,563. Patented May 25, 1869.

"My invention relates to velocipedes; and it consists mainly in a seat-spring of novel construction, upon which the seat is made adjustable in a novel manner."

This is another of the Dalzell patterns. The mechanism is not claimed in the patent, as will be noticed from the above brief.

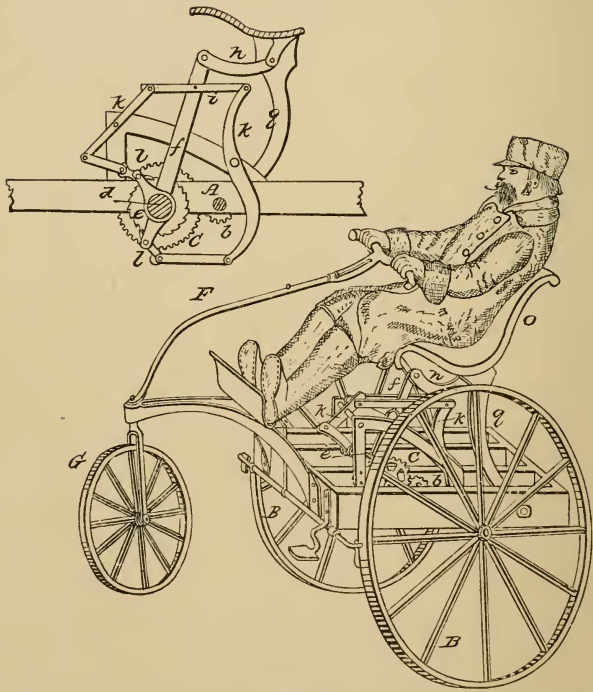


L. B. Flanders, of Philadelphia. Velocipede No. 91,534. Patented June 22, 1869.

"The steering of the velocipede may be readily effected by the movement of the body, or by bringing one or other of the stirrups in contact with the ground. Owing to the roller on the stirrup, its contact with the ground will not interfere with the convenience of the operator.

"Although I have shown the driving-wheel as arranged for being operated by hand, the ordinary treadle-devices used in connection with common velocipedes may be employed, so as to impart the desired movement to the wheel by the legs and feet of the operator."

This monocycle inventor has not forgotten to provide a means of steering, which is done by the stirrups. Simply tilting the body will not answer.



F. Schmitt, of Springfield, Ill. Velocipede. No. 91,169. Patented June 8, 1869.

SCHMITT SPECIFICATION.

"The nature of my invention consists in constructing a velocipede with three wheels, one in front, for a guide, the other two in rear, connected together by a revolving axle.

"The motive-power is communicated to the velocipede by means of machinery over the revolving axle and under the seat, which machinery is put in operation by the weight of and backward or forward motion of the occupant of the seat, or rider.

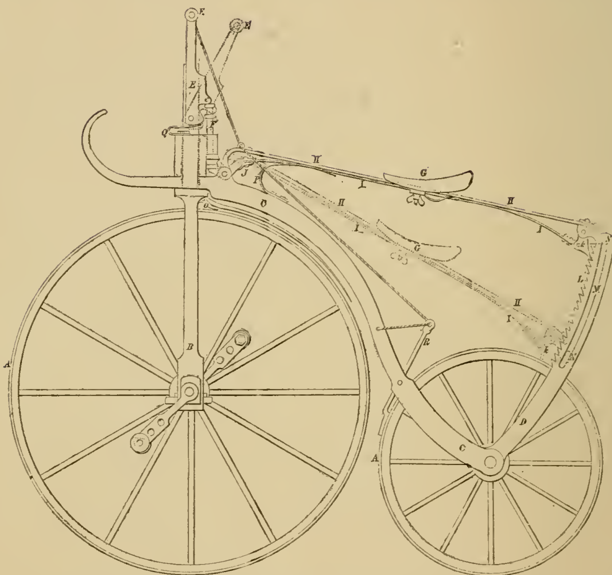
"The operation of this machinery is as follows:

"The weight of the rider upon the seat *o*, and a slight movement backward or forward causes the seat-support *g* to move backward or forward, which motion is communicated to the upright lever *f* by the connecting-bar *h*, which in turn starts the revolution of the driving-wheel axle *l*.

"This movement of the lever *f* also gives a corresponding movement to the jointed levers *k*, *k*, and in such a way that one lever, *k*, is moving backward while the other is moving forward, and so one of the snappers, *l*, is always caught in the ratchet-wheel *e*, and assisting in the revolution of the driving-wheel axle *d*, and in this way the impelling force of the machine never ceases for an instant.

"This revolution of the ratchet-wheel *e* forces the revolution of the driving-wheel *c*, which, by its connection with the pinion *b*, forces the revolution of the axle *A* and wheels *B*."

This patent shows a clever method of transmitting power by means of an oscillating motion of the body, and is valuable as a curiosity. The overcoat might be dispensed with, however, as it is not probable that the rider would need it even on the coldest of days.



Leftwich's Specification, English. No. 2173. July 19, 1869.

"SPECIFICATION in pursuance of the conditions of the Letters Patent, filed by the said William Leftwich in the Great Seal Patent Office on the 18th January 1870.

"TO ALL TO WHOM THESE PRESENTS SHALL COME, I, WILLIAM LEFTWICH, of Tufnell Park West, Holloway, in the County of Middlesex, send greeting.

"WHEREAS Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the Nineteenth day of July, in the year of our Lord One thousand eight hundred and sixty-nine, in the thirty-third year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the said William Leftwich, Her special licence that I, the said William Leftwich, my executors, administrators, and assigns, or such others as I, the said William Leftwich, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for 'IMPROVEMENTS IN CONSTRUCTION OF VELOCIPEDES.'

"Having thus described and ascertained the nature of my said Invention, and in what manner the same is to be performed, I would observe in conclusion that what I consider novel and original, and therefore claim as constituting the Invention secured to me by the said herein-before in part recited Letters Patent is, the combination and arrangement of parts and mechanism for lowering the saddle bars of '*bicycles*,' substantially as herein-before described and set forth, or any mere modifications thereof."

This is one of the earliest patents using the word *bicycle.* The method of raising the saddle while in motion might be used to scare off the dogs or to raise yourself up out of their way, but is of doubtful utility in other respects.

Richard C. Hemmings, of New Haven, Conn. Velocipede. No. 92,528.
Patented July 13, 1869.

HEMMINGS SPECIFICATION.

"This invention relates to a new and improved method of constructing and operating velocipedes, whereby they are made more durable, and at less expense, than heretofore; and

"It consists in rotating a traction-wheel, by means of a traversing-wheel bearing on its inner surface, and revolved by the operator within the rim of the wheel, as hereinafter more fully described.

"The propelling-power is applied to the band-wheels *E* by means of the hand-cranks *f*, *f*, leaving the feet of the operator at all times free.

"In starting the velocipede, the first movement is given by the operator's running or walking a short distance on the ground while astride the saddle. When a start is thus obtained, the motion is readily continued by turning the pulleys *E* with the hands.

"When the weight is below the centre, and the feet near the ground, and always free, very little difficulty is experienced in balancing and guiding the machine; and, as numerous experiments have proved, the ease with which it is worked and the velocity obtained render it quite equal, if not superior to any velocipede in use, while the expense of constructing them is far less.

"Having thus described my invention,

"I claim as new, and desire to secure by Letters Patent,—

"1. In combination with a single-wheeled velocipede, the reach *C*, with its guide-pulleys *e*, *e*, and traverse wheel *B*, arranged substantially as and for the purposes herein shown and described.

"2. The combination of the traction-wheel *A* with the traverse-wheel *B*, substantially as and for the purposes herein shown and described.

"RICHARD C. HEMMINGS."

S. Wortmann, of New York. Velocipede. No. 93,030. Patented July 27, 1869.

An early tandem showing the true sociability of the same; observe the peaceful harmony of the city gentleman, with chimney-pot hat, and the sombreroed cow-boy.

WORTMANN SPECIFICATION.

"This invention relates to a new vehicle, which is to be propelled by the upper or lower extremities of the person or persons which it supports, and which is provided with a fly-wheel in such a manner that the same may at will be thrown into or out of gear. This fly-wheel will gather power in going down-hill, and will then give it up in going up-hill, thereby facilitating the ascending of hills, and preventing too great rapidity while going down-hill.

"The invention consists in the general combination of parts, whereby two persons may be accommodated on the vehicle, and also in the aforementioned arrangement of the fly-wheel.

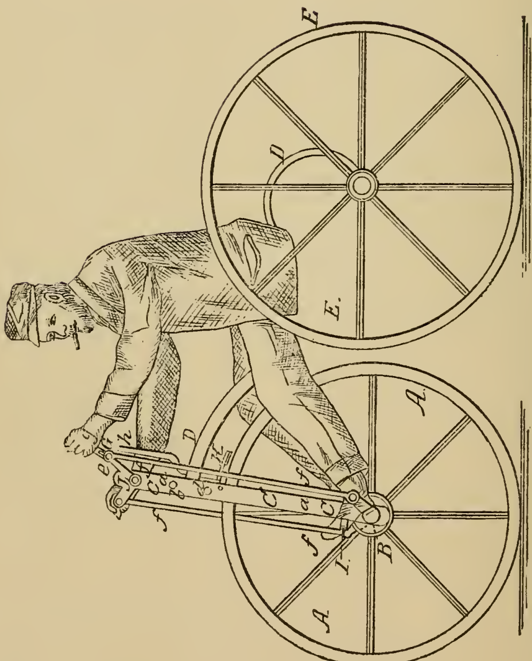
"When the fly-wheel is thrown into gear, as aforesaid, it will serve to gather power, to facilitate the riding up-hill, and to steady the motion down-hill.

"2. The fly-wheel *K*, mounted on a separate shaft, *J*, the sliding pinion *f*, in combination with the lever *g*, substantially as herein shown and described, for the purpose specified.

"The above specification of my invention signed by me, this ninth day of June, 1869.

"SIMON WORTMANN."

You will have to make that front man do some work, Simon, or you will fall behind the band-wagon in spite of your fly-wheel.



S. H. Sawhill, of Cambridge, Ohio. Velocipede. No. 93,751. Patented August 17, 1869.

SAWHILL SPECIFICATION.

"This invention relates to a new two- or three-wheeled velocipede, which is to be propelled by hand, and which is so constructed that it can be easily operated, and that the body will be sustained in the most advantageous position.

"The invention consists in several improvements of the driving-mechanism, of the foot-supports, and steering-mechanism, which, separately or combined, tend to produce a simple and convenient apparatus.

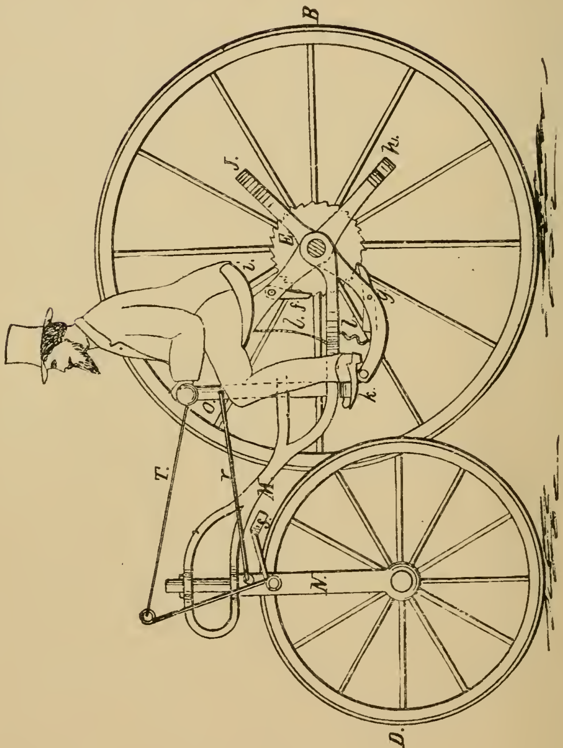
"*A*, in the drawing, represents the front wheel of my improved velocipede.

"The rider, holding the feet on these fixed bars *I*, can readily, and by an imperceptible motion, turn the post to guide the apparatus in any desired direction.

"I claim as new, and desire to secure by Letters Patent,—

"1. The steering-post *C*, constructed, as described, of the two parallel bars *a*, *a*, hung upon the crank-axle *B*, and connected by the plates *b*, *d*, between which the end of the reach *D* is pivoted, said post being provided at its upper end with the crank-shaft *J*, and near its lower end with the foot-rests *I*, as herein described, for the purpose specified."

Another manumotor carriage. Had the inventor ever attempted to climb some of the hills to be seen in Maryland, I fear he would have sacrificed his ambition, let the idea go unheralded to the world, and saved his patent fee.



G. Lowden, of Brooklyn, N. Y. Velocipede. No. 96,128. Patented October 26, 1869.

"There are only a few of us left."

"This invention relates to a new and useful improvement in velocipedes, and consists in the method in which power is applied for driving it.

"Power is applied to this ratchet by means of the pawls *f* and *g*, the former of which is pivoted to the frame *h*, and to which the saddle *i* is attached; the other pawl is pivoted to the frame J, to which the foot-pieces *k* are attached.

"When the weight of the rider is thrown either upon the saddle or upon the foot-pieces, the pawls act upon the ratchet-wheel, and rotate the axle.

"As before stated, motion is given the velocipede by working the pawls in the ratchet-wheel, as the weight of the rider is thrown alternately upon the saddle and upon the foot-pieces.

"This operation gives him the motion and exercise of a *horseback* ride.

"No crank is employed, and consequently the vehicle may be started at any point, and the operating parts being attached to and supported by the main axle, there is nothing likely to break or get out of order.

"Having thus described my invention,

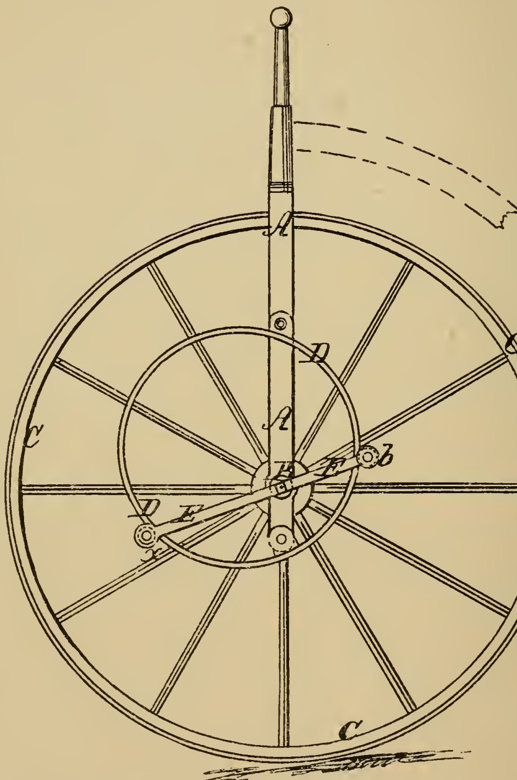
"What I claim as new, and desire to secure by Letters Patent, is,—

"1. In combination with a velocipede, the ratchet-wheel *E*, pawls *f* and *g*, and yokes *h* and *J*, arranged and operating on the axle *A*, substantially as described.

"In combination with the ratchet-wheel *E* and weighted yokes *h* and *J*, the reach *M*, post *O*, brake *S*, and rods *r*, arranged substantially as described, for the purposes set forth.

"GEORGE LOWDEN."

Only get the motion of a man on horseback, and our early cycle inventors thought the goal was reached. One would almost think that this motion was what gave power to the horse in those days.



E. A. Lewis, of Missouri. Velocipede. No. 96,124. Patented, Oct. 26, 1869.

"This invention has for its object to so construct the cranks of velocipedes that they are made longer where the greatest power is required, without increasing the diameter of the circle to be described by the foot.

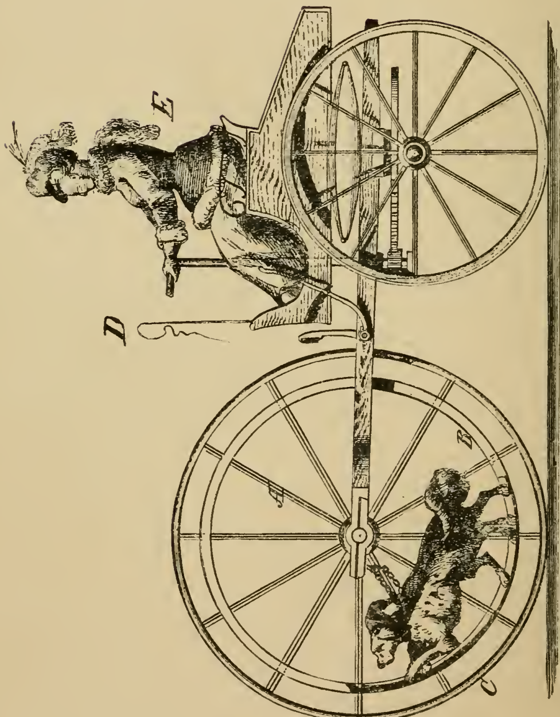
"The invention consists in the use of sliding cranks, which project from both sides of the shaft.

"One end of each crank is guided by a fixed eccentric groove or track, in such manner that the crank-pin is moved away from the shaft as long as the power is applied to the same by the foot. When the power is not required, on the return stroke, the crank-pin is drawn close to the shaft, and thus, without describing a large circle, the crank-lever is made longer than usual, when required.

"Thus, a twelve-inch crank-bar can produce a nine- or ten-inch working-crank, while the crank-pin describes a circle of not more than twelve inches diameter. Heretofore, a twelve-inch circle was described by a six-inch crank. Greater leverage and power are thus obtained by my invention.

"EDWD. A. LEWIS."

This is one of the most deceptive schemes in cycle history; if it worked as the inventor implies, we should have perpetual motion in fact. A man cannot transmit power to the wheel while the crank is coming up, except the little he can get by ankle-motion. A close examination will show that, whereas the crank is longer, the man has a proportionally less number of degrees through which he can drive it. Time, as well as force, enters into the problem of driving a bicycle; the time is equal to the number of degrees the crank travels through; here a man only has one-third, or less, of the circle, through which he has any power to turn the wheel. It is of no advantage to have one-third longer leverage if you have one-third, or over, less time, or number of degrees, to transmit power. The enormous mistake of this inventor consists in the fact that it would actually be better if he transmitted his power through the arc of short, rather than that of the long, leverage. If you do not increase your vertical amplitude, or resultant, depend upon it you cannot increase your power unless, at least, you push through a comparable number of degrees at better advantage.



F. H. C. Mey, of Buffalo. Velocipede. No. 109,644. Patented November 29, 1870.

"*To all whom it may concern:*

"Be it known that I, F. H. C. Mey, of Buffalo, in the county of Erie and State of New York, have invented a new and improved Dog-Power Vehicle.

"This invention relates to vehicles which move from place to place on roads, pavements, etc., and consists in an improved construction thereof.

"*A* is the driving-wheel, which in this instance is in the front of a vehicle having three wheels, but may be in the rear, if preferred, or in any other location.

"The animals being placed in this tread-rim, as represented in Fig. 2, and caused to work, will impart motion to the wheel and to the vehicle, as will be clearly understood.

"Having thus described my invention,

"I claim as new, and desire to secure by Letters Patent,—

"The combination of wheel *A B C* with a pair of wheels and body to form the running-gear of a vehicle, in the manner shown and described.

"F. H. C. Mey."

The claim could have been greatly improved by including the whip *D* and female *E* in the combination; at least, it is certain that these two elements would be needful. Two twenty-five pound dogs would hardly tread-mill a hundred-pound vehicle and a hundred-and-fifty-pound female up some of the Baltimore hills.

J. L. Hornig, of Jersey City. Velocipede. No. 191,145. Patented May 22, 1877.

HORNIG SPECIFICATION.

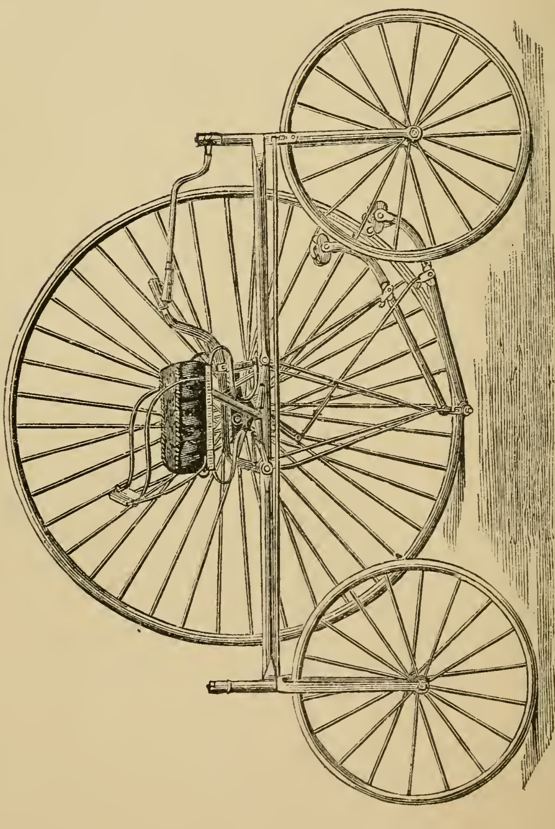
"The saddle *I* may be made adjustable longitudinally on the balance-beam *E*, or it may be made to slide thereon longitudinally.

"A hand-lever, *K*, pivoted to the reach, and connected with the crank *g*, serves to throw the crank off the centre in starting the vehicle.

"The saddle *I* may be a side-saddle for ladies' use, and two removable saddles may be provided for a single vehicle, one of which may be a side-saddle, and in this way a single velocipede may be used either by a gentleman or lady, or by boys and girls.

"The operation of the invention is as follows: The rider throws his weight alternately on the treadle and on the seat, rising on his feet when throwing his weight on the treadle, and lowering himself upon the saddle again, *as in riding a galloping horse.* In this way the entire weight of the body is utilized, both in rising and falling, to propel the vehicle, the muscles being used in a far more advantageous manner, and furnishing a much more healthful exercise than in the propulsion of a velocipede by the use of first one foot and then the other in the highly-disadvantageous method of applying muscular power heretofore employed."

Good for Mr. Hornig! But he will have to get his galloping velocipede on the market pretty soon or his patent will expire.



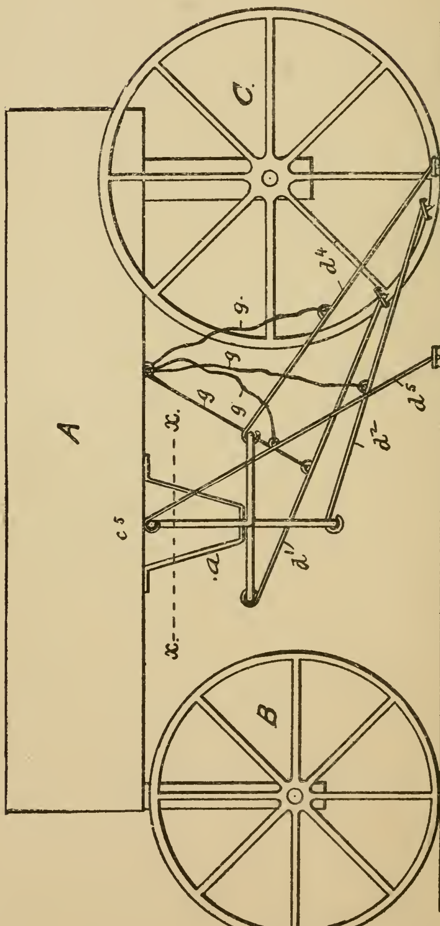
Scientific American, September 1, 1877.

"THE COVENTRY TRICYCLE.

"The tricycle, as it is designated, shown in the accompanying engraving, consists of a rectangular frame made of iron or steel tube, which carries a double-cranked shaft in patent parallel bearings. The driving wheel, forty-two inches in diameter, is arranged on a left-hand side of the rider; and the other side of the rectangular frame is produced, front and back, for carrying the forks of two 22-inch steering wheels. These forks are connected by a rod, fixed to the outside of one and the inside of the other, so that both wheels are turned together by the steering handle. The effect of this arrangement is that the rider is enabled to thread his way between other vehicles with the greatest ease; and it is even said that he can describe a figure 8 in a length of twelve feet. The seat is mounted on four steel springs of S form, which are attached to the frame by nuts on the screwed ends of the stays carrying the pin on which the pedals work. Rods jointed to the pedals turn the crank-shaft, as will be seen in the engraving. The second handle is merely to afford support for the left hand while the right is occupied in steering.

"The tricycle is fitted with tangent wheels, in which the spokes are crossed, and each spoke locks the other. By this arrangement greater lightness can be obtained for a given strength; and another great advantage is that in the event of a spoke being broken, another can be replaced by the rider in a few minutes. The machine can be readily taken to pieces and packed in small compass."

This is the pattern of tricycle shown upon the Starley monument at Coventry, and is that which was afterwards changed from the lever-motion to the crank and sprocket-chain, and extensively manufactured at a great works in the Cycle City.



E. Baker, of Salem, Mass. Devices for propelling wagons. No. 200,016. Patented February 5, 1878.

"*To all whom it may concern:*

"Be it known that I, ELBRIDGE BAKER, of Salem, in the county of Essex and State of Massachusetts, have invented Improvements in Wagons, of which the following is a specification:

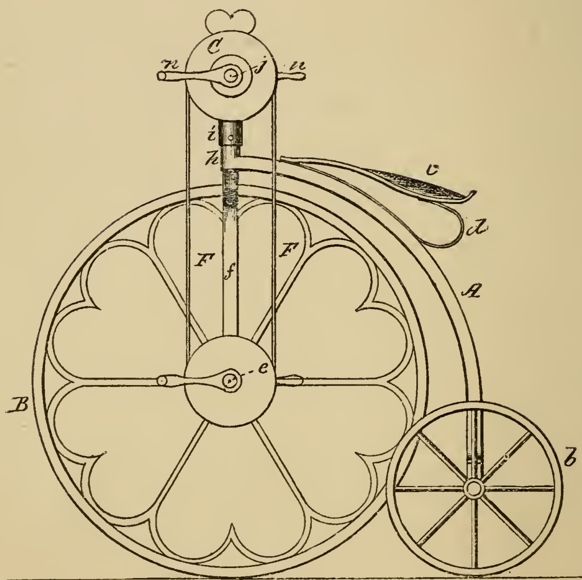
"This improvement in wagons consists in mechanism arranged, as hereinafter described, to act directly on the ground to propel the wagon.

"Each rod has a pronged foot-piece, *f*, and between the foot-piece *f* and the crank-hanging of each rod the rod is suspended by a flexible line, *g*, from the body of the wagon.

"Turning the crank-shaft *b* in any suitable manner causes the pronged foot-pieces *f* of the rods d^1, d^2, d^4, and d^5 to take hold of the ground, and thereby propel the wagon, and by arranging the cranks as is shown in the drawings one rod after the other is brought into and out of action, securing a continuous action of the mechanism to propel the wagon, all as is obvious without further explanation.

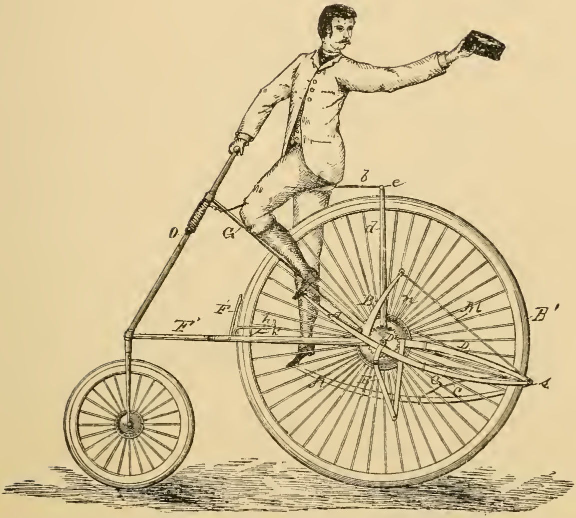
"The lines *g* hold and keep the rods to the action of their crank-arms, and cause the rods to be properly brought, from time to time, by the cranks into operating positions on the ground."

This device is a logical sequence of Mr. Croft's, being a combination of shoving-bars worked by machinery instead of by hand. This patent is now expired and can be used by anybody.



E. N. Higley, of Somersworth, N. H. Velocipede. No. 201,179. Patented March 12, 1878.

"The invention consists in an arrangement of pulleys upon each side of the crank-arm, and pulleys of similar construction upon the sides or ends of the axle of the road-wheel, and connected together by chains or other suitable means, whereby the carriage may be propelled by the feet alone without turning around or otherwise operating the hand-shaft; or the hand-shaft may be employed, when desired, to aid or assist the feet, as circumstances may require; or both sets of pulleys may be used by the hands and feet to increase the speed of the carriage."



W. Klahr, of Meyerstown, Pa. Bicycle. No. 285,821. Patented October 2, 1883.

Mr. Klahr was one of the early geniuses that appreciated the utility of the anti-vibrator. Notice the spring upon the front reach. This is a device quite similar to that used by many makers of rear-drivers in the past few years. The inventor does not claim this, however.

Bruton's English Patent. Provisional specification. No. 208. January 18, 1879.

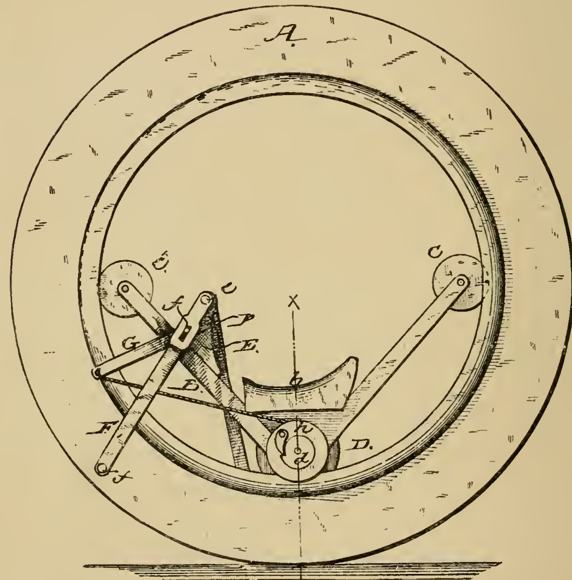
IMPARTING MOTION TO VELOCIPEDES, &c.

(*This Invention received Provisional Protection only.*)

"EDWARD GEORGE BRUTON, of No. 1, Park Crescent, Oxford. 'CERTAIN IMPROVEMENTS IN THE FORM AND METHOD OF IMPARTING MOTION TO VELOCIPEDES, CARRIAGES, OR OTHER VEHICLES.'

"This Invention consists of a new form of imparting motion to velocipedes or other vehicles having three or more wheels, which wheels shall receive their motion from a traversing platform, to which motion is imparted by walking or running thereon ; the platform consisting of endless bands, of a substance offering resistance to the foot, passing over rollers suspended from the said vehicle, which rollers, by pulley-bands, chains, or other means, put in motion certain wheels of the said vehicle and thereby propel the same."

We have heard the tricycle compared to a tread-mill by unkind and wearied riders, but it has remained for our English brother, Mr. Bruton, to make the comparison a veritable fact.



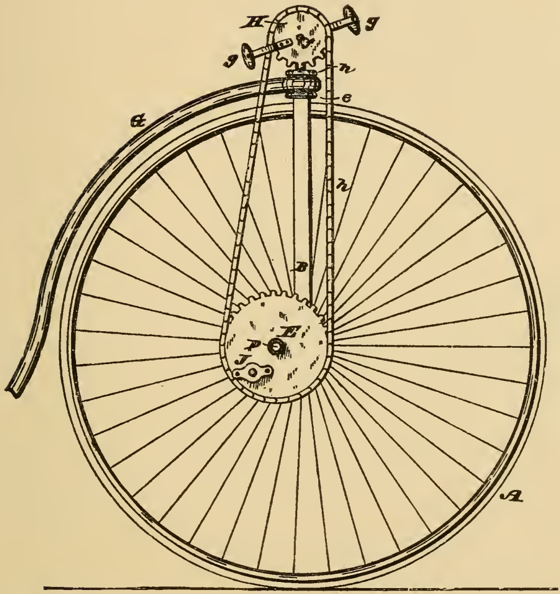
F. Langmaak and P. Streiff, of San Francisco. Velocipede. No. 228,908. Patented June 15, 1880.

A LEVER-MOTION UNICYCLE.

" . . . By having a pair of the levers an alternate motion is kept up and a continuous revolution of the driving-wheel maintained.

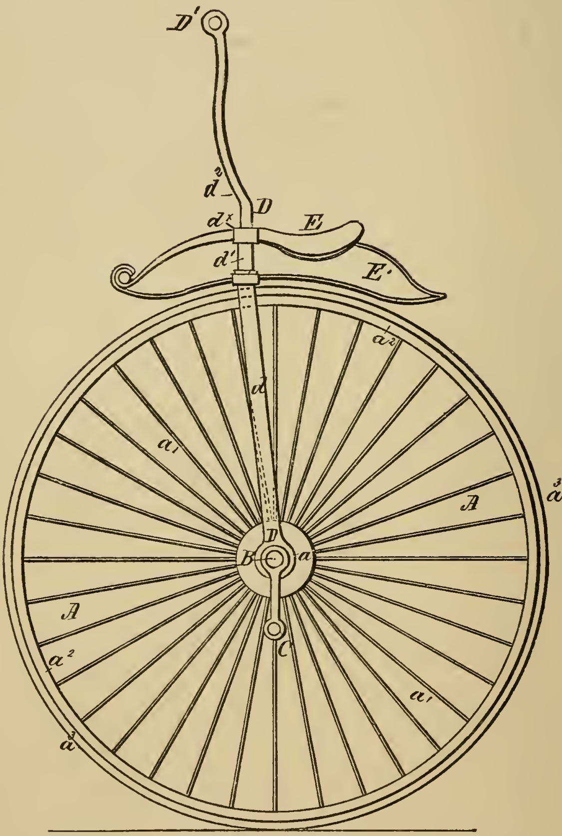
" A ratchet and pawl, ball-clutch, or eccentric friction-clutch will accomplish this object, the latter being preferable, owing to the absence of noise.

" With the large wheel, and the rider sitting below the centre of gravity, a slow motion can be maintained and the effort to propel it need not necessarily be great."



A. C. Monnin and P. Filliez, of Canton, O. Bicycle. No. 361,310. Patented April 19, 1887.

"It will be seen that by our peculiar arrangement an operator can use his hands and feet in propelling the bicycle proper, and that great speed can be made by reason of the wheels *E* working on the pinions *b*. It will be understood that to the rear end of the arm *G* is attached, in the ordinary manner, a small travelling wheel, and, if desired, two wheels may be attached to the arm *G*. It will also be understood that a suitable saddle is to be properly attached to the arm *G*."



G. B. Scuri, of Italy. Velocipede. No. 242,161. Patented May 31, 1881.

" *To all whom it may concern:*

" Be it known that I, G. BATTISTA SCURI, a citizen of the Kingdom of Italy, residing at Turin, have invented new and useful Improvements in Velocipedes.

" My invention relates to improvements in that class of velocipedes called 'monocycles,' in which but one wheel is employed, that serves both as a propelling and steering wheel.

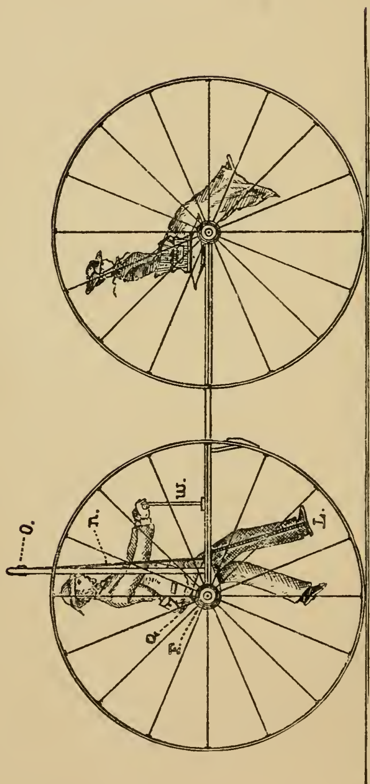
"The velocipedes which have heretofore been chiefly used are the bicycle and the tricycle, and to a limited extent the quadricycle, or four-wheeled velocipede, in all of which the support for the driver is so arranged as to practically throw his weight upon the front and rear wheel axles. The power required to propel these various species of conveyances increases proportionally with the number of wheels employed, and the relative diameters of the latter, as well as the mechanism employed for propelling and steering the same, together with the weight of the apparatus. It is obvious therefore that the power required to propel these conveyances diminishes proportionally with the number of the elements referred to. Consequently, to reduce this power to a minimum, it will only be necessary to correspondingly reduce the number of propelling-wheels, the propelling and steering mechanism, and the weight of the apparatus.

"To obtain these results I employ but one wheel.

"In a monocycle that is constructed to support the entire weight of its driver, it is absolutely necessary that said weight, as well as that of the supports for the same and all other mechanism, either for propelling or steering, should be thrown upon the one wheel-axle and be adapted to be equally balanced thereon.

"By means of this construction and arrangement I obtain a velocipede that can be propelled with comparatively little fatigue, and the cost of construction of which is reduced nearly one-half of that of the ordinary velocipede."

Judging from this invention they must be expert riders in every way in Italy; it must be supposed that the inventor at least could manage it. If reducing the mechanism increases the power in such a proportion, why not do away with all mechanism and have infinite power?



B. Smith, of San Francisco. Velocipede. No. 249,207. Patented November 8, 1881.

SMITH SPECIFICATION.

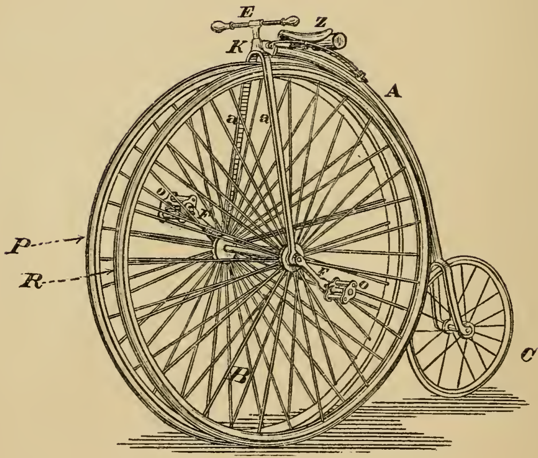
"The rider is supported upon a seat or saddle, *Q*, directly above the stirrups, in a nearly standing position, his feet resting upon the stirrups, and he operates the clutches alternately by a walking movement, or he can operate the mechanism in a standing position without the seat or saddle. The clutch-levers alternately engage with the rims or pulleys on the axle, as their outer ends are pressed downward by the backward walking movement of the foot of the rider, and releasing them as the foot rises in stepping forward, the rope reeving through the pulleys in each direction alternately as the levers are alternately raised and depressed.

"The operation will then be as follows: When a downward pressure is applied to one lever its lower arm or prong, g', pressing upon the face of the disk *F*, draws the case or frame forward, so as to press the rollers *h* against the face of the disk, thus clutching or gripping the disk at three points, so as to clamp the frame or case to it. The downward pressure of the lever then turns the disk and axle until the lever of the opposite clutch has gripped the other disk in the same way.

"In a four-wheeled carriage a seat or body can be placed upon the front part of the vehicle for carrying another person or parcels.

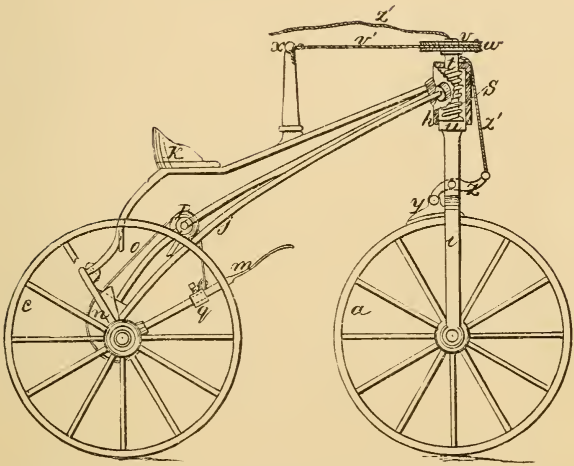
"I thus provide a vehicle that is propelled by a walking movement similar to that employed in operating the bicycle. It can be operated with very little exertion, and it enables the rider to carry another person or packages, if he desires."

This gallant tandem inventor was at least not guilty of requiring his lady to do any work.



R. Tragardh, of Chicago. Velocipede. No. 250,607. Patented December 6, 1881.

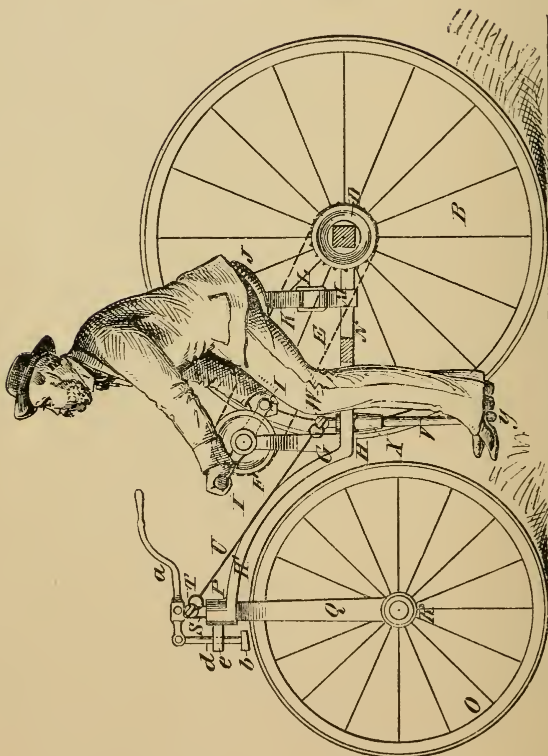
This is a sample of many patents in which the inventors try to combine the elements of a bicycle and tricycle, thereby defeating the end of each.



J. Renetti. Velocipede. No. 96,963. Patented November 16, 1869.

A clutch-lever machine of some merit, considering the early date of the patent.

This is a rear-driver with front wheel as large as the rear, though not a single-track machine.



W. H. Hull and J. W. O'Rear. Velocipede. No. 259,853. Patented June 20, 1882.

HULL AND O'REAR SPECIFICATION.

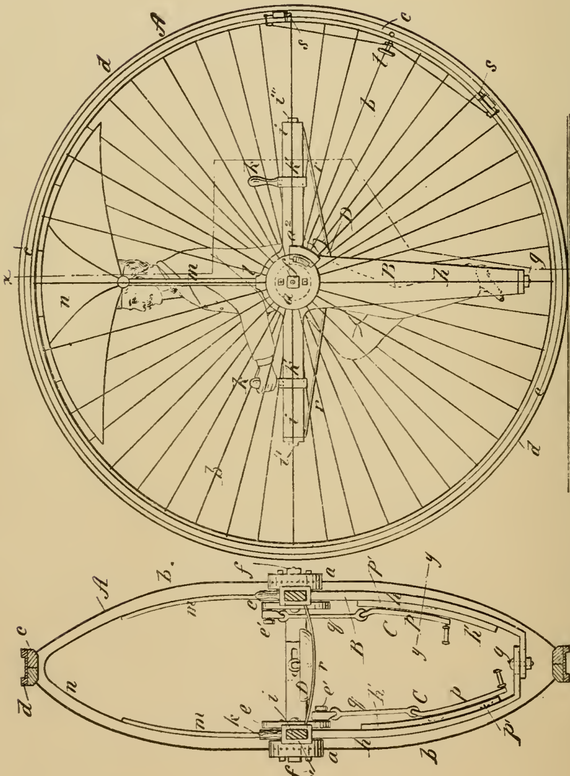
"This invention consists of the construction and arrangement, as hereinafter described, of a vehicle to be propelled and guided by the rider, the driving-power being applied by means of hand-cranks and the guiding being effected by the foot of the operator.

"*A* represents the hind axle, whereon the two hind wheels, *B*, are fitted by means of the well-known rose-clutch device *C*, the frame *H*, and turned by hand-cranks *I*, to be worked by the operator, who sits upon the saddle *J*.

"We have also arms, *Y*, for the application of the feet of the operator to steer the vehicle, while the lever ranges rearward towards the operator for being conveniently worked by hand.

"The construction is very simple and cheap, and the arrangement is calculated to afford a convenient and easily-operated hand-power vehicle."

Messrs. Hull and O'Rear find that it is better to steer with the feet and propel the machine by the arms. The rider is peering anxiously forward as though somebody was ahead of him, and he appears rather disconcerted from some cause; which makes us think the picture has been taken from real life.



C. M. Schaffer, of Louisville, Ky. No. 291,781. Patented January 8, 1884

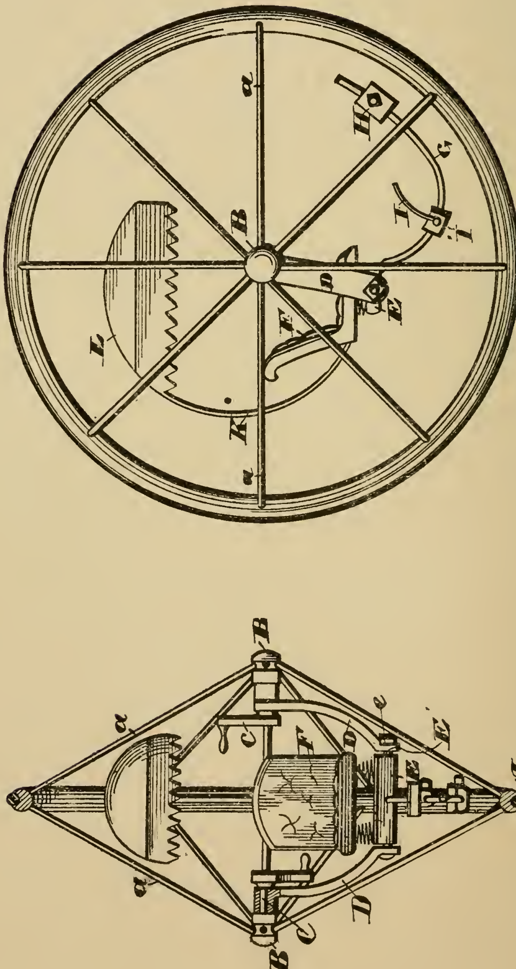
SCHAFFER SPECIFICATION.

"The object of my invention is to furnish a safe and convenient velocipede of the unicycle type; and to that end my invention consists in certain novel features of construction and arrangement, as hereinafter described and claimed.

"The operator may stand erect, and in order to obtain the necessary vertical space without too large a wheel the rim or felly is made of considerable width, as shown in Fig. 2. With this wide tire the wheel will stand without support, and I prefer to use a recessed tire or two smaller tires, as shown, between which is a rubber or elastic band to prevent concussion and noise.

"To allow of entering the machine, a portion, c', of one felly is made separate, and the hub a made with a hinged segment, a^2, to which the spokes from the felly-segment c' connect, so that the latter can be swung out."

Mr. Schaffer does not seem to have provided any very ready means of escape for the bird in case the cage should run away or collide with another.



B. G. Burlinghausen, of Cleveland, O. One-wheeled Velocipede. No. 299,617. Patented June 3, 1884.

BURLINGHAUSEN SPECIFICATION.

"My invention relates to improvements in one-wheel velocipedes; and it consists in certain features of construction and in combination of parts hereinafter described, and pointed out in the claim.

"As the operator must sit some distance back of the axis of the wheel, some force is required to support or balance the seat and operate in the required position, and this is furnished by the sliding weight *H* secured by a set-screw on the rod *G*.

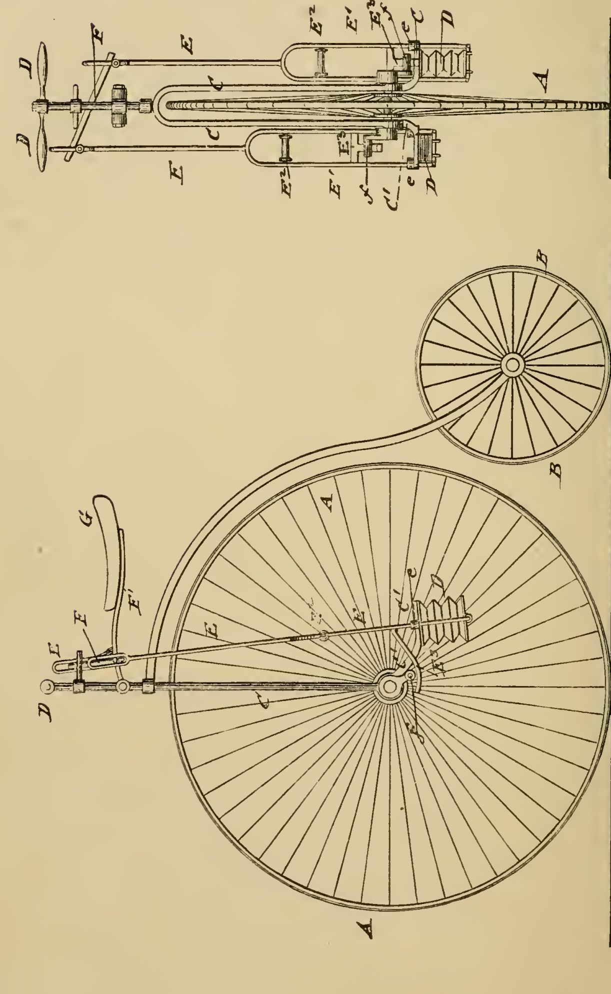
"What I claim is,—

"In a one-wheel velocipede, the combination, with the hubs, the hangers *D*, depending from said hubs, and cranks secured to the hubs for revolving the wheel, of the cross-piece *E*, the balance-rod provided with the adjustable foot-rest, and the seat secured to the upper surface of the cross-bar, substantially as described.

"In testimony whereof I sign this specification, in the presence of two witnesses, this sixth day of March, 1884.

"BERNERD G. BURLINGHAUSEN."

This device works entirely as a manumotor or hand-carriage. It is questionable if any prudent rider would care to be enclosed within this structure if there were many hills to descend. To be sure, if the seat gets fast, he can kick the spokes, as in the case of a squirrel and cage-reel, thus keeping himself upright, but this would be attended with great labor and requisite skill.



R. von Malkowsky, of New York. Velocipede. No. 310,548. Patented January 6, 1885.

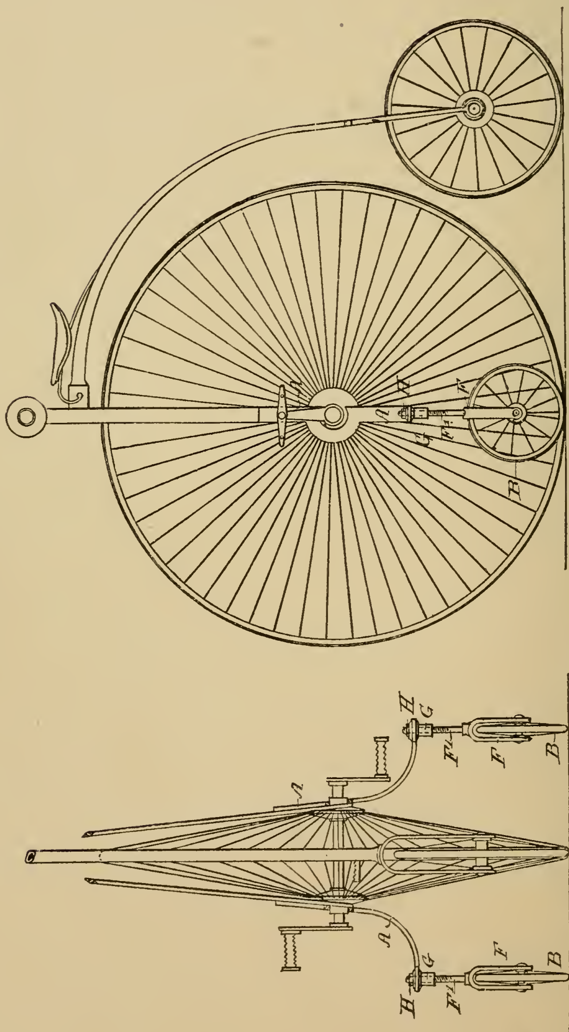
COMBINED BICYCLE AND ACCORDION, PATENTED BY MR. VON MALKOWSKY.

Just fills a need long felt by the cyclist. There is a certain action claimed for it, in which pressure of air is used on the treadles which helps to propel the machine; but this is only a secondary element in the mind of the wary cyclist; no sooner will he see this invention than he will grasp the idea of getting keys to it and having it play him a tune, as he speeds on his lonely way. And then, how nice to sit down, unscrew a pedal, remove his treasure, and produce sweet strains of silvery music. A new short method of instruction for playing upon this new combination may go with each cycle sold, such that any rider could soon comprehend. Below find brief of specification.

"From the lower ends of the fork *C* extend, in downwardly or backwardly direction, fixed brackets, C', to which are applied closed expansible bellows, *D*, of oblong shape, one at each side of the driving-wheel *A*.

"The combination, in a velocipede, with the driving-wheel, of closed bellows supported on fixed brackets of the fork, forked pedal-rods connected at the lower end of the bottom of the bellows, and at the upper end to a transverse oscillating balance-rod.

"R. von Malkowsky."



W. Bevan, of London, England. Safety Attachment for Bicycles. No. 319,385. Patented June 2, 1885.

"*To all whom it may concern:*

"Be it known that I, William Bevan, a subject of the Queen of England, residing at London, England, have invented a new and useful Improved Bicycle Safety Attachment for Learners, of which the following is a specification.

"If the wheels *B* be raised from the ground a short distance, considerable swaying of the machine will be possible without its quite tumbling over.

"As shown in Fig. 2, the wheels are upon the same level as the large wheel, and the machine is well supported, so that a person ignorant of the art of riding a bicycle can ride a machine fitted with this appliance."

This is another gentleman who thinks he can balance the bicycle by means of out-riggers. However ridiculous this scheme may be, this inventor does not deserve the first prize. A machine shown at one of the London exhibitions, in which the two small wheels were replaced by iron sled-runners, should be the subject of our highest award. The inventor of our machine shown can well say that a person need not be able to ride; I recommend he make himself expert at headers, however.

J. O. Lose, of Paterson, N. J. One-wheeled vehicle. No. 325,548. Patented September 1, 1885.

" I may operate my unicycle by either clock-work or steam, instead of foot-power.

" A small boiler may be placed under the platform *O*, with steam-pipe to convey the steam to the inner rim of the large wheel *A*."

You have all heard of the " merchant of Rotterdam, whose legs were a compound of clock-work and steam."

"*To all whom it may concern:*

"Be it known that I, John Otto Lose, a subject of the Emperor of Germany, residing at Paterson, in the county of Passaic and State of New Jersey, have invented certain new and useful Improvements in One-Wheeled Vehicles.

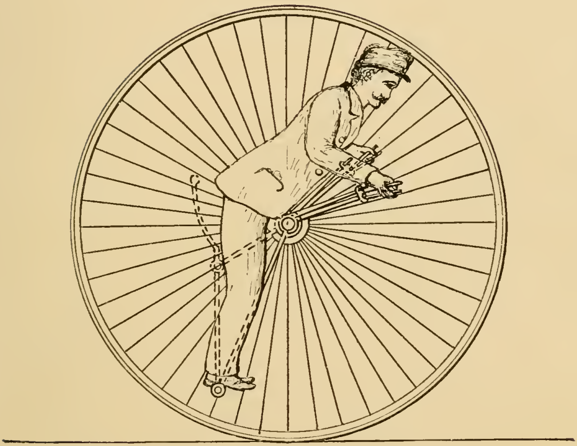
"My invention relates to a unicycle or one-wheeled vehicle, without spokes, which will carry one or more persons, as well as a bicycle or tricycle, and which is operated from within, carries the passenger inside, and only one wheel touching the ground. I attain these objects by the means of the devices illustrated in the accompanying drawings.

"When the machine is not in operation, it will stand by itself, for the treadle and driving wheels being heavier than the idler-wheel *H*, *H* will rise and the front part of platform will drop, and the treadle-wheels will rest on the ground."

Mr. Lose drew his unicycle in better proportions than his man; perhaps he made the rider's limbs light to show that the machine would run easy.

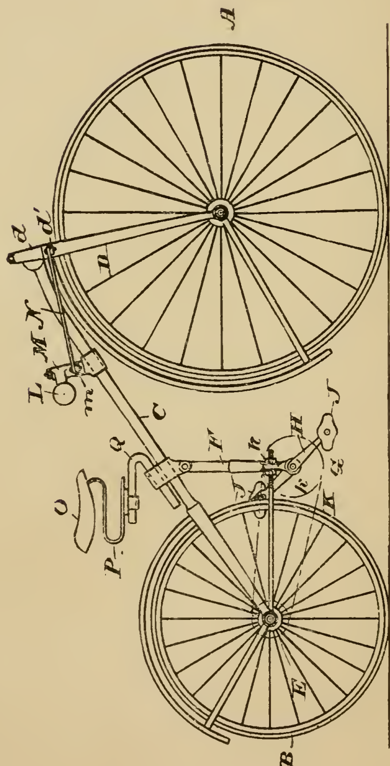
H. W. Libbey. Hood attachment for bicycles. No. 339,793. Patented April 13, 1886.

"The object of my invention is to provide a means for protecting riders of bicycles and tricycles from exposure to the sun and rain."



Leske, two-wheeled machine on the Otto principle.

This is a German patent by Herr Leske, of Berlin, dated August 4, 1887. The inventor can, at least, be said to accommodate the entire body with plenty of work. Mr. Leske may be heard from later.



H. J. Lawson. Velocipede. No. 345,851. Patented July 20, 1886.

LAWSON SPECIFICATION.

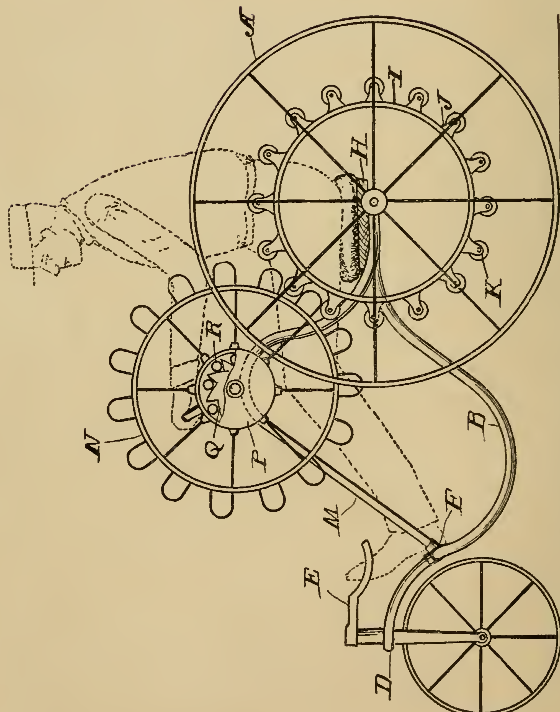
"My invention relates to that class of bicycles in which the front wheel is employed for steering and the rear wheel for driving, the pedal crank-axle being arranged between the wheels and connected with the axle of the rear wheel for driving by an endless driving-chain.

"The object in this construction is to secure the rider against being thrown forward over the front wheel by keeping his centre of gravity low and setting his seat or saddle as far back as is practicable from the centre of the front wheel. This mode of driving through the medium of sprocket-wheels and chains also allows the driving-wheel to be geared up or down to suit individual tastes.

"What I do claim is,—

"1. A bicycle having two wheels arranged tandem as shown, the rear wheel being no larger than the front wheel, and provided with a pedal crank-axle arranged between said wheels and connected to the rear wheel, for driving by an endless chain and sprocket-wheel, substantially as specified."

The other drawing of this patent is used to illustrate the Rover rear-driver. I wish to call particular attention to the claim as given in above brief of specification, as it is somewhat extraordinary. The English patent to this same inventor would indicate that he was an early, but negligent, inventor of the modern rear-driver safety.



A. Hoak, of Pennsylvania. Velocipede. No. 341,911. Patented May 18, 1886.

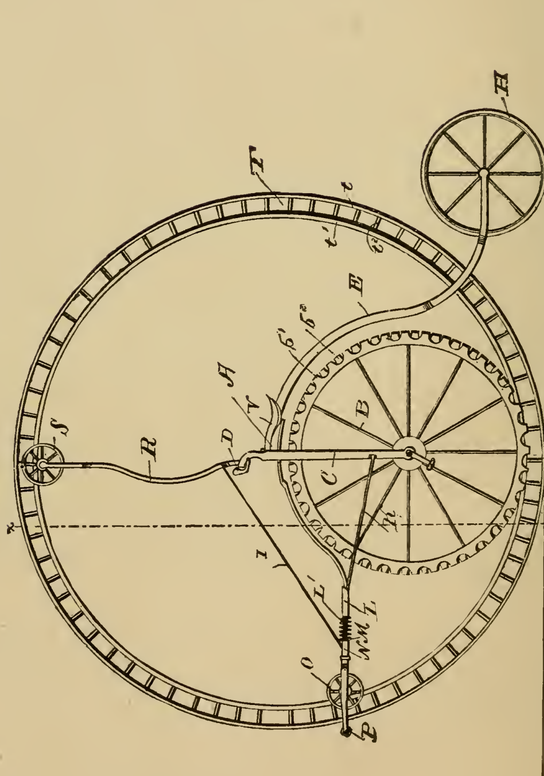
A. HOAK'S VELOCIPEDE.

The important part of the specification is as follows:

"The shaft-gearing of these spur-wheels consists of impact roller motions, so that the crank centrally on the shaft, within easy reach of the operator upon the seat and between the driving-wheels, may be effectually operated by the hand, and a lever from the guide-wheel is designed to be in such a position as to be within easy reach of the operator's feet forwardly, so that no difficulty will be encountered, all of which will now be fully set forth.

"The operation of this device is very simple. The operator seated within the machine operates the crank *O* of the shaft *L*, and the spur-wheels *N*, engaging with the spur-wheels *I*, move the vehicle forward. The steering-wheel *C* is operated by the feet in connection with the lever *E*."

It is all right, except that it would seem cruel to have such legs as the draughtsman has given the rider, and only use them for steering purposes.



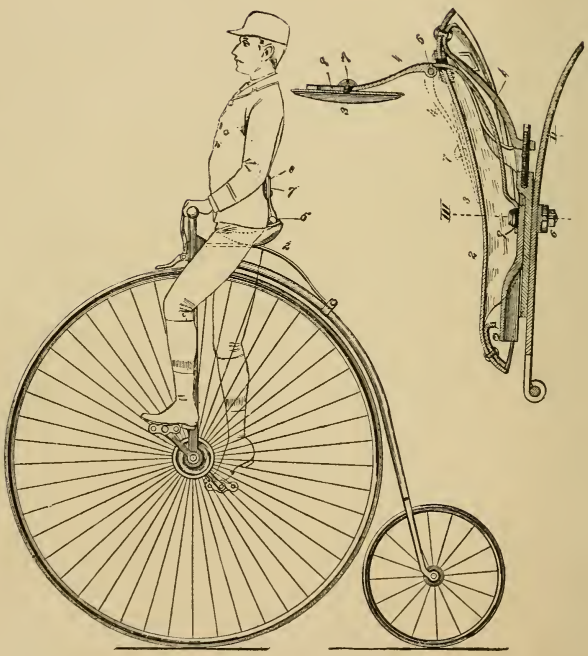
E. S. Burbank, of Iowa. Velocipede. No. 352,989. Patented November 23, 1886.

BURBANK SPECIFICATION.

"By thus providing the bicycle with a circular track engaging the driving-wheel the said track forms virtually the driving-wheel of the bicycle or velocipede, and as it is of very greatly increased diameter as compared with the driving-wheel of the velocipede, it enables the machine to be driven over rough and uneven roads without violent bumping and jolting, and without discomfort to the rider. It also prevents the velocipede from being overturned when it encounters an obstruction, and prevents the rider from 'taking a header.'

"When the machine encounters a stone or other obstruction, the frame *M* is moved rearwardly against the pressure of the spring *L′*, and thus causing the wheel *B* and the rider to be moved forwardly past the centre of the circular track for a corresponding distance, thus enabling the weight of the rider to be utilized in causing the circular track to pass over the obstruction."

This patent is a fair sample of the big-wheel idea; it has some good features, such as the spring *L′*, which allows the inside machine, together with the rider, to swing forward when the outer wheel strikes an obstacle, thus acting as an anti-vibrator or momentum spring. The small inner wheel with cranks would make the machine run slow, but the appearance of the thing would be, I think, rather unique.



C. A. Williamson. Seat for bicycles. No. 364,075. Patented May 31, 1887.

"The advantages of my back support or rest for a bicycle seat will be readily understood by users of the machine.

"Instead of folding the rest down upon the seat as shown, it might be arranged to be folded down behind the seat, if desired.

"I am aware that various forms of seats have been provided with hinged back-rests, and do not claim, broadly, a seat having a hinged back-rest.

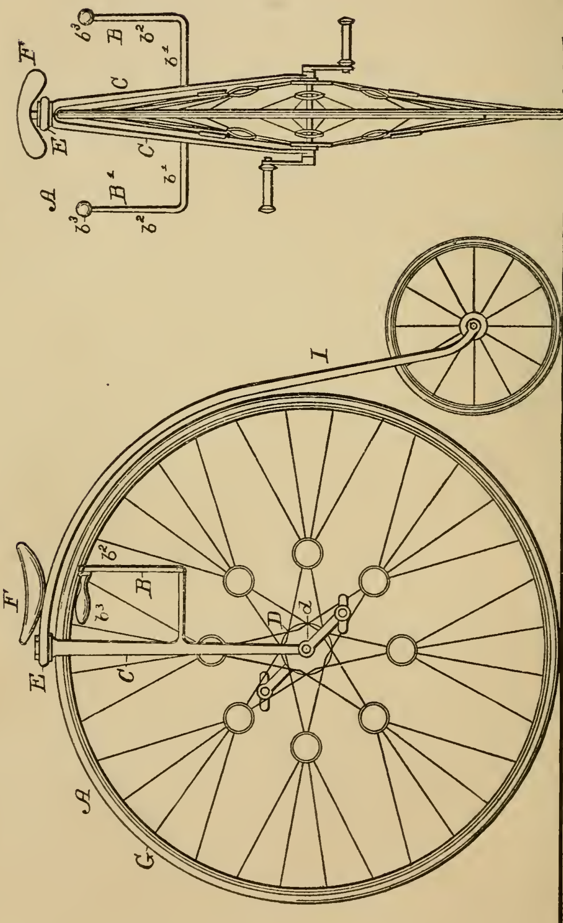
"I claim as my invention—

"In combination with the frame and an ordinary seat of a bicycle, an arm secured at one end to the frame under the seat and extending upwardly at the back of the seat, and a back-rest located behind the seat and having hinge-connection with the arm above the top of the seat, whereby it is adapted to be folded down, substantially as set forth.

"CATHERINE A. WILLIAMSON."

Miss Williamson is mistaken in her disclaimer. I do not think anybody ever put a back on a bicycle seat before.

It is also probable that a "dis" (before advantages) was omitted by the printer in the first line of above brief; but we must not be ungallant to the ladies, and criticise too harshly. Perhaps the invention will come in on the Rovers where the ladies may mount in front.



C. E. Duryea, of St. Louis. Bicycle. No. 364,231. Patented June 7, 1887.

DURYEA SPECIFICATION.

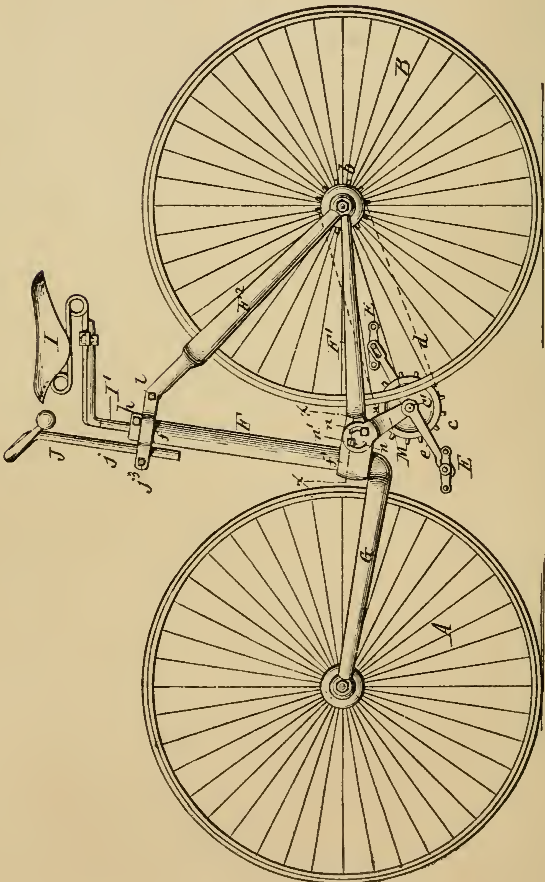
"The improvement relates partly to the handle-bars, partly to the pedals, and partly to the head, of the bicycle.

"The advantage of this form of handle-bars is that it enables the rider to mount from in rear of the large wheel in the usual manner, and to dismount either in the rear or in the front of the large wheel. It also permits of an upward pull upon the handle in propelling the wheel.

"The structure of the spokes, hub, and rim will not be claimed in this case, as they will form the subject of another application by me for patent thereon.

"I am aware that heretofore the handle-bar has been angled, but know of no case where it extends backwardly, outwardly, and upwardly."

This idea for handle-bars has often occurred to riders of the old Ordinary; it would have saved many serious falls, by way of the front dismount, heads down. The weight and complication are its defects.



E. G. Latta, Friendship, N. Y. Velocipede. No. 378,253. Patented February 21, 1888.

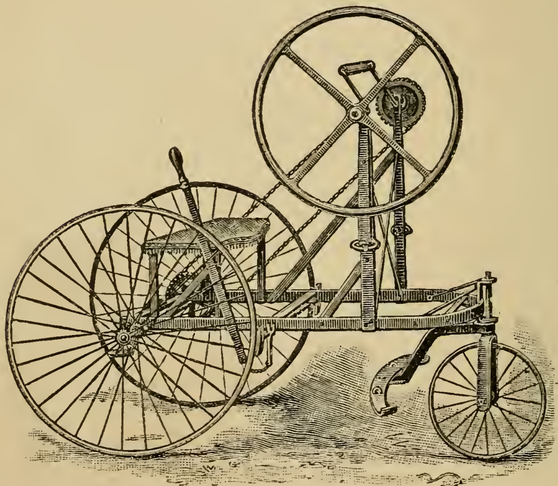
LATTA SPECIFICATION.

"The object of this invention is to provide a machine which is safe, strong, and serviceable, and more easily steered than the machines now in use, and also to construct the machine in such manner that the same can be folded when not required for use, so as to require little storage-room and facilitate its transportation.

"In bicycles of ordinary construction, when the rider anticipates a fall it is customary to turn the steering-wheel in the direction towards which the rider is inclined to fall. When the steering-wheel of my improved velocipede is deflected, the saddle swings in an opposite direction to that in which the rider tends to fall, which enables the rider to regain his balance with very little movement of the steering-pivot, and also to maintain a direct course with greater ease than with the ordinary machines."

This is one of Mr. Latta's weekly patents, and is a sample of the many efforts now being made to overcome the sensitive steering qualities of the recent rear-driver. The invention is also intended to answer the purpose of the "Rothigiesser system," spoken of in a former chapter.

Mr. Pat. Gallagher, of New York, invents a tricycle with fly-wheels.



"A tricycle designed to be easily operated and guided is illustrated herewith, and has been patented by Mr. Patrick Gallagher, of No. 145 East Forty-second Street, New York City. It has a light but strong iron frame-work, and is propelled by means of a crank-handle mounted in arms adjustably pivoted to uprights on the frame, one of the ends of the crank-handle having a sprocket-wheel connected by an endless chain with a sprocket-wheel on the axle of the driving-wheels, while the other end of the crank-handle has two fly-wheels to steady the motion of the machine, and so that but little exertion will be required to run it after a high degree of momentum has been obtained."

R. J. Spalding. Flying-machine. No. 398,984. Patented March 5, 1889.

Cadiz and Wheeling Plank Road.

AN AMERICAN BONE-SHAKER, 1869.

As it is a common practice to present patrons with a portrait of the venturesome culprit who aspires to engage the temporary notice of the public, by works of this kind, it is possible that some readers may, perchance, procure books with such expectations in view, and feel disappointed if no such custom has prevailed. Now, therefore, the writer has overhauled his effects and brought to light a picture which, "though not as new as it was," is a fair specimen of the photographer's handicraft, which represents your hopeful tyro upon his original velocipede, one made by himself in 1868-69. This machine was probably the earliest single-track crank-machine made in the State of Ohio and one of the first in the United States.

Looking at the reproduction herewith annexed, I notice, with regret, that the rider has not improved as rapidly as have the machines.