LABORATORY TESTS OF THE BICYCLE.

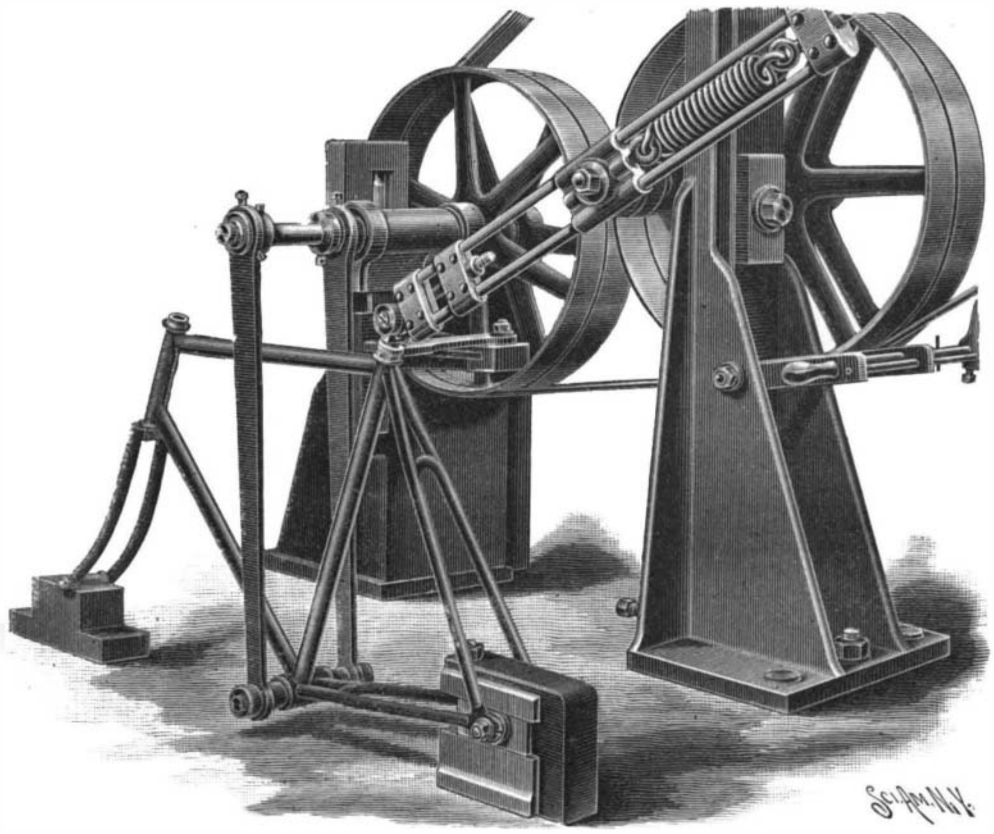
There is probably not a machine in the world that works on such a small margin of safety as the bicycle. It has been estimated that the safety "factor" is only about 1¼ in the lightest machines, and while this is probably too low an estimate, it is certain that, when a powerful 200-pound rider is climbing a steep hill, or worse, coasting down a hill whose surface is rough and lumpy, the margin of safety must be a very narrow one—narrow, that is to say, compared with that allowed in other forms of mechanical construction. Thus the bridge builder provides sufficient steel in the various members to insure that the heaviest possible loads that can come upon them will not strain the metal above from 20 to 30 per cent of its elastic strength, and even in designing structures that are subject to quiet or static loads, the material is not strained beyond 33 per cent of its strength; that is to say, the parts are made not less than three times as strong as is necessary to bear the greatest stress that will be put upon them.

We cannot calculate the maximum stresses of a bicycle with the nicety with which they can be computed in engineering structures and in the heavier classes of machinery. The conditions of use and abuse are so various—the hard use of a powerful but cautious rider being less severe than the abuse of some reckless boy—that the only way in which the proper strength for a wheel can be determined is by trial, and by a careful selection and test of the materials of which it is constructed. If an engineer were told to work out the strain-sheet of a bicycle in the same way as he would that of a railway bridge, taking the possible maximum stresses due to the work of heavy and powerful riders upon rough and hilly roads, and proportioning his parts so that the metal should not be strained above 10,000 to 15,000 pounds to the square inch, the wheel built from such a strain-sheet would be as heavy as the primitive boneshaker of thirty years ago.

A comparison of the bicycle considered as a means of transportation with a railway car brings out the remarkable fact that it takes forty-six times as much dead weight of material to carry a man on the railway as it does on a wheel. For a modern coach carrying sixty people will weigh about 70,000 pounds, which is at the rate of 1,167 pounds to the passenger; while a modern bicycle will weigh only 25 pounds. If we take the Pullman car as an example, the disparity is yet more striking; for here we have only twenty-four passengers carried on a car weighing 100,000 pounds, or say 2 tons to the passenger. In this case the car weighs 167 times more per passenger than does the bicycle.

From these considerations it is evident that the light weight of the bicycle can only be maintained by the most careful inspection of materials and workmanship, and in the case of all the standard bicycles it is safe to say that this inspection is very carefully made. Every lot of stock is subject to tests in the testing department, which, by the way, is coming to be recognized as an indispensable part of all large American establishments in the engineering and kindred trades, and the finished parts and finished machines are in some cases put to special tests to determine their strength and running qualities.

We present an illustration of one of many testing machines installed in the laboratory of the Pope Manufacturing Company. It is used for trying the strength of the frame, and it is designed to reproduce as far as possible the actual stresses to which a frame is subjected when put to hard usage on the road. The principal stresses are those due to the weight of the rider applied at the top of the seat-post tube and the alternate transverse bending stress due to the pressure on the pedals. The frame is mounted upon two blocks, one under each hub as shown, the crank-hanger being left unsupported. The stresses due to the weight of the rider are reproduced by means of a short-throw crank driven by a pulley, and a spring connecting rod, as shown, one end of which is clamped to the seat-post, while the crank engages a sliding head which is attached by a powerful spiral spring to the other end. The rapid rotation of the crank thus imparts a series of cushioned blows whose effect on the frame is similar to that due to the speed of the machine, inequalities of the road, the pneumatic tires, and that part of the rider's weight which is on the saddle.



MACHINE FOR TESTING BICYCLE FRAMES.

The crank-shaft stresses are applied by means of two connecting rods, one on each side of the frame, which are driven by eccentrics set at 180° and carried on a second pulley-driven shaft. The stroke of the eccentrics is of course very short, merely sufficient to bring a heavy bending stress alternately on each side of the crank-hanger. One machine out of every lot is placed in this instrument of torture, and if, after it has been merrily thumped and wrenched for a stated length of time, its tubing is true, brazing sound, and the whole frame in line, it is considered that no fair usage on the road can ever break or distort it.

One must confess that, interesting as the various departments of a bicycle factory undoubtedly are, the most fascinating plant is to be found in the department of tests, for here we see the fruition of the labor of the whole establishment. That all-absorbing question as to the respective ease of running of a chain and a chainless wheel is here determined to absolute demonstration on an ingenious device known as a float dynamometer. The wheel is mounted at the side of a tank of water in which are two separate floating platforms. On the first platform is mounted an electric motor, on the other a friction brake. The motor is connected by a universal joint shaft with the axle of the bicycle, and the friction brake is similarly connected with the shaft of a pulley upon which the rear or driving wheel of the bicycle runs. It is evident that the power given out by the floating motor will be in part absorbed by the internal resistance of the bicycle, the rest being returned at the floating brake.

The tangential reaction of the motor will cause the float on which it is carried to tilt over; similarly, the pull of the brake will tilt the brake float. If, now, the tilting in each case be corrected by moving a sliding weight on a horizontal graduated arm, the readings of the two arms will show respectively the power given to the bicycle by the motor and the power returned to the brake from the bicycle. The difference will represent the loss by friction in the bicycle. If a chainless and a chain wheel be tested in the same apparatus, their respective efficiency can be determined with the greatest accuracy.

It is found that, with the gears new and perfectly clean under light loads, there is practically no difference in efficiency between the Columbia chain and chainless wheels, but, as the load is increased, the chainless wheel begins to show a gain which grows rapidly as the load is still further augmented—a result which shows the bevel gear to be superior to the chain gear for hill climbing, and superior to it in all cases where the chain has "stretched" or is fouled with grit or dust.

Size of gear.	Gear used for	Distance covered in two strokes or one revolution of the cranks compared with distance covered (5 feet) in walking two steps.
120	Paced racing	31 ft. 4 ins
105	High gear for road riding	27 ft. 6 ins
88	Sprint racing	23 ft
80	Ordinary gear for road riding	21 ft
68	Lady's wheel	17 ft 9 ins
Two steps	Walking	5 ft

BICYCLE GEAR AND ITS EQUIVALENTS.

A safety geared to 120, in one revolution of the crank, covers the same distance as that covered by one revolution of an ordinary wheel ten feet high, or two strides of a man thirty-five feet high.

BICYCLE GEAR—WHAT IT IS AND WHAT IT DOES.

Those of our readers who were bicycle enthusiasts in the days of the old "ordinary" will remember that a wheel was designated by the diameter, in inches, of its driving wheel, which varied from 48 to 62 inches, according to the length of leg of the rider. Thus we were wont to speak of the respective merits of our 50-inch Rudge, or 54-inch Victor, or 60-inch Columbia, as the case might be. The diameter of the driving wheel was the most variable element, and hence it was chosen as the designating feature.

With the introduction of the rear-driven safety it was no longer possible to grade the wheels according to the diameter of the driving wheel, for the reason that the latter all settled down to a common size of 28 inches; but as the introduction of the chain drive enabled the speed of revolution of the driving wheel to be increased over that of the cranks, thereby increasing its circumferential speed, it was decided to designate the bicycle by the effective diameter of the rear wheel as thus secured. The increased circumferential speed of the wheel is obtained by placing a larger sprocket on the crank axle than on the rear wheel; for the rear sprocket (with its wheel) will run just as much faster as the front sprocket is larger than itself. Thus, if there are 24 teeth in the front sprocket and 8 in the rear, it is evident that, by the time the 24 teeth of the front sprocket have engaged and drawn forward the chain, the chain will have engaged and drawn forward 24 teeth on the rear sprocket, and to do this it must have rotated the 8-tooth rear sprocket three times. Now, this will cause the 28-inch rear wheel to travel over a distance equal to three times its own circumference, or equal to the single circumference of a wheel three times as large as itself, or 84 inches in diameter. Since this effective diameter is due to the chain and sprockets, it is spoken of as "gear," and a bicycle with an effective driving wheel diameter of 84 inches is known as an 84-gear wheel.

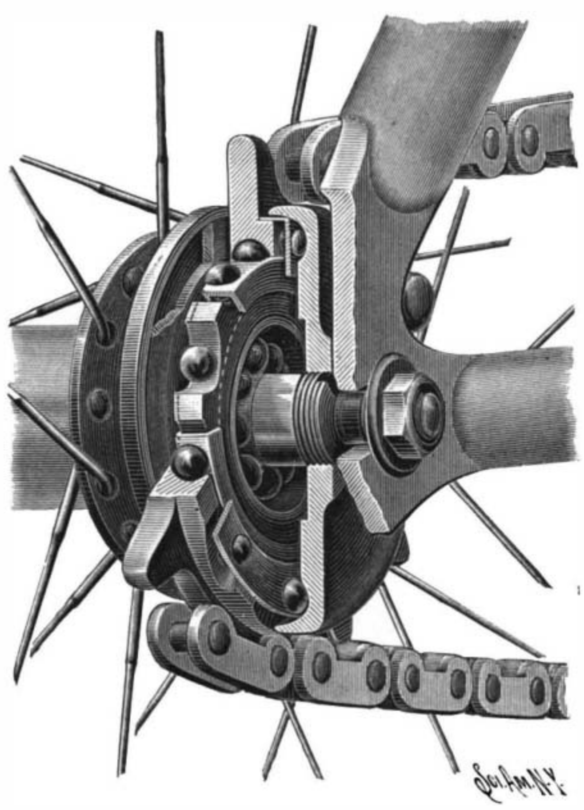
It is evident, then, that since the diameter of the rear wheel is constant, the gear depends solely upon the relative size of the sprockets employed, and is found by the simple formula, $G = \frac{D \times F}{R}$, where G = the gear; D the diameter (28 inches) of the rear wheel; F the number of teeth in front sprocket and R the number of teeth in rear sprocket. Thus 84 gear can be obtained by a 21-tooth front and a 7-tooth rear or a 30-tooth front and 10 tooth rear. The gear of a bicycle, then, is the diameter of a circle whose circumferential length is equal to the distance traveled by that bicycle in one revolution of the cranks.

It is largely the possibilities of "gear" that make the safety so incomparably superior to the ordinary bicycle. Formerly one was restricted to what he could stretch, and only a tall man could negotiate a 60-inch wheel. Now a child's wheel is geared to 60, and many women are riding wheels of 76 to 84 gear. Gears of 96 to 105 are not infrequently met with on the road, and there is one famous rider in paced races who has won his reputation on a wheel geared to 120 inches. It is the great distance covered in proportion to the speed of pedaling that constitutes the charm of the high gear, at least as far as the imagination is concerned; for that frailty of human nature which expresses itself in a desire to get "something for nothing" will not down, and asserts itself in all kinds of places and at unexpected times. In riding a high gear there is a sense of getting out of the machine something more than we put in—even though mechanical orthodoxy tells us this cannot be—and there is no denying that, under favorable conditions of grade and wind, a day's journey can be made with less fatigue on a high than a low gear.

Of course, we all know that the total work done by a rider in propelling the same wheel over the same stretch of road, under identical conditions, never varies, whatever may be the gear employed. If I ride a 25-pound wheel a mile on the turnpike with a gear of 60, I do a certain amount of work; and if I ride the same wheel over the same mile in the same time with 120 gear, I do the same amount of work. In the latter case I turn my cranks more slowly, but I have to exert just as much more pressure upon them as their speed of rotation has decreased. If, with a view to reducing the pressure, I double the length of the cranks, then my feet must travel twice as far in a circle twice as large. Since work at the cranks may be regarded as pressure multiplied by distance, the total amount of work I do will be the same, whether I exert heavy pressure on short cranks moving in a small circle or light pressure on long cranks moving in a large circle.

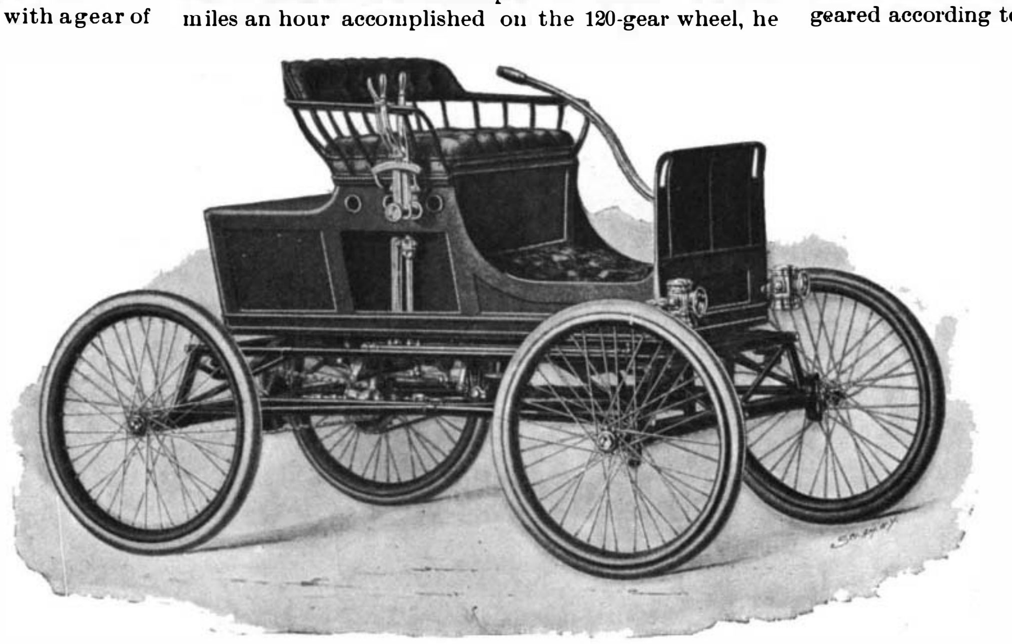
Since in riding the same distance at the same speed, on the same wheel, the total work is the same, whatever the gear and whatever the length of the cranks, the question arises, What is the best gear to use? The answer is that, The gear must be determined by the physical and temperamental make-up of each individual rider. If we were to pick out a dozen men, and start them out to walk a hundred yards, we would find that no two of them took the same length of step. Some would fall into a long swinging stride of 36 to 40 inches, while others would trot along with little mincing steps of 18 to 24 inches. The speed might be the same, but the length of stride would be that which each individual had unconsciously found to be agreeable to his own idiosyncrasies of physique and temperament. So with the question of gear and crank length. Some riders will get the best results with high gear and long cranks, others with low gear and short cranks, while a rider of the writer's acquaintance uses on the road a 104 gear with a 6½ crank, and will ride all day without any apparent distress. As a rule, tall men should use high gears and long cranks, a 6-foot rider being able to negotiate a 7½-inch crank with as little bending of the knee (a fruitful source of weariness) as a 5½-foot rider using a 6½ crank.

Our artist has shown in the accompanying sketch



THE TREBERT COASTER AND BRAKE.

how the gear increases the effective diameter of the driving wheel, raising it from 28 inches to as much as 120 inches in the case of one rider already mentioned. As a matter of fact, our fastest racing men are using a wheel from 2 to 3 feet larger than the largest locomotive driving wheels used in this country. Another interesting point brought out in the sketch is that the modern bicycle has increased the locomotive powers of man to such an extent that to cover as much ground at each step in walking as he does at each stroke of his pedals, he would have to be a giant fully 35 feet in height. It was found, by measuring the number of steps taken by several employes in walking 150 feet down the SCIENTIFIC AMERICAN office, that the average stride is 2½ feet in length, or 5 feet for two steps. Now two "strokes" of the legs of a cyclist on a 120 gear wheel would carry him a distance of 31⅓ feet; and, supposing the step is roughly proportionate to the height, our giant would have to be about 35 feet tall, and to make the maximum speed of between 35 and 40 miles an hour accomplished on the 120-gear wheel, he would have to step as frequently as a person of ordinary stature walking at a brisk rate.



THE VICTOR AUTOMOBILE CARRIAGE.

A FRENCH firm has undertaken the manufacture of a new metallic curtain for the Opera House at Besançon. The curtain is to be lowered after each act or in case of great danger. It is 60 feet wide and 54 feet high and is to be composed of aluminum sheets 13 feet long and 29 inches wide and $\frac{1}{12}$ of an inch thick. The total weight will be 4,000 pounds. If such a curtain were made of sheet iron, it would weigh 11,000 pounds.

THE TREBERT COASTER AND BRAKE.

Since the introduction of the automatic coaster and brake, improvements in construction have constantly been made which have increased the efficiency of the device to such an extent that the old plunger brake is beginning to disappear. Among the latest types of these brakes is the Trebert brake, made by the Trebert Automatic Coaster and Brake Co., of Syracuse, N. Y.

The brake in question comprises essentially a friction-disk secured to the hub of the rear wheel, a clutch on the disk, and a clutch on the rear sprocket-wheel. The two clutches are provided with inclined surfaces upon which balls, held in place by retaining rings, roll. The balls on the disk-clutch serve to lock the sprocket and clutch together when the wheel is in motion; and the balls on the sprocket clutch serve to bind the sprocket against the friction-disk in order to stop the wheel.

When the chain of the bicycle is pulling forward, the balls on the disk-clutch will also move forward and ride up their inclines, thereby locking the clutch and sprocket together so that both rotate with the wheel. When the rider desires to coast, he applies a slight back pressure to the pedals, thus causing the balls on the disk-clutch to roll down their inclines in order to release the sprocket from the clutch and to permit the wheel to rotate independently. When the rider wishes to stop, he applies a further back-pressure to the pedals, thereby causing the balls on the sprocket clutch to ride up their inclines and to bind the sprocket and friction disk so tightly together that the wheel is prevented from turning.

The brake, besides giving the rider full command of his wheel and enabling him to hold his feet stationary upon the pedals for the purpose of coasting, possesses the additional advantage of being readily applied to any wheel without the necessity of remodeling or changing the frame.

THE VICTOR AUTOMOBILE.

While we are considering hydrocarbon and electric vehicles, it must not be forgotten that there are also on the market excellent motor carriages driven by steam, and we take pleasure in presenting an engraving of the "Victor automobile," which is a steam wagon entirely automatic in its regulation, made by the Overman Wheel Co., Chicopee Falls, Mass. When the word steam is used it naturally brings to mind a certain uneasiness, but users of the Victor automobile need have no anxiety, for the boilers are tested and insured by the Hartford Steam Boiler Insurance Company, each boiler being tested by the expert of this well known company and a certificate given as to the test. The boiler is truly automatic, the water being fed into the boiler automatically with absolute precision. Thus the user will be relieved from the point which is the chief difficulty of putting steam in the hands of laymen. The pressure on the fuel tank is also regulated automatically. The fuel tank holds enough common gasoline to go fifty to one hundred miles, and gasoline is readily obtainable in every village. It also holds water enough to run twenty-five miles, and a collapsible soft rubber bucket enables one to get water at any place. The engines are of three and one-half horse power and the boiler capacity is five horse power. The machine is geared according to the roads and hills, and it is capable of running from a speed which is slower than one would walk to its maximum speed, which would ordinarily be about twenty miles an hour.

Infection by Speaking Tubes.

The speaking tube is an excellent means of infection, and The London Lancet has recently issued a note of warning concerning them. These tubes are practically unventilated except when in use, and when the person using them speaks, the moisture in the air which he exhales condenses on the sides of the tube, so that the products of respiration remain for the benefit of the next persons using the tube; and it is little wonder that the telephone is recommended in preference to the speaking tube by sanitarians. It is quite possible for tuberculosis or other diseases to be spread by speaking tubes; for it is necessary for the person in calling to place his lips in actual contact with the mouthpiece at the near end to make the whistle sound at the far end.

TUNNELS under the Thames at London are multiplying rapidly. Hardly has the Blackwall tunnel been open when another at Rotherhithe is projected. It is to be 30 feet in diameter—3 feet more than the Blackwall tunnel. It is to be a mile and a quarter long. The total work will cost about $7,000,000, but nearly $4,000,000 of this will go for the approaches.