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THE PALACE OF WAR AND OF THE NAVY AT THE EXPOSITION OF 1900.

THE competition opened to all the architects of France for the construction of the palace of the ministers of war and the navy at the Exposition of 1900 has just been judged by a commission of generals and architects.

The first prize was awarded to Messrs. Umbdenstock and Auburtin, who presented a project that was exceedingly remarkable from an æsthetic point of view, and possessed the stamp of an originality that does the greatest honor to the young artists.

These gentlemen conceived the ingenious idea of

A foot bridge established opposite the main entrance will connect the two banks of the Seine.

This palace will certainly be one of the great attractions of the Exposition of 1900.—*Le Monde Illustré*.

THE AMERICAN BICYCLE—ITS THEORY AND PRACTICE OF CONSTRUCTION.*

By LEONARD WALDO, D.Sc. (Harv.)

OVER the portals of a great nation are written in armaments of steel the words "Dieu et mon droit." Enshrined in the hearts of another great nation and crystallized from the furnace of war are those other words

to the human economy. There are two broad channels through which human efficiency becomes available: one by utilizing energy exterior to ourselves, as in the driven horse or the water power at Niagara; and the other where the entire energy is derived from the human frame, and is made skillful and useful without magnification, but with an economy for the direct object in view which is proportioned to the energy which can be saved from apparently necessarily connected and attendant operations. If a man can move without the loss of energy of lifting and stopping his feet at each step, he has gained an important economy of energy.

Now man is profoundly interested in anything which

THE PALACE OF THE MINISTERS OF WAR AND OF THE NAVY AT THE EXPOSITION OF 1900.

showing the public the great transformation that has taken place in our navy during the last two centuries. At the left extremity of their design they have placed the poop of one of those immense galleys that formed the navy of Louis XIV, with its antique guns, its wonderful blue and gold decorations, its royal flag and the rigging of sail navigation that characterized the ancient navy.

This ship enters the palace, and, after undergoing all the transformations of progress, makes its exit in the form of a modern armored vessel, provided with steel turrets, huge smokestacks, a fighting mast armed with revolving guns, and, in a word, equipped with everything that goes to make up the modern naval vessel.

In the interior of the palace, a large hall is reserved for the military balloon of the Meudon aerostatic park. This new edifice will be built upon the bank of the Seine along Quai d'Orsay, between Rapp and Bosquet Avenues. At the foot of the structure a small port will permit the minister of the navy to exhibit the light vessels of our fleet.

"E pluribus unum." The one sentiment has built an industrial condition founded on the growth of the individual mechanic, whose personal handiwork should remain a large part of the value to be sold in England's products to the rest of the world, while the second sentiment has led where possible to the abdication of the direct result of hand labor, and has sought for the magnification of such labor by the substitution of the automatic machine, whose intelligence is that of the single man, but whose output is that of a hundred men working with untired muscle and ever fresh brains. Eleven years ago, and before an equally distinguished audience in this hall, we considered the application of machinery to the piece making of watches according to what was then known as the American plan; to-night we shall consider an application of the same system, but in a larger field of engineering.

We are apt to mistake the true relation of the bicycle

* Paper read before the British Society of Arts, December 1, 1897, and published in the Journal of the Society.

is strongly individual, and which is a virtual extension of his own powers. The Tourte bow is none too good for the violinist. The utmost care is given to the shape of the sculler's oar. A half ounce addition is destructive to an individual tennis racquet.

It is this principle of individuality which separates the skate and the bicycle from all other means of transportation. No energy is added, none can be added. The chemical energy of digesting and, therefore, combusting food is absolutely all there is, and yet the man moves with the speed of the railway express. Is it a wonder that with the rapid passing of the contrivance and toy to the splendid machine of 1898, in which is incarnate the highest state of the art in every single mechanical procedure involved in its production, there should be a history of mechanics for the period concerned.

See the first safety—whether tinkered by the Scotch cooper, Gavin Dalzell, of Lesmahagow, in 1846, or made earlier by McMillan, of Courthill and Dumfries, I know not; certain it is that the low wheels, the front steer-

ing, the back driving, the mud guard are all in it—everything but that other name for a portable good road, the pneumatic tire.

What fun old Dalzell had with his machine! The royal mail coach was pledged to its ten miles an hour, and, when it lumbered into sight, out Dalzell would get with his machine, and before, behind, would go cavorting, rousing the horses to trembling fear and the passengers to excited bets as to which could win, then disappearing in the roadway ahead to the consternation and disgust of every one but Dalzell. Good oak, good sense, what we should now call weak iron and honest work, went into this first safety; but after it came an evolution of bicycle distortion compared to which the evolution which led to the megatherium was a continued line of grace and beauty. I cannot go into this in an evening's paper, for it is the present we have much with us in the bicycle, and the history is in the books; especially in that most excellent of all books by Mr. Archibald Sharp, against which an American might file the complaint of scant attention to the American wheel.

Let us now enter upon the more technical ground of considering along what lines the manufacture of the bicycle must lie, and first how are scientific measures to be made which shall allow the constructor to express in exact numbers the progress he is able to make toward all the perfection which the state of the art allows in the individual parts. We are accustomed to think of the locomotive as a high expression of mechanical art; there is not a single part of the locomotive which has anything like the care in the selection of materials and the crucial testing which is given to the bicycle. The locomotive may be honeycombed with castings about its various parts. It is the fundamental axiom of the best American bicycle construction that every single piece is forged hot or drawn cold. The carbon and phosphorus of the steel in locomotives may vary within wide limits; in the bicycle the variation is small, and the steel is transformed into another and much stronger steel by the addition of 5 per cent. of nickel. In the locomotive the tubular construction may be irregular as to size, and drawn by regular draw bench methods. In the bicycle nickel steel tubing must be cupped up from the disk and drawn by special hydraulic presses of enormous strength and exquisite precision.

It is not as an assemblage of parts that we must finally regard the bicycle. Like the violin it is as an organic whole, under live tension, ready to answer the slightest muscular call, that it must be considered. The testing department, therefore, first regards the materials of construction, and then the machine as a whole. In our illustrations we shall see the successive stages of the preparation of nickel steel tubes. We have in such tubes the maxima of resistance to bending and breaking and crystallization under continued jar, with the minima of weight; but to reach this conclusion many thousands of tests of materials of all kinds had to be made.

Begin with the very tempting metal, aluminum. Pure, in drawn tubes, it has the specific gravity of 2.7, while steel has 7.9, so that an aluminum tube weighs but one-third of the same sized steel tube. Its strength, soft drawn, does not much exceed 20,000 pounds per square inch under most favorable circumstances, and this might be improved by the addition of something less than 5 per cent. of nickel or copper. Unfortunately, however, the metals of the aluminum class have no well defined elastic limit. When a strain which may not be one-quarter of the ultimate breaking strain is applied, the metal begins to stretch, and does not wholly recover when the strain is removed. Now let us approximate, for the purpose of comparison, by assuming that an aluminum nickel alloy tube can be made which in its soft and annealed state will stand 10,000 pounds per square inch without stretch or set, it would have three times the bulk and clumsiness of the nickel steel tube, and not one-half, probably not one-quarter, the resistance to deformation or set under strain, even if it were the same weight as steel. If the use of aluminum is advocated to lighten the frame, and sizes approaching those of steel tubes are used, then the comparison is still more unfavorable, so that the aluminum nickel taken may have only one-sixth or even one-tenth of the resistance of the nickel steel. One point must constantly be borne in mind in thinking of the material to be used in bicycle frames. It must all be reduced to the soft or annealed state. The frames have to be assembled and brazed at their joints. If the tubes are hard, the heat of brazing anneals them at such joints, and the frame is unequally strong throughout. If the attempt is made to assemble the frame by screw joints, without heat, then it is only a question of time for the racking of the frame in one to start the threaded joints and render the whole frame less taut. Thus nickel steel tubing is drawn in the tube department of the Pope works at Hartford which sometimes reaches the enormously high tensile strength of 250,000 pounds per square inch in its hard state, and to a certainty of gage not exceeding a variation of 5 per cent. from the gage thickness. With such a strength the present ordinary steel frame could be one-sixth its present weight, but it would not be good practice to so make it. The tube is immediately brought to a condition known among metal workers as that of "dead soft," i. e., as free from any temper as possible, and so that no further change can take place when the tubes are heated in brazing.

There is another reason for this, and one which reaches into the molecular physics of steel. One of the usual tests for steel tubes at the works mentioned is to clamp one end of a tube, which may be two or three feet long, in a rapidly driven lathe chuck, and leave the other end free to turn on a fixed dead center. A strong pressure by a rolling wheel is brought against one side of the tube at its middle and securely clamped, so that at every revolution of the tube it must bend at its middle point. Steam power is then applied, and the number of hundred thousand turns, and consequent bends, which the tube will stand before breaking is noted by automatic counters. This number is an indication of the fatigue, the jars, and checks the metal will undergo without taking a set or breaking. A somewhat similar method of torture is applied to the whole frame of the bicycle after the parts have been brazed together. In this latter case the base of the frame is securely clamped, as we shall see in our illustrations later in the evening, and a twisting around a

TABLE I.—COPY OF TEST SHEET No. 35.

Driving Float.

Description of Wheel. Test No. 1.	Time in seconds per 100 revolutions.	Revolutions of cranks per minute. N.	Reading of counter- poise c.m. s.	Foot-pounds delivered to crank. 2 n S	Average foot- lbs.
1	2	3	4	5	6
1. Model 50, Pope chainless, tire A	36.2	165.8	28	5,900	6,146
2. Gear 71½ = G	37	162.2	30.8	9,992	9,897
3. Weight on saddle = 183 pounds = L	37.8	158.7	48.8	15,489	15,300
4. Diameter of tire, 60 pounds air pressure, before loading = 27.65 = D ⁰	38.8	154.6	65	20,098	20,046
5.	40.4	148.5	82.5	24,502	24,484
6. Diameter of tire, 60 pounds air pressure, after loading = 27.35 = D	39.4	152.3	82.4	25,099	—
7.	38	157.9	64.5	20,369	—
8.	37.4	160.4	48.5	15,559	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$	37.2	161.8	30.0	9,105	—
10. Circumference of track wheel = 63 inches	36.2	165.8	18.3	6,068	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = C	35.8	167.6	19.1	6,402	—
12.	37	162.2	30.5	9,894	—
13.	37.8	158.7	48	15,235	—
14.	39	153.9	65.1	23,038	—
15.	40.6	147.7	82	24,223	—
16.	41.2	145.6	84.8	24,110	—
17.	40	150	65.6	19,678	—
18.	38.6	155.4	48	14,917	—

Driven Float.

Description of Wheel. Test No. 1.	Revolutions of brake wheel per minute. n.	Reading of counter- poise c.m. s.	Grade in per cent. equivalent to values of s for 175 lb. rider. 9	Foot-pounds utilised.			
1a	7	8		By brake. 2 n s.	Aver- age.	By track wheel.	Total Col. 11 + Col. 12.
				10	11	12	13
1. Model 50, Pope chainless, tire A	555	1.5	0.33	1,666	1,707	915.1	2,622.1
2. Gear 71½ = G	544	5	1.11	5,440	5,412	889.8	6,301.8
3. Weight on saddle = 183 pounds = L	530	10	2.06	10,600	10,571	869.2	11,440.2
4. Diameter of tire, 60 pounds air pressure, before loading = 27.65 = D ⁰	519	15	3.02	15,570	15,437	846	16,281
5.	496.5	20	3.97	19,860	19,585	805.2	20,390.2
6. Diameter of tire, 60 pounds air pressure, after loading = 27.35 = D	502	20	—	20,080	—	—	—
7.	521	15	—	15,570	—	—	—
8.	533	10	—	10,660	—	—	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$	537	5	—	5,370	—	—	—
10. Circumference of track wheel = 63 inches	555	1.6	—	1,776	—	—	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = C	559.5	1.5	—	1,678.5	—	—	—
12.	542.5	5	—	5,425	—	—	—
13.	530	10	—	10,600	—	—	—
14.	518	15	—	15,540	—	—	—
15.	490	20	—	19,600	—	—	—
16.	470	20	—	18,800	—	—	—
17.	500	15	—	15,000	—	—	—
18.	521.3	10	—	10,426	—	—	—
Average = 523.54 = 31.234 miles per hour.							

Slip Data and Efficiency.

Description of Wheel. Test No. 1.	Slip data.		Efficiency.	
	$C = \frac{2\pi}{63 \times 28} G \left[\frac{D_0}{2} - (D_0 - D_1) \right]$		With Slip.	For zero slip.
	$\frac{N}{n}$	Per cent. of slip. $\frac{C}{100} \frac{N}{n}$	Col. 13 Col. 6 100	Col. 16 100 - Col. 15
1b	14	15	16	17
1. Model 50, Pope chainless, tire A	3.348	3.88	42.66	44.43
2. Gear 71½ = G	3.354	3.70	63.67	66.40
3. Weight on saddle = 183 pounds = L	3.340	4.11	74.77	77.97
4. Diameter of tire, 60 pounds air pressure, before loading = 27.65 = D ⁰	3.357	3.62	81.22	84.72
5.	3.344	3.99	83.29	88.00
6. Diameter of tire, 60 pounds air pressure, after loading = 27.35 = D	3.297	5.34	—	—
7.	3.320	5.25	—	—
8.	3.323	4.59	—	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$	3.319	4.71	—	—
10. Circumference of track wheel = 63 inches	3.317	3.90	—	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = C	3.338	4.16	—	—
12.	3.345	3.96	—	—
13.	3.340	4.11	—	—
14.	3.366	3.36	—	—
15.	3.318	4.74	—	—
16.	3.228	7.32	—	—
17.	3.333	4.31	—	—
18.	3.355	3.68	—	—

circle motion given to the free top of the frame by steam power, so that it is racked in every direction. Here too the number of twists the whole frame stands is automatically recorded.

If the large class of bicycle riders who firmly believe that a bicycle is a thing animate, possessing a disposition and an obstinacy peculiarly its own, should form a society for the prevention of cruelty to bicycles, there is no such field in existence as the testing department of the bicycle company named under its chief inquisitor, the engineer of tests, Mr. Henry Souther. Not a bicycle which enters that domain lives to tell the tale. Not only are the individual parts racked and pulled with a knowledge of metallurgical anatomy, but the completed machine is clamped against a spring to a rigid frame, and then two rotating wheels with projecting blocks in their circumferences are brought directly under and against the wheels of the bicycle to be tested. Steam power, again applied, gives the bicycle wheels the continuously repeated hammering of the rapidly turning lower wheels with the projecting blocks. The roughest cobblestone pavement under the speeding machine of the scorcher is very mild treatment in comparison with this roughest of roads fast driven under the spring-loaded bicycle. Here, too, the hundreds of miles and corresponding revolutions are automatically registered to the destructive point of the weakest part of the wheel.

Once, in going through the splendid testing laboratory of McGill University in Montreal, I heard the late Eckley B. Cox, one of the most lovable and brightest of our American engineers, say: "Why do we always test small parts of bridges and machines? Why don't

we build an entire bridge truss, and then break it down—or test the shaft of a steamship at full size?" He had in mind that no metal construction can grow from the small to the large state with all of its section strengths unchanged.

The test bar, half an inch in diameter, gives a far more favorable indication of strength than a bar cut from the solid part of a full sized casting weighing tons of the same material. It is important that the strength of the whole be known and determined, and it is only possible to do this by regarding the bicycle as a unit and testing the assembled machine to destruction. This is the theory and also the practice of our greatest company, not only with reference to their own construction, but, for comparative knowledge, with reference to such forms as may be prepared by others.

Besides a system of tests which shall indicate necessities of the strengthening of parts so that the factor of safety may be the same throughout the bicycle, there is another system of tests having in view a totally different purpose, namely, the loss of work and energy which occurs in the bicycle under its normal load, and meeting a varying resistance at varying speeds. We shall see later upon the screen photographs of the beautifully accurate Webb floating dynamometers, built for the department of trade of the Pope Manufacturing Company, by which Prof. Denton, of the Stevens Institute of Technology, has made the first valuable contribution to our knowledge of the actual efficiency of types of bicycles.* There appeared at the last (Hartford) meeting of the American Society of

* The Iron Age, No. 7, October 21, 1897.

TABLE II.—COPY OF TEST SHEET No. 39.

Driving Float.					
Description of Wheel. Test No. 1.	Time in seconds per 100 revolutions.	Revolutions of cranks per minute.	Reading of counter- poise, c.m. S.	Foot-pounds delivered to crank. 2 N S.	Average foot- lbs.
1	2	3	4	5	6
1. Model 50, Pope chainless, tire A ...	40'6	73'9	15'1	2,232	2,177
2. Gear 7½ = G ...	41	73'2	28	4,009	4,082
3. Weight on saddle = 183 pounds = L ...	41'4	72'5	63'2	9,164	9,297
4. Diameter of tire, 60 pounds air pressure, before loading = 27'70 = D ₀ ...	43'2	69'4	131'8	18,294	18,391
5. ...	44'8	67	183'4	24,573	24,945
6. Diameter of tire, 60 pounds air pressure, after loading = 27'38 = D ...	44'6	67'3	186'5	25,102	—
7. ...	44'4	67'6	186'1	25,159	—
8. ...	43'2	69'4	133'2	18,488	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$...	41'4	72'5	63'8	9,250	—
10. Circumference of track wheel = 63 inches ...	40'6	73'9	27'5	4,064	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = C ...	41	73'8	14'5	2,123	—

Driven Float.

Description of Wheel. Test No. 1.	Revolutions of brake wheel per min. M.	Reading of counter- poise c.m. S.	Grade in per cent. equivalent to values of S for 175 lb. rider.	Foot-pounds utilized.			
				By brake 2 N S.	Average.	By track wheel	Total Col. 11 + Col. 12
1a	7	8	9	10	11	12	13
1. Model 50, Pope chainless, tire A ...	247	1'1	0'33	543	521	407'8	928'8
2. Gear 7½ = G ...	244	5	1'11	2,440	2,455	403'7	2,858'7
3. Weight on saddle = 183 pounds = L ...	239	15	3'02	7,170	7,185	393'8	7,578'8
4. Diameter of tire, 60 pounds air pressure, before loading = 27'70 = D ₀ ...	233	35	6'68	16,310	16,240	381'5	16,621'5
5. ...	222'7	50	9'70	22,270	22,273	366'2	22,639'2
6. Diameter of tire, 60 pounds air pressure, after loading = 27'38 = D ...	221'5	50	—	22,150	—	—	—
7. ...	224	50	—	22,400	—	—	—
8. ...	231	35	—	16,170	—	—	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$...	240	15	—	77,200	—	—	—
10. Circumference of track wheel = 63 inches ...	247	5	—	2,470	—	—	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = C ...	249	1	—	498	—	—	—

Slip Data and Efficiency.

Description of Wheel. Test No. 1.	Slip data.		Efficiency.	
	$C = \frac{2\pi}{63 \times 25} G \left[\frac{D_0}{2} - (D_0 - D_1) \right]$		With slip.	For zero slip.
	$\frac{N}{n}$	Per cent. of slip. $\frac{C}{100} \frac{N}{n}$	Col. 13 Col. 6	Col. 16 Col. 10 - Col. 15
1b	14	15	16	17
1. Model 50, Pope chainless, tire A ...	3'342	3'07	42'66	43'62
2. Gear 7½ = G ...	3'333	3'31	70'03	72'35
3. Weight on saddle = 183 pounds = L ...	3'297	4'38	82'32	85'93
4. Diameter of tire, 60 pounds air pressure, before loading = 27'70 = D ₀ ...	3'357	2'61	97'38	93'23
5. ...	3'424	3'60	99'76	94'63
6. Diameter of tire, 60 pounds air pressure, after loading = 27'38 = D ...	3'291	4'55	—	—
7. ...	3'314	3'89	—	—
8. ...	3'328	3'48	—	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$...	3'310	4'00	—	—
10. Circumference of track wheel = 63 inches ...	3'342	3'07	—	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = C ...	3'402	1'33	—	—

Mechanical Engineers papers on and a discussion of the efficiency of bicycles, and these papers, together with Prof. Denton's, must be taken as the beginning of our technical special investigations into the energy economies of the bicycle. Prof. Denton's curves showing for varying foot pounds of energy delivered to the bicycle crank, and for varying foot pounds of resisting energy put on the brake, and which represents the resistance to be overcome by the rider under varying conditions, are in these diagrams correlated to the curve of efficiency, which shows the per cent. of the total energy exerted by the rider which is utilized in moving the bicycle forward. So much interest has been roused by the final success in building automatic gear-cutting machinery, so that the direct-gear bicycle is now permanently in the certainties of American manufacture, that I quote you the results of Prof. Denton's investigations, referring you to the published paper for its details. He says:

"The results of the investigation show that both the Columbia chainless wheel and the Columbia chain wheel wastes in its propelling mechanism from about 15 per cent. at high speed (30 miles per hour) and on low grades to 7 per cent. at moderate speed (13 miles per hour), and on heavy grades of the power applied at the cranks by a rider weighing about 180 pounds,

provided the chain of the chain wheel is cleaned and well lubricated.

"Any difference of efficiency of the two styles of propelling mechanism with a clean, lubricated chain is equalled by the difference liable to exist in the power absorbed by two tires of the same grade, which is about 1 per cent. of the average power expended by a rider.

"It is probable that the efficiency shown by the chainless wheels in the tests will be maintained for long periods of road use without any cleaning or lubrication of the mechanism, but the efficiency of the chain wheels, after a short road use, may be considerably less than that shown by the tests by the soiling of the chain.

"The tests of other makes of chainless wheels show that differences in the power wasted by different constructions of tire and by lack of proper stiffness of frame, combined with an arrangement of the gears whose efficiency is affected by the distortion of the frame by crank thrust, may make the waste of power reach 50 per cent. of the energy applied to some chainless wheels at high speeds on low grades."

I have gone thus at some length into the forms of testing in the typical and greatest of our American works, because if a knowledge of facts is the founda-

tion of science, it is especially the foundation of bicycle structure; and the art is too new to have a literature or established traditions.

The next thing after the laboratory determinations have furnished the data for construction is the field trial. This is done with the most careful system. Paid riders, with marked routes and blank reports to be filled out in minute detail, are dispatched in all kinds of weather and over all kinds of roads. On the screen we shall see later two such riders who have just come in, one on a chainless wheel, and the other with a chain wheel, both over the same rainy, muddy, sandy in parts, and hilly route. From these reports, which are indorsed by inspectors in distant towns, the opinion is formed as to the wisdom of constructions planned or new things to be attempted. Single wheels embodying some special idea are thus ridden as much as 15,000 miles under different riders, with an accurate register of every mishap.

One other point ought to be mentioned in this connection, something which for a better name may be called the democratic council.

At least once in every day, and sometimes many times in a day, the ubiquitous inventor appears. It may be the man who is prepared to prove that he takes out four times the energy he puts in, by his particular contrivance, or it may be a thing of merit. Whatever it is, if it is endorsed on a preliminary examination, it is fully discussed in a public meeting of riders, salesmen and general officers, under all the forms of parliamentary rules. It has always been the policy of this particular company to avoid the making of what are known as bicycle accessories, with the exception of a hand kit of small tools, which we shall show later on the screen.

So much for the determination of the facts, and the democracy of the advice. It is not strange that the manufacture should have assumed large proportions: this particular company has as high as 3,800 names on its pay rolls at times, its buildings are spread over 19 acres of the city of Hartford, and its investment is estimated at £1,000,000. The output per day reaches 600 finished bicycles in the busy season, and preparations are making to extend this output with the advent by most of the principal makers of the chainless wheel.

All of the essentially American characteristics of such highly organized machine working companies are carefully carried out. Plenty of clear daylight in every department; lunch rooms, where at cost price soups and the essentials of a hot meal are furnished by the company's cooks; rooms with comfortable fittings of tables and chairs, with good literature or games for the leisure hours; long, separate water tanks for easy washing, and separate lockers for those who wish to keep clothes or property under private lock and key; strikes unthought of; the clear sunlight through long hours; every man at his machine or his dozen machines—his only thought and pride that it be of the best of its kind! O sons of England, that you could only see in your striking work meetings that your work interests and your capital interests are the same! Not always will there be a high protective tariff in the United States for the benefit of European industries in the markets of the world. When that day comes, and scales of value are the same in the civilized world, you will miss the help of the multiplying machinery which you now refuse.

The company's works are complete within themselves. The making of rubber tires, described in Engineering by its correspondent, Major Wiley, is carried on for its own benefit and that of most of the other American companies. Steel tubing, formerly brought from England, is now made in their own tube works to limits of precision in drawing as follows:

Tubes 1 inch diameter and over must not exceed the gage thickness by more than 0'003 inch, nor be less than their gage thickness by 0'001 inch. Tubes less than 1 inch diameter must not exceed their gage thickness by more than 0'002 inch, nor be less than the gage thickness by more than 0'001 inch. In tubes of No. 21 B. W. G. (0'032 inch) and thicker, the gage extreme variation of thickness does not exceed 0'003 inch, and it does not exceed 0'002 inch for tubes less than 0'032 inch thick.

It may interest those present concerned in tube drawing that these figures are enforced. I cannot, in the limits of this paper, follow the consecutive operations of making the bicycle. You will see on the screen photographic sections of the bicycle in various stages, and I think they will reveal the answer to most of the questions which suggest themselves to your minds. The essential thing to be remembered is that the frame is considered the unit for work. Nothing is done in the way of fitting or centering any of the parts until the completed frame with its reinforced joints, with all the brazing, heating or other distorting influences, is complete. The entire frame is then securely held in gaged clamp vises and the boring and centering done by tools also rigidly set to gage.

The interchangeability of parts under this system is the same as in that other product of American machinery—the American watch. Another point is the nature of the hardening of the spherical bearings on

TABLE III.—EFFICIENCY AT EQUAL FOOT-POUNDS DELIVERED TO CRANK AS TAKEN FROM CURVES.

	1	Number of Sheets.	Date of Test.	Gear.	Weight in Saddle, in lbs.	Average miles per hour.	Foot-pounds delivered to Crank as taken from Efficiency Curves on Plates.						
							25,000	23,000	20,000	17,000	12,000	10,000	8,000
	2	3	4	5	6	7	8	9	10	11	12	13	
Columbia chain.....	1 Wheel 1.—No. 80 1½ in. Hartford Tire A	29	Aug. 26	71½	123	13'25	...	93'75	93'50	92'75	90'75	89'62	88'50
	2 Wheel 1.—No. 80 1½ in. Hartford Tire A	30	Aug. 26	71½	183	13'16	...	93'00	92'90	92'50	90'00	88'25	85'50
	3 Wheel 1.—No. 80 1½ in. Hartford Tire R	38	Aug. 28	71½	{ Saddle 63 } { Pedal 120 }	12'93	...	94'00	93'10	92'25	89'00	86'80	83'80
	4 Wheel 1.—No. 80 1½ in. Hartford Tire B	37	Aug. 28	71½	183	12'56	...	...	94'30	93'50	91'20	89'75	87'61
Columbia chainless.....	5 Wheel 2.—No. 80 1½ in. Hartford Tire A	33	Aug. 27	71½	123	12'93	...	93'00	92'75	92'25	90'75	88'75	85'50
	6 Wheel 2.—No. 80 1½ in. Hartford Tire A	34	Aug. 27	71½	183	12'98	...	92'75	92'50	91'65	89'50	87'75	85'00
	7 Wheel 2.—No. 80 1½ in. Hartford Tire A	39	Aug. 28	71½	183	14'01	94'75	94'50	93'75	92'65	89'25	87'10	84'00
	8 Wheel 2.—No. 80 1½ in. Hartford Tire B	31	Aug. 26	71½	123	12'94	...	94'00	93'75	93'40	91'50	89'25	87'50
	9 Wheel 2.—No. 80 1½ in. Hartford Tire B	32	Aug. 26	71½	123	13'12	...	93'75	93'50	93'25	91'50	89'25	87'50
	10 Wheel 2.—No. 80 1½ in. Hartford Tire A	40	Aug. 28	71½	{ Saddle 63 } { Pedal 120 }	13'80	...	94'25	93'75	93'00	90'40	88'50	85'75
	11 Wheel 3.—1½ in. Tire 3	37½	Aug. 30	74'75	183	13'86	90'75	90'50	90'10	89'40	86'85	85'10	82'60
Other makers	12 Wheel 4.—No. 80 1½ in. Tire C	43	Aug. 31	63'8	183	11'53	...	89'50	88'25	84'00	81'25	77'00	72'25
Old chains	13 Wheel 5.—1½ in. Tire 5	42	Aug. 31	65'7	183	11'93	...	...	90'00	89'00	84'25	81'25	77'25
Foreign	14 Wheel 1.—No. 80 1½ in. Tire B	36	Aug. 27	71½	183	13'67	...	85'75	83'75	80'60	73'00	67'50	58'75
	15 Wheel 2.—No. 80 1½ in. Tire B	35	Aug. 27	71½	183	13'23	...	86'75	84'25	80'75	72'00	66'10	56'50
	16 Wheel 2.—No. 80 1½ in. Tire A	41	Aug. 27	71½	183	13'6	...	...	83'00	79'25	71'40	66'50	58'00
	17 Wheel 5.—1½ in. Tire 5. 42 A	42a	Sept. 1	65'7	183	13'75	...	...	...	65'75	50'25	41'75	...

which the balls roll, and I can best consider this with a photomicrograph of the highly magnified fracture of the broken steel surface before us on the screen. You will then see by the marked difference in granular structure how perfectly the surface hardening has been carried out. As for the balls themselves, they are case-hardened in the same careful manner, and I give below the measures of twenty of them picked up at random to show the uniformity of manufacture:

Number of the Ball.	Measured Diameter.	Number of the Ball.	Measured Diameter.
	Inch.		Inch.
1	0.1878	11	0.1880
2	0.1881	12	0.1880
3	0.1882	13	0.1879
4	0.1880	14	0.1879
5	0.1878	15	0.1880
6	0.1880	16	0.1880
7	0.1882	17	0.1880
8	0.1878	18	0.1880
9	0.1880	19	0.1880
10	0.1880	20	0.1880

Now for the chainless bicycle—the state of the art toward which the American machine methods have been struggling for years back. Three great difficulties had to be overcome to make the venture commercially or technically successful.

First, some material which could be worked into tubes had to be found which should possess the requisite strength, lightness and resistance to torsion. This material must be worked in machinery specially designed, since no plant existed in which one inch and a half hard steel tubes could be drawn cold with the necessary precision to give their tubing at 250,000 lb. per square inch tensile strength or 150,000 lb. elastic limit. This is the condition of such tubes before annealing.

Second, while involute and epicycloidal gears had been cut on machines, such machines were far too slow, and consequently too costly, to make such gears for the bicycle in the quantities required. It remained for the two great firms of machine tool makers, the Pratt & Whitney Company, of Hartford, Conn., and the Brown & Sharpe Company, of Providence, R. I., each to bring forward compact machinery which should occupy small floor space, and at the same time automatically cut an epicycloidal or involute shaped tooth at the will of the mechanic in charge. We shall see upon the screen such machines in operation.

Third, a process was to be devised for the hardening of gears, ball and spherical cup bearings throughout, which should not, in practice, result in any appreciable deformation of the tooled surfaces.

It has been a surprise to me to find that here in England many regard the chainless wheel as something new, something radical. It is the chain that is new, not the gear. A generation before the modern bicycle was born, the mathematicians had shown theoretically that if spur or conical gear teeth were cut in certain curves, not circular, power would be transmitted with as small a loss as by any other method. No thinking American mechanic ever analyzed the chain bicycle construction without convincing himself that the compact, rigid, tightly inclosed shaft power transmission would be adopted for the bicycle whenever rigid enough frames and hard enough gears could be manufactured in a commercial way. The chainless bicycle is neither a discovery nor an invention; it is an evolution, and so far as we can now see, it will be the survival of the fittest. The use of the rigid under-strut of the rear triangle as the means of carrying the tube to which are brazed the end gears is the most elegant solution of the gear case problem yet proposed. Here you have the gear case rigid, a little over one inch in diameter, and firmly secured to the thin steel covering caps at each end. The gears may run in a cup of oil, if necessary, and the stiff under-strut thus serves the double purpose of part of the frame and gear case as well. I must bring this part of the paper to a close, leaving details to the explanation of the illustrations on the screen.

It was in 1865 that Pierre Lallement, living in the manufacturing town of Ansonia, first made an American bicycle. He rode from that town to New Haven, fourteen miles, on one; but it was not until 1877 that Col. Albert A. Pope, after riding a wheel in the Back Bay district of Boston, foresaw its possibilities and founded the great industry of which he has remained the conspicuous chief. He has been justly called the father of the American bicycle. Not that he invented any of its parts, but in the broadest sense he has steadily nurtured the bicycle art in the United States. This, what John Stuart Blackie would call virtuous energizing, has been equally prevailing, whether in the conduct of this great company or whether before State legislatures urging proper measures for good roads, or combating the restrictions of small town councils on bicycle traffic, or urging upon the technical schools and assisting financially technical education, or pushing to effective completion highly organized and contributory companies, such as the motor carriage department of the Pope Manufacturing Company. You get your peers by heritage, we must find ours by survival; and Col. Albert A. Pope, when he laid aside the soldier's uniform he had always honored, at the close of our civil war, entered upon a career which has made him respected alike by those whose business schemes he opposes or advocates, while by his men he is loved, because he has constantly regarded their welfare, and no one can complain of an unredressed grievance who had a just cause. It is men of his stamp and mould which constitute our American aristocracy, whether in literature, or pure science, or mechanical art.

The divining rod is still thought an efficient means of finding water. Witness the small English town of Porthcawl, which, according to Nature, has paid about \$4,000 to a man who pretended he would locate springs by the use of the miraculous rod. His endeavors were fruitless, and the government ordered the members of the city council to refund to the city the amount uselessly expended.

GAS AND PETROLEUM ENGINES AT THE BRUSSELS EXHIBITION.

It probably will interest our readers to know that the English types of both gas and petroleum engines more than held their own at the Brussels Exhibition, and that on the whole they were well and extensively represented. Eight different firms belonging to the United Kingdom contributed fifteen gas and petroleum engines, most of which worked constantly under the eyes of the visitors to the exhibition, and seven of which were actually engaged in the production of power or electric current for the various services of the show. Foreign makers, nine in number, of various nationalities, contributed nineteen engines, of whom very few were actively engaged in producing power or electric current, and were mostly smaller than those contributed by British makers, and designed for small workshops and house installations rather than for use in works or electric stations of a more important size. The total horse power of the British display was

gine is started with a strong impulse. The lubricator is positive in its action, and the ignition is controlled by a mechanically worked ignition valve. Their next size engine is a 4 nominal horse power, with special governor, of the inertia type, but otherwise of the same details as the larger engines, and is used for furnishing the power for a bread-making installation of the "Complete" Bread Company. Our lower illustration shows the 4 nominal horse power gas engine with one flywheel and pulley for ordinary driving, but the one exhibited was for electric lighting, having two heavy flywheels and without pulley—the dynamo being driven by a belt from one of the flywheels. The last of the series is a 6 horse power petroleum engine, which is very simple; it is constructed on the same general lines as the gas engines of this firm, but has only two cams on the shaft instead of four: one for the inertia governor, and one for the exhaust. Another simplification is the absence of any pump for feeding the lamp, this being fed under a head from a reservoir attached to the engine. The lamp consists of a burner surrounded

FIG. 1.

FIG. 2.

TANGYES' OIL AND GAS ENGINES AT THE BRUSSELS EXHIBITION.

nearly 300, while that of the foreign makers was but one-third of that amount.

Messrs. Tangyes, of Birmingham, showed four engines of 69 horse power. The largest engine was a 55 horse power gas engine, which was shown in motion, but did no useful work. This engine is nominally of 25 horse power, but is capable of giving a maximum of 55 brake horse power at a speed of 160 revolutions per minute; it is recommended for working regularly at 46 brake horsepower with town's gas. The bed is carried down to the ground line, thus being specially adapted to resist vibration and rocking. Pinkney's patent combustion chamber is fitted, the object of which is to give a steady burning of the gaseous mixture during the power stroke. An efficient pressure starter is fitted to this engine, by which a charge of gas and air is pumped into a strong steel receiver, up to a suitable pressure; the charge is then let into the cylinder, the crank being in the right position for starting; the engine then moves off from the pressure thus exerted, and in so doing a trip arrangement fires the charge by means of the ordinary igniter, and the en-

gine is started with a strong impulse. The lubricator is positive in its action, and the ignition is controlled by a mechanically worked ignition valve. Their next size engine is a 4 nominal horse power, with special governor, of the inertia type, but otherwise of the same details as the larger engines, and is used for furnishing the power for a bread-making installation of the "Complete" Bread Company. Our lower illustration shows the 4 nominal horse power gas engine with one flywheel and pulley for ordinary driving, but the one exhibited was for electric lighting, having two heavy flywheels and without pulley—the dynamo being driven by a belt from one of the flywheels. The last of the series is a 6 horse power petroleum engine, which is very simple; it is constructed on the same general lines as the gas engines of this firm, but has only two cams on the shaft instead of four: one for the inertia governor, and one for the exhaust. Another simplification is the absence of any pump for feeding the lamp, this being fed under a head from a reservoir attached to the engine. The lamp consists of a burner surrounded

The engine shown in our upper illustration is for a constant working load of 6 brake horse power, and is tested at the works to about 25 per cent. more than this. We must also remark that the working of these engines is unusually silent, and that they have attracted much favorable attention in the exhibition.—Engineering.