GREAT BUSINESS ENTERPRISES

The Marvels of Bicycle Making.

III.

A VISIT TO THE WORKS OF THE POPE MANUFACTURING COMPANY.

By Cleveland Moffett.

THE modern bicycle is such a small affair, so light and apparently simple in construction, that few people realize what a wonderful mechanical product it is, or know that the manufacture of a high-class wheel presents one of the most complex problems in engineering. Here is a machine containing over a thousand pieces as delicate in their adjustment as the parts of a watch, a machine that outruns the horse and vies with the locomotive, one that will carry a heavy man all day although weighing no more than a baby, one that ranks in importance with the steam engine and is all but revolutionizing the world.

How interesting it would be to tell the story of the evolution of this wonderful vehicle from those early days in 1878 when the Columbia was made of Norway iron and weighed fifty pounds, when the backbones were made of welded iron pipe, and the spokes of iron wire, three times as heavy as the spokes of to-day! What progress there has been since then, what wonderful changes! In the first year the Columbia plant occupied one corner of a sewing-machine factory; now its floorage covers more than seventeen acres. In 1880 the company's entire office force consisted of Colonel Albert A. Pope, his cousin E. W. Pope, and two boys; they did all the work, filled all the positions, were at once salesmen, bookkeepers, and corresponding clerks, and their quarters were in a loft crowded with rickety desks. Now the office force can be scarcely accommodated in a large and beautiful building fitted with every modern convenience, while three thousand workmen swarm in the great stretch of factories. In 1880 a single man ran the whole bookkeeping department, and did other work besides; now this department requires the undivided labors of a manager and thirty-six subordinates, including auditors, cashiers, entry clerks, ledger clerks, claims clerks, checking clerks, stenographers and messengers. In 1884 the company had only about 200 agents in the whole country; now they have upward of 3,000. In 1884 they had but one man travelling to represent the company, now thirty men travel constantly from place to place in the various States, organizing new agencies, reporting on the condition of the old ones, and in general

looking after the interests of the company. And while seven or eight years ago one man was able to attend to all the correspondence of the sales department, to-day twelve clerks, each with his stenographer, are kept busy at it from morning to night. Ten years ago a hundred letters a day would have been a high average for the company's mail; now they receive from 1,500 to 2,500 letters a day. So great is the contrast between start and finish, if one may use the word "finish" in an institution where progress toward still higher perfection is in the very air one breathes.

THE GUIDING PRINCIPLE.

One of the most remarkable points in the early development of the Pope Company is the unswerving confidence in the future of the bicycle shown by its founder, Colonel Albert A. Pope, in the face of all obstacles and discouragement. In 1877, when most people looked upon wheeling as a silly fad, a boy's amusement, destined to die out as the velocipede craze had died out before it, he persisted in his belief that the bicycle had in it splendid business possibilities. And late in the summer of that year he gave up all other business interests and, with small capital, but boundless energy, proceeded to devote himself exclusively to the sale of bicycles and the development of bicycle interests. This almost clairvoyant foresight must be regarded as one of the chief elements in the splendid success since achieved, for greatness in business, as in other things, often consists chiefly in the power of seeing and seizing an opportunity. Already, in those early years, in that difficult pioneer period, Colonel Pope began to lay the foundations for the great structure that has since been reared, outlining clearly the policy that has been consistently adhered to by the company, of working for the future, not for the present, of striving for the final result, not for immediate gain. Every new step was taken with a view to expansion in coming years, every season's policy was approved, not so much because it would pay in that immediate season, but because it would pay in the long run. In the first factory was the germ of all the other factories—the germ of the tube works, the rubber works, the motor carriage works, the Hartford cycle works, and all the other departments which have followed and are still to follow. One of the Colonel's favorite maxims was, that an army is not for a single battle, but for the whole campaign.

No one can realize what a tremendously complicated thing is the making of a modern bicycle until he has visited the main factory, or, rather, paid many visits there, for this factory is really a stretch of workshops that, to the newcomer, follow one another in bewildering and endless confusion. Eight acres of flooring there are in these shops, all thronged with workmen and whirling with machinery, a veritable forest of wheels. And this without counting the other works just mentioned, which are little worlds by themselves, and very important worlds, as we shall see.

A mere enumeration of the processes that go on constantly in this main factory fills the mind with wonder, but to observe these processes, to take them in through eye and ear, is to increase that wonder tenfold. There is the forging, the annealing, the brazing, separate departments each of them; there is the making of the balls, the chains and the spokes; there is the general machine shop where special tools are made; there is the model room, the designing room, the departments for polishing, nickelling, buffing, wheel assembling, and pattern making. Then there is the press room, the hand blacksmith shop, and a great department for machining all the parts, this being subdivided into various lesser departments, for the "frame job," the "crank job," the "automatic screw machine job," the "brake and handle-bar job," the "hub job," etc. Then there is a complete electric plant and a power department containing five large steam engines.

To direct such an industry as this is like managing a great circus or commanding an army; there are few men in the world capable of it. One day, after a tour through the works, General Miles said to Colonel Pope with the greatest admiration in look and tone: "No, I shouldn't want to undertake the running of this factory; I'd rather fight Indians."

WHERE THE FORGES THUNDER.

After the first dazzle of impression has passed away and one begins to recognize things with a half understanding, and distinguish between the main operations and those of lesser importance, one sees that the making of a bicycle may be classified more simply under four heads: (1) the forging and pressing of a multitude of

A VIEW OF THE FORGE ROOM, SHOWING ONE OF THE BIG TRIP-HAMMERS, WHICH STRIKE TWO HUNDRED TIMES A MINUTE.

parts out of hot or cold steel; (2) the treatment of these in various ways in furnaces; (3) the "machining" of the parts to smoothness and exactness of fitting, and (4) the processes of finishing, assembling, and inspecting. As the forges and furnaces come first, we may begin with them, and shall find ourselves presently in a region of flame and shadows and unceasing noise.

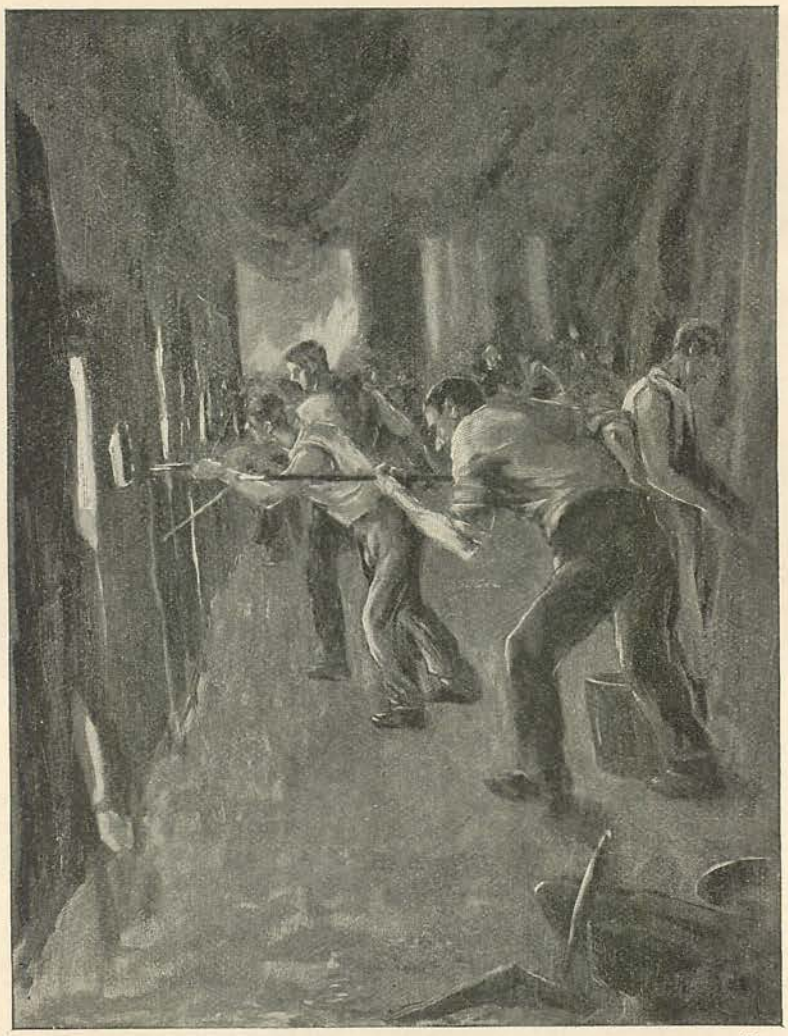
Now we are before the forge room, a black place with lines of fire stretching in rows from end to end, with hissing flames that shoot out in white sheets from the blast fires, with spots of red in the shadows where the steel is being hammered on the forges. A roar of quick blows comes from the six trip-hammers, each one striking 200 times a minute. There is a screaming of belts as grimed workmen, pressing the foot pedals from time to time, pull them taut on the pulleys; there is a buzz of wheels and belts that spin ceaselessly overhead.

At frequent intervals there sounds above all the other din a heavy boom that shakes the walls. It is one of the big drop-hammers striking. Down shoots the ram, carrying on its head a cube of steel weighing as much as a man. This is the die, and it strikes upon a sister die beneath it at the bottom of the fall. When the two come together there is exerted a striking force of 1,100 tons. No wonder a double foundation of timber and concrete is needed underneath.

Besides these big fellows there are many drop-hammers down the lines, arranged in pairs, one giving the first rough-forming stroke to the hot metal, the other giving the finishing stroke. And between each pair of forges is a press with steam-driven jaws that trim off the rough edges of "flash" from the piece that is being shaped.

For each pair of forges three fires burn, the line of these running parallel to the line of forges down the shop. These are the hottest fires in the works, hotter than the furnaces for case-hardening or annealing. They are fed by crude oil brought in pipes from large tanks under the lawn, the oil being pumped through these and on its way mixed with a draught of high pressure air, which vaporizes the oil so that it is projected into the forge fires in a fine spray, and the combustion takes place almost instantaneously.

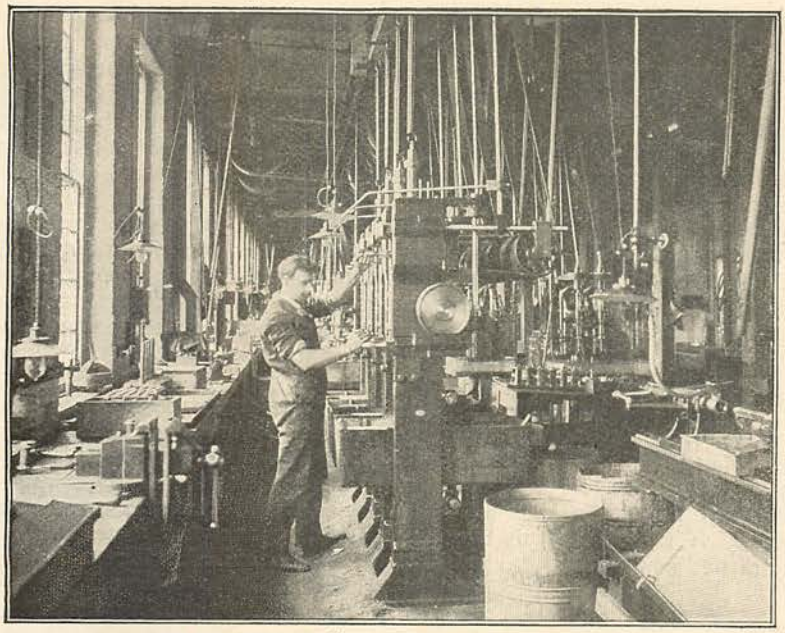
Since the beginning of the industry great advances have been made in the methods of the forge shop, by the introduction of heavier hammers, by the substitution of oil for coal at the fires, and by the perfecting of the furnaces. In the old days when the forges were served with open-top furnaces, burning Lehigh coal, the men suffered much from the heat and the strangling fumes. Now



A VIEW OF THE FORGE ROOM, SHOWING THE FURNACES—"THE HOTTEST IN THE WORKS."

only closed furnaces are used, with doors guarded by sheet-iron screens to protect the men. While the operation of forging has been thus perfected, and remains of the greatest importance, it should be said that from year to year the tendency has been to reduce the number of forgings in the construction of a bicycle, and, as far as possible, to replace by tubing the solid parts that previously had to be bored out. One reason for this change is that improvements in tube construction have made it possible to give a more elegant finish at the joints by the use of tubing. Thus, in the Columbia of 1897, the crank hanger, which was previously drilled from forgings, is made from steel tubing.

Coming now to the next process, we enter a big furnace room where the annealing is done and the case-hardening and the "pickling." Case-hardening makes steel harder when it is too soft, annealing makes it softer when it is too hard, and "pickling" cleans it of scale that forms on the surface. In both case-hardening and annealing the parts of the bicycle to be thus treated, numberless pieces, some as large as a handle-bar and others as small as the tiniest screw or bolt, are packed into cast-iron retorts—queer little boxes that look like coffins for kittens or pet dogs—and in these are slid into rows of furnaces and left there for a varying number of hours. Up to this point the two processes are identical, except that in case-hardening the bicycle parts are placed in the retorts along with a quantity of charcoal and crushed bone to assist in carbonizing their surfaces,



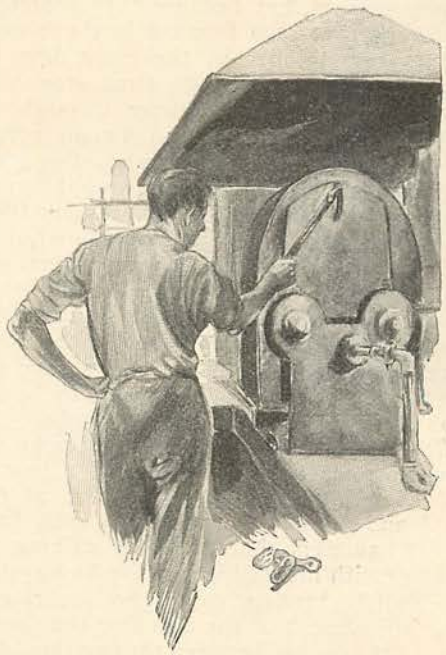
THE DRILLING-ROOM, "A FOREST OF BELTS AND WHEELS."

while in annealing the retorts are spread with charcoal only.

A FOREST OF WHEELS.

Next we pass into one of the largest parts of the factory, a bewildering place, the great drilling-room, a confusion of belts and wheels which turn so many machines that the untrained mind can scarcely remember their names, much less understand their purposes. There are scores of lathes, drill presses, boring machines, reamers, chucking machines, milling machines, threading machines, and many others whose general purpose is to bore out the various forgings, the hubs, crank sleeves, pedal centres, etc., cutting away every particle of superfluous metal, smoothing the surfaces without and within, putting on threads where they are needed, boring holes for screws, and, in general, adapting each part for use in the finished bicycle. This preliminary drilling and smoothing having been done, the various parts go to their own departments, each a little factory by itself, with its separate force of men, its specially devised machinery, and its numerous problems to solve.

One of the most interesting of these many factory processes is that of making the chains. The ordinary bicycle chain contains fifty-three links, each composed of five pieces: the block, the two side links, and the two rivets. These five pieces are woven together by an assembling machine, an extraordinary piece of mechanism, which can do everything except talk. The finished chains are then taken to another machine, where they pass between two rotating surfaces which spin heads on the rivets and make the links secure. This machine is driven by a man who is said to be the greatest "kicker" in the factory, since every day of his life he has to kick over 32,000 times, that being the number of times his right foot comes down upon the spring treadle that works the mechanism, and the strange part of it is that although this man's right leg does all



THE OVEN WHEREIN THE CHAIN LINKS ARE GIVEN THE PROPER COLOR.

the work, it is his left leg that gets tired.

Near this "kicking" man is another interesting character in the chain room, a young lad whose business in life is to cut up strips of felt into tiny pieces and to put one of these into the centre of each chain block for lubrication. By actual count this boy puts an average of 15,000 of these pieces of felt into 15,000 chain links every day of his life, and on one day he pushed the total up to 17,000.

The last step in the process of chain making is to put the chains through a testing machine which produces the conditions of actual riding. In this machine the chain is kept turning for some minutes under great pressure, the effect being the same as if it was put upon a bicycle and driven up a very steep hill by a man weighing 800 pounds. If it endures this severe strain it is regarded as perfect.

SWAGING THE SPOKES.

The noisiest place in the works is the spoke department, which suggests the screaming of a dozen sawmills or the wailings of a hundred mad women. The most interesting process here is performed by the swaging machines, which deserve some notice, not only because they are the great noise makers, but because they represent an important step forward in the history of spoke-making. In the early days bicycle spokes were made from steel wire having a uniform diameter through its whole length. This method of manufacture was followed until 1891, when the great demand for lighter machines caused bicycle makers everywhere to cast about them for some means of lightening the spokes. After many consultations with experts and after months of experiment, the officers of the Pope Company decided to attempt a reduction of weight by lessening the diameter of the spokes at all points save the two ends, where shoulders were to be left for attachment to rims and hubs. To effect this thinning out of the spoke the swaging machine was devised, a pair of whirling jaws that grip the wire at one end and drag it between two dies, little steel hammers that are kept striking together with incredible rapidity by a system of swiftly turning rolls. So accurate is the adjustment of the dies that the diameter of the spokes between the two shoulders is always exact to within one one-thousandth of an inch.

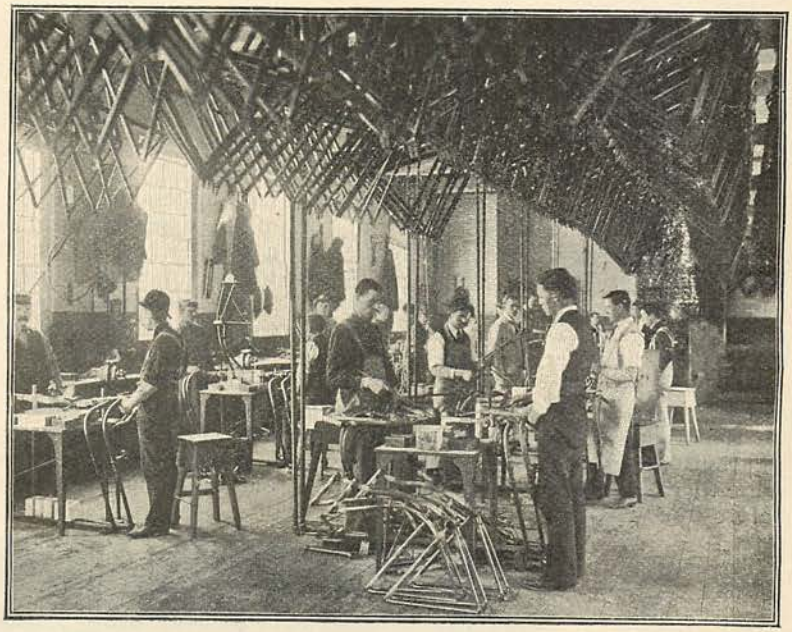
On leaving the swaging machines the spokes are cut off by a revolving cutter, and headed, and then they formerly went to three little boys who sat on a bench and did nothing from morning till night but bend the heads of the spokes to a right angle with the lengths, for insertion in the hubs. It must be said, however, that the company have decided to give up this bending of the spokes in their '97 bicycles, as experiments in the testing departments have demonstrated that far greater strength and power of resistance are assured by using spokes that go into the hubs straight.

Many other departments there are where strange machines labor; to describe them all would fill many chapters of a large volume. There is the making of the sprockets or gear wheels with queer teeth-cutting machines, which eat out the metal slowly, working in baths of oil. There is the bending of the handle-bars, done in powerful gear presses by huge steel hands which descend slowly from above upon dies holding the tubes and bend these latter into any desired shape. There is the turning out of various brackets and shafts and cases, small parts of the bicycle, but of vast importance for smooth running. These are made in the turret machines, which no one but a machinist can understand, each one with half a dozen arms that turn in succession against a bar of steel and do some act of drilling or cutting or smoothing. And as the bars of steel are fed into these machines the finished pieces drop from the end one by one, the workmen doing little but manage a wheel or lever.

Some of these turret machines actually work automatically, turning out screws and nuts and other little pieces by the hundreds of thousands, working on by themselves day after day, week after week, and only asking the workmen for oil now and then and a proper supply of steel to feed upon. These "automatics" have proved themselves particularly valuable for their accuracy in making screws and nuts, which are used of course in immense numbers every year. For a long time the Pope Company tried to buy screws and nuts ready made, but they could not secure them up to the desired standard, the threads and sizes were not sufficiently accurate, and the quality of stock was below Columbia requirements, so they were forced to start what might be called a screw factory of their own.

AMONG THE BRAZING FIRES.

Now that we have seen how some of the chief parts of the wheel are made, we may observe how these are put together, and first we will enter the brazing-room, where the tubes of the frame are fastened to the various "hangers" and connecting parts. This is one of the most important processes in bicycle manufacture, for unless the brazing is done solidly all else will be done in vain. And it is of interest to note that the growth of the bicycle industry has led to a much better understanding of the art of brazing than had previously existed; indeed, so recently as 1880, American mechanics generally thought it impossible to braze light tubing to solid forgings, and for several years the company were in a constant tension of effort to overcome existing difficulties and bring to perfection the art of brazing as applied to bicycle construction. The best authorities in this country and abroad were consulted, libraries were ransacked for treatises on the subject, and large sums were spent before the secret was discovered which gave and still gives to the Columbia frames the strength in the joints for which they are famous. Indeed it is no easy matter to braze tubing as thin as paper to a piece of solid steel and make the two as if they were one piece.



THE BRAZING-ROOM, "WHERE THE TUBES OF THE FRAMES ARE FASTENED TO THE VARIOUS 'HANGERS' AND CONNECTING PARTS."

As one enters the brazing-room the ear is struck by a sound like the roar of a distant surf. This comes from the long lines of brazing fires, each one darting and hissing on its little iron table, the blue-tongued flames striking into adjustable iron ovens of fire-brick that rest on the tops. The heated area within the fire-brick is very small, not larger than the top of a man's hat, but it is intense in proportion; indeed the points where the two tongues of flame come together are nearly as hot as the forge fires.

It is interesting to follow a batch of frames as they start at one end of the double stretch of fires, and advance joint by joint to the last fire, which leaves them completely brazed. In every bicycle there are thirty joints that require brazing, and each operation of brazing takes from thirty seconds to a minute and a half. The excellence of the work done here is shown by the fact that in something like a million and a half brazings done on the machines of 1896 less than a dozen joints were the cause of any complaint.

THE POLISHING AND NICKELING.

On leaving the brazing department, the handle-bars, cranks, pedal centres, and other parts of the bicycle to be finished in nickel, are carefully brought to a certain smoothness at the joints, and are then sent to the polishing department, where this smoothness is increased many fold, it being essential that the surfaces to receive the nickel be almost like glass.

Here are gloomy, heavy-walled rooms where wheels spin with rapid buzz, wheels along the ceilings for the pulleys, quadruple rows of wheels along the floors for the grinders and polishers, huge gear wheels

at the far end that drive all the smaller wheels and work the big blower. The whole floor shakes in heavy, quick vibrations. The workmen wear little black caps drawn over their eyes to protect them from the sparks. The air is full of dust and the odor of glue and walrus hide.

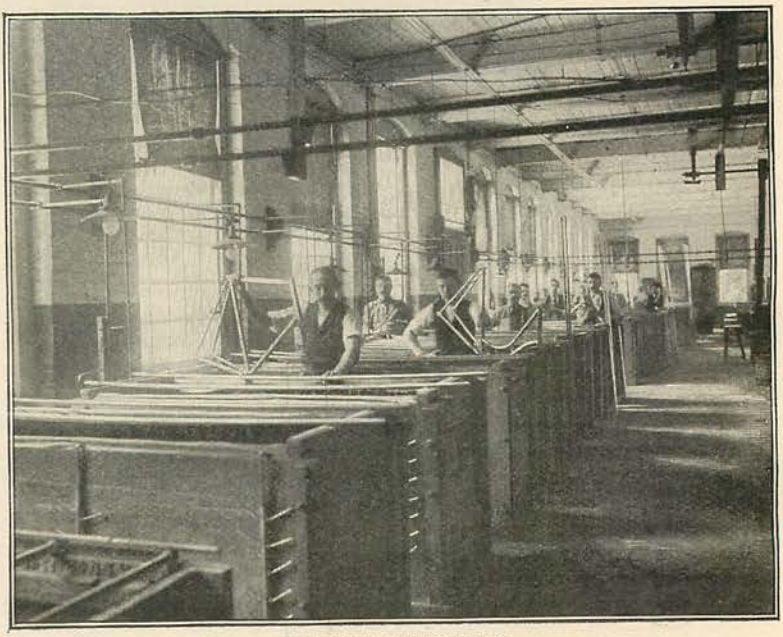
Emery powder and walrus hide are staple necessaries in this department. The walrus hide is used to make polishing wheels, and the emery powder is sifted over the periphery of these wheels and held there by glue, so as to offer a grinding surface to the steel. For heavy grinding, wooden wheels are used, covered with "oak tan" polishing leather, and this covered again with emery, but where a high degree of polish is desired nothing has been found to equal walrus hide, which makes a wheel at once tough and sufficiently yielding.

Having been thus polished, the handle-bars, cranks, etc., are taken to the nickeling department, the largest plant of the kind in the country. Here everything is clean, there is little noise, there is no confusion of wheels, only a few pulleys that drive two dynamos in the center of the room. On the other side, stretching from end to end, are big nickeling vats filled nearly to the tops with a dark blue liquid. On the other side are vats steaming with solutions of potash, lime, muriatic acid, these to make the parts chemically clean before the plating.

The articles to be nickeled, the handle-bars, brakes, spoons, seat posts, cranks, etc., are first thinly coated with copper in big tanks holding a cyanide solution; then they are immersed by the hundred in the line of nickeling tanks, three or four hours here being usually sufficient to insure the best plating. When taken out, nickeled parts present a dull color, not brighter than silver which has been much used, and by no means resembling the ordinary nickel plate seen on bicycles. Before the parts will take on that high gloss they must go through the buffing department, where we will now follow them.

THE BUFFING AND ENAMELING.

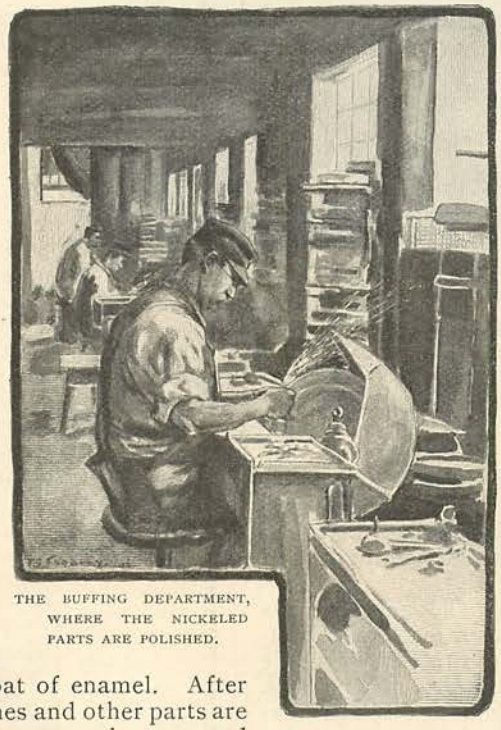
The buffing department is a place of fantastic shapes and sounds that set the teeth on edge. Down the center stretches a huge blower of galvanized iron, which looks for all the world like a curving sea-serpent, with thirty-six necks wriggling out of the sides, and thirty-six heads, each with wide-gaping jaws. And at the thirty-six heads are as many workmen, who seem to be feeding the serpent with cotton waste from the swift-turning wheels that do the buffing. It is the peculiar composition of these buffing wheels that makes necessary the great blower, for they are composed of nothing less than disks of cotton cloth, 120 of these being placed side by side to form a single wheel. One might imagine that wheels of such flimsy stuff would offer small resistance to the steel, but the eighteen lathes turn with such great rapidity—2,600 revolutions to the minute—that the centrifugal force drives the flaps of the cotton hard together, so that when the wheels are turning at full speed they form a surface, not as hard as board, to be sure, but quite hard enough for the purpose.



THE NICKELING DEPARTMENT.

And the friction of these wheels against the bicycle parts wears out the wheels so rapidly that much cotton waste and emery dust are thrown into the air that might do harm to the workmen's lungs were they not carried away by the suction of the big blower. When used in buffing, the cotton wheels are smeared with "white polish," and so effective is this treatment that a few seconds' contact with the rapidly driven wheels is sufficient to bring the finest polish to the nickel, a polish which it retains permanently.

Of the finishing processes there remains the enameling, which is done in a series of large rooms ranged with huge ovens and vats filled with liquid enamel. In the enameling department are treated the frames, forks, chain guards, and rear shields, which must all be black and shining in the finished machine. The first step is to give these parts a careful cleaning in vats of boiling water. Then, after thorough drying, they are smoothed down with emery cloth, and washed with benzine, which removes all the dust, and leaves them ready for the first coat of enamel. After this first coat the frames and other parts are baked for hours in gas or coal ovens, and then other coats are applied, with a baking in the ovens between each, and so they advance gradually to the necessary gloss and smoothness. After the last coat they are taken to the finishing-room, the most immaculate place in the works, and here they get their final baking, in a line of special ovens, a veritable street of little houses, eight or nine feet square and the same in depth, the gas ovens made of galvanized iron, the coal ovens built with heavy brick walls. In them all are bars of iron along the ceiling, and swinging shelves to support the various parts, and heavy doors that close with long iron bars and bear queer little thermometers on the outside, disks of metal, with arrows which indicate the temperature—anywhere from zero to 500 degrees Fahrenheit.

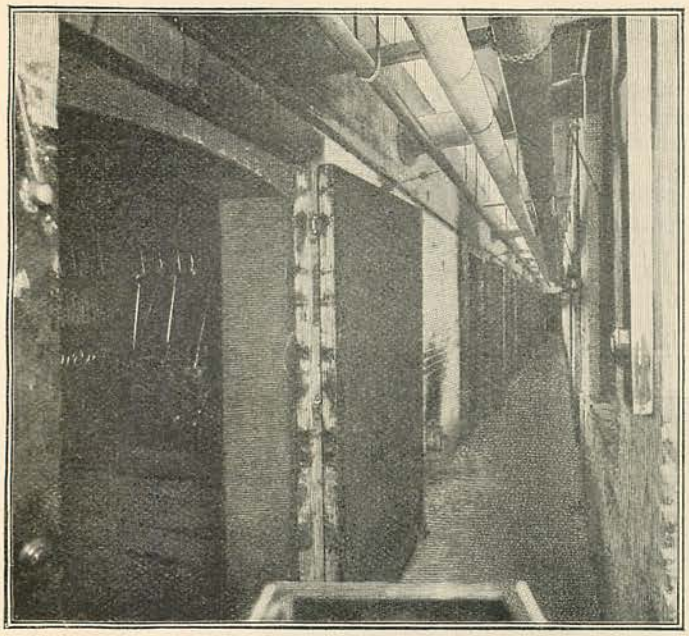


THE BUFFING DEPARTMENT, WHERE THE NICKELED PARTS ARE POLISHED.

THE INSPECTION DEPARTMENT.

So much for the chief processes of the factory, but before the various parts of the machine can be "assembled" into the finished bicycle they must pass through the inspection department, one of the most admirable features of the works, and well worth some brief consideration. It is not until one has visited this department and studied its methods that one understands what elaborate precautions are taken in the Columbia Factory against any blemish or defect in any one of the numberless parts that make up a bicycle. A small army of men devote their entire time to this work, which means an annual expense of many thousands of dollars, to make sure that every smallest and largest part, every joint, every bearing, is exactly as it should be.

There are special reasons which render imperative this work of bicycle inspection, one of the chief of these growing out of the fact that what scientists call the "factor of safety" is lower in the bicycle than in almost any other mechanical product, and has been growing still lower every year as the machines have been made lighter. In high pressure guns the "factor of safety" is often as great as twenty, which means that the guns are made twenty times as strong as is theoretically necessary for the strain they must bear; in ordinary guns the "factor of safety" is twelve; in boilers it is about six; in bridges it is usually five, and in almost every construction or machine it is at least four; in the perfected bicycle of to-day it is estimated that the "factor of safety" has been reduced to 1.25. This means that if any joint or screw or bolt or bit of wire in a machine



THE OVENS WHEREIN THE FRAMES ARE BAKED TO SET AND HARDEN THE ENAMEL.

fails in strength or perfection of fitting by only so much as twenty-five per cent. of what is expected of it the bicycle may be crippled, the rider's pleasure destroyed, perhaps his safety threatened. In these days, when bicycles are being driven at the speed of railroad trains, it behooves a wheelman to see to it that he is not riding a machine where lightness has been obtained at the expense of strength and rigidity.

From the very start, Colonel Pope has regarded it, not only as a matter of business policy, but as a positive duty to the public, to take such extraordinary pains in the manufacture of Columbia wheels that riders may feel safe against accident due to faults of construction. As a means to this end there has been established not only the inspection department, which we shall now consider, but also the testing department, which is perhaps even more important, and which we shall consider presently. Coming now to the work of inspection: All the forgings in a Columbia bicycle, and there are about a dozen of these, are separately inspected, before going into the shops, for any seams, cracks and "cold shuts," or other defects. Some of these forgings are inspected twice, so that for the forgings alone between 4,000 and 5,000 pieces have to be examined daily by men who devote their whole time to such inspection. About five per cent. of all the forgings are at once rejected as not up to the standard and are sent to the scrap heap.

This inspecting of the forgings is but a small part in the work of this department, for at every step in the subsequent machining and finishing all parts are again inspected, and it is literally true that every portion of a Columbia bicycle, from the largest piece of tubing down to the tiniest screw, receives separate and individual inspection at least three times, frequently six or eight times, and in some cases twelve times. For instance, every Columbia crank is inspected eight times, every handle-bar six times, every sprocket five times, every chain four times, and so on.

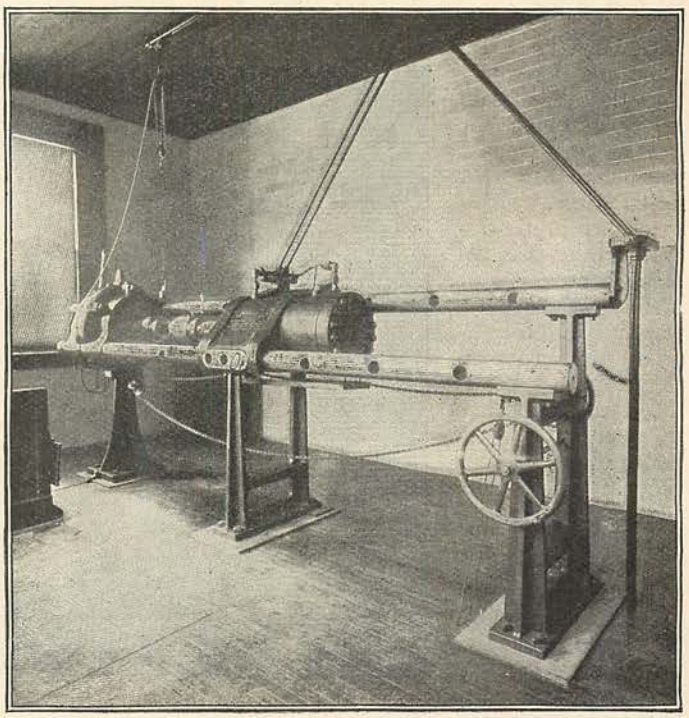
And after all this there is the general inspection of the completed wheel, which is very severe; and it is safe to say that when a Columbia bicycle has passed the ordeal of the inspection department it will stand any criticism. Indeed as one passes through

INSPECTING STEEL BALLS.

the various departments of the factory one sees everywhere how the danger of greater lightness has been offset by greater strength of material and improved methods of construction, so that the shell-like Columbia of to-day is actually stronger in many respects than the lumbering model of a few years ago.

THE TESTING DEPARTMENT.

That such high perfection has been attained is largely due to the scientific testing department, a unique feature of the Columbia Works. In all the other parts of these great factories the aim is to build up, to put together; here the aim is to tear apart, to destroy. Elaborate and expensive machines have been devised for no other purpose than to determine how much force is necessary to wear out a finished bicycle, to bend, break, or drag asunder its various parts. In order to learn how to make the strongest possible bicycle it is necessary to find out what makes a bicycle weak and exactly how much power of resistance should be possessed by each individual part—the frame, spokes, tire, axles, cranks, pedals, forks, etc. To find that out means putting such excessive strain upon these parts that the manner of their breaking may be clearly understood.



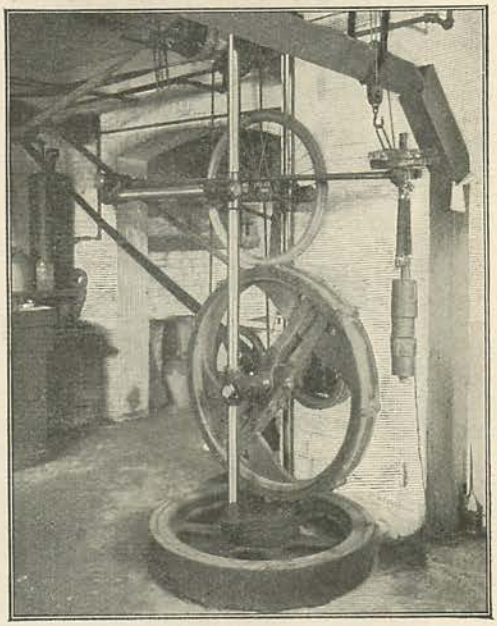
THE 100,000 POUND TENSION AND COMPRESSION MACHINE, USED ESPECIALY FOR TESTING STEEL.

The expense involved in maintaining this department of destruction is so great that no other bicycle makers have felt justified in establishing a similar one. The 100,000-pound tension and compression machine, for instance, is the only one in any bicycle factory in the world. This machine, the usefulness of which has been described in a previous article, consists of two heavy jaws, which can grip and tear apart anything placed between them, from a heavy steel bar down to a hair, its movement being started by hydraulic power so perfectly controlled as to give any desired amount of force, from a few ounces up to a maximum of fifty tons. And the working of the alternate stress machine in testing various grades of steel tubing has also been described. These two machines furnish the physical tests which every new grade of steel tubing has to undergo as soon as it leaves the tube mills. There, of course, in a single year, hundreds of grades of tubing are drawn, each possessing individual qualities or defects, different blending of those two great requisites—strength and toughness, and it is for the testing department to decide whether one kind of tubing is superior or inferior to another kind, whether a certain change in the process has been made for the better or for the worse.

THE FAMOUS NICKEL STEEL.

The value of these tests was shown most conclusively in the early part of 1894, when Colonel Pope began to consider the advisability of introducing, in certain parts of the bicycle, tubing made of the famous five per cent. nickel steel similar to that which has been used with such excellent results in the construction of armor plates for the government. This nickel steel was known to be more costly than the high carbon grade they were then using, and

far more difficult to work, and the question was whether its adoption would give a sufficient increase in strength and tenacity to justify the added trouble and expense. A few tests in the alternate stress machine left no possible doubt on this point. Two specimens of tubing were successively introduced, both of the same gage, and in every respect identical, save that the one was made of high carbon steel, such as had been previously used, while the other was made of nickel steel. The first tube endured a strain of 250,000 revolutions before breaking, which was considered a good record, but the other tube under the same load, after enduring a strain of over 2,000,000 revolutions and remaining in the machine for nearly two weeks, was taken out still unbroken. The expert promptly declared that this alloy of nickel and steel possessed a strength and toughness not to be found in any other metal and rendering it peculiarly well adapted for use in bicycle construction. Accordingly the Columbias for 1897 contain nickel steel tubing, and it has been found that this change results in a saving of weight as well as in a gain of strength, the great resisting power of the nickel steel making it safe to reduce the thickness of the walls of the tubing in some places to twenty-five one-thousandths of an inch or less.



MACHINE FOR TESTING THE STRENGTH OF BICYCLE WHEELS.

Another piece of apparatus in constant use in the testing department is the vibratory machine, a large wooden wheel about four feet in diameter, on the circumference of which are a number of heavy cogs of unequal lengths and shapes, varying in height from half an inch to two inches, some sharp at the ends, some rounded, their purpose being to produce as rough a surface as could be found on even the stoniest road. Against this uneven periphery a bicycle wheel with spokes taut and pneumatic tire inflated, a brand new wheel fresh from the factory, is pressed by means of an iron bar heavily weighted at the end, so that the pressure on the bicycle wheel against the cogs may equal the weight of an average rider.

Thus arranged, the machinery is set in motion, the cogged wheel turning 162 times a minute and making the bicycle wheel turn against it as if it were being driven over some terrible cobblestone road at the rate of thirteen and a half miles an hour, and that under the weight of a heavy man. This test puts upon the wheel, upon every spoke, upon the hub and rim and tire, a strain many times more severe than could be experienced under any ordinary conditions of riding. Thirteen hours is considered a good length of time for a wheel to last under this tremendous strain, but so great is the strength of the perfected Columbias that some of them have stood this murderous test for thirty, forty, sometimes fifty hours without a spoke bending or any defect showing itself; on the other hand, the wheels of other companies have frequently been put through this test to determine their strength as compared with that of the Columbia, and the result has always been most satisfactory to the Pope Company.

STILL OTHER TESTS.

Still another feature of the testing department is the chemical laboratory, where specimens of steel by the score are submitted to a chemical analysis in determining their composition. There are all sorts of appliances here, including delicate balances, capable of weighing one-twenty-thousandth part of a drachm, a powerful microscope and a Le Chatelier pyrometer, by means of which a spot of light moving along a graduated dial allows the men of science sitting in their laboratory to know exactly to a degree the temperature of the

great annealing furnaces in distant parts of the works, where the parts of the bicycle are being submitted to fire.

One device in the testing department is a novel dynamometer for measuring the effort put forth by a rider in overcoming the friction of a bicycle. In a general way this dynamometer is the familiar Atwood gravity machine with its two tall columns, a bicycle wheel with ordinary gearing being substituted for the usual frictionless pulleys. Then the deviation in the descent of the weight from what would be required in the ordinary Atwood machine is taken as representing the friction of the bicycle, and comparisons between various machines are made by noting the various amounts of these deviations. Thus the company are able to demonstrate practically by the evidence of the impartial pulley wheels that they have succeeded in building a wheel that is second to none in ease of running.

THE TELEPHONE CLERK.

And, as supplementing the work of the testing department, the company employs constantly a corps of expert wheelmen, who are kept riding in all seasons over all sorts of roads, the rougher the better, and on machines of almost every make, whether foreign or American. These riders are instructed to put the wheels to the most severe tests, and are called upon for regular reports. It is of interest to note here that in the fall of 1896 thirty machines of the 1897 pattern were in this way ridden a distance exceeding 100,000 miles in the aggregate before a single 1897 machine was put on the market. Such tests give the company at the outset of the season a better knowledge of the detailed capacities of their new machines than most makers can gain by the close of the season.

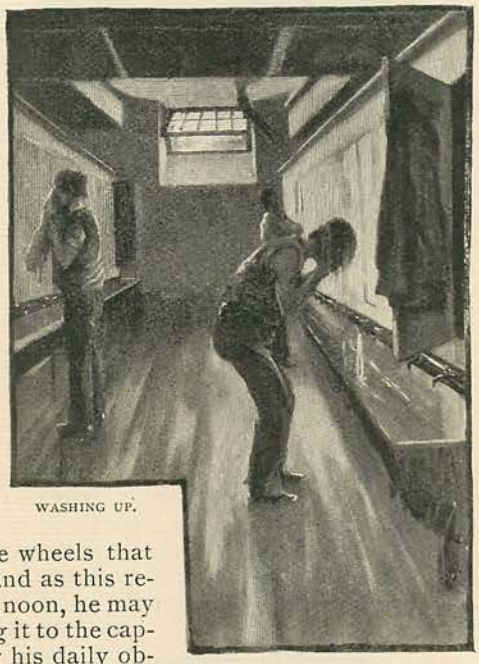
THE RECORD ROOM.

The reports of this corps of riders are considered at the regular councils, in which some twenty heads of departments take part, and which form another important feature of the establishment. Great are the arguments and discussions that take place at these councils, hours being devoted to such minute details as the shape of a handle-bar, the curve of a fork, the proper width of a tread, the thickness of a bit of wire, a trifling increase in the diameter of a sprocket wheel, etc. Every cycling paper in the world is read and studied by these men, every new pattern is pounced upon with critical interest, and reports from the army of agents all over the country, and from hundreds of agents in foreign lands, are read with the importance of state papers. What wonder that with such admirable organization in every department, with such constant vigilance and attention to every detail, with such mechanical facilities in the shops, and such an assemblage of practical scientists and specialists for the work of direction, and, above all, with such a broad and enlightened general policy, and the constant oversight of the guiding mind which has built up this great industry, —what wonder that the Columbia bicycle stands today unrivalled among the wheels of the world !

HOW THE BUSINESS IS MANAGED.

And here a few words will be of interest as to the relations existing between this remarkable merchant manufacturer, Colonel Albert

A. Pope, and the men in his employ. Colonel Pope lives in Boston, and usually spends only one or two days of each week at the factory in Hartford; indeed, he finds it a positive advantage to manage the great interests controlled by him from a distance. He is able thus to take a broad view of things and follow clearly the path of advancement with no distraction from irrelevant details.



WASHING UP.

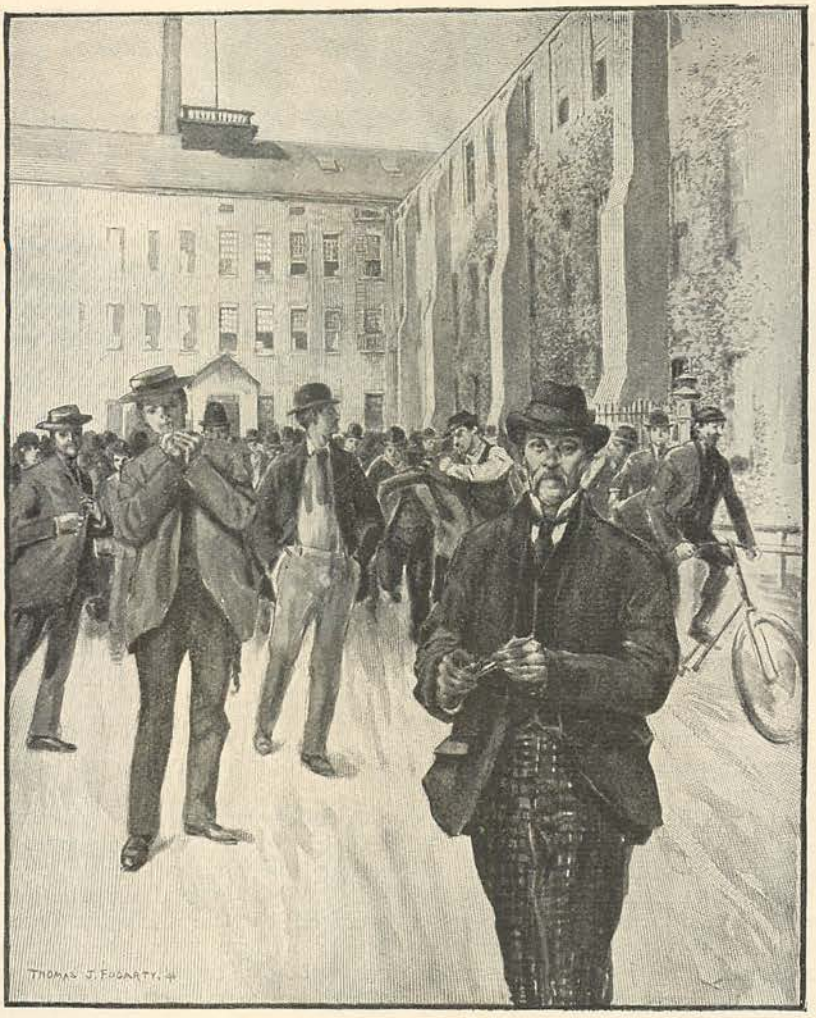
And yet Colonel Pope is absolutely in touch with everything going on at the works, down to even the smallest detail. Every day he receives an elaborate report from the factories which is nothing less than a perpetual inventory of the stock on hand, the wheels that have been sold, etc., and as this report runs from noon to noon, he may be compared in reading it to the captain of a vessel taking his daily observations. On the days of his visits to the factory he is occupied from seven in the morning until eleven at night in consultations with the heads of the departments, who come to him in succession with their portfolios ready; in talking with the travelling salesmen and managers of branch houses, to whom he delivers regular lectures in the lecture-room; in making a tour of the works and observing things for himself—in a word, in settling questions that have come up since his last visit and in stimulating every one to his best exertions. He might be called the president of a great bicycle university where faculty meetings are held once a week, and it is literally true that his spirit pervades and dominates the entire institution.

CHEF OF THE LUNCH ROOM.

COMFORT OF THE WORKMEN.

In the course of frequent journeyings through the factories I have been struck by the care shown for the comfort and well-being of the workmen. Take the noon hour, for instance. At three minutes before twelve the automatic signal clock in the timekeeper's office sets electric bells ringing in all the shops, and forthwith the workmen in the tube mill, the rubber mill, the motor carriage department, and the main factory leave their lathes and presses, their forges and furnaces, and with one accord troop down to the basements of the several buildings, where every man has a spacious locker to himself, with best facilities for cleaning up. Up and down the rows of lockers run troughs through which warm water is kept flowing, this to serve for the first rinsing, while, in addition, each locker has its individual faucet with clean water for the final washing. Thus there is no delay, no waiting in turn, no crowding or confusing, and within three minutes some thousands of men are ready for their midday meal.

Some of the workmen prefer to go home for the luncheon hour, and when the big doors open at the stroke of twelve a double line of them are seen going up and down the road, mounted on bicycles taken from the bicycle stable, where each man who wishes has his own stall for his own wheel. Others remain at the works, either bringing their own lunches or buying them at the lunch coun-



WORKMEN COMING FROM THE FACTORY.

ter provided by the company. This lunch counter is one of the unique features of the factory. Everything here is of the best quality and sold at cost price. Two large mugs of coffee cost five cents, a bowl of crackers and milk costs five cents, a quarter of a real home-made pie costs five cents, and a large bowl of soup or stew costs five cents. The men get oranges at the rate of four for five cents, bananas at fifteen or twenty cents a dozen, and other things at prices which are proportionately reasonable. Everything is done methodically; on Mondays the men get tomato soup, on Tuesdays chicken broth, on Wednesdays oyster stew, on Thursdays beef broth, on Fridays clam chowder, and on Saturdays veal stew. This is the general order, with variations according to the season.

Their hunger satisfied, the workmen spend the rest of the hour in recreation, and with pipes lighted, settle down in the big lunch room to the gossip of the factory and their favorite games of cards. There are workmen here who could play whist with college professors and hold their own. For those who do not care to smoke or play cards another large room is furnished opening out of the lunch room, where are shelves filled with books and the latest daily and weekly papers. On long tables are the monthly magazines, and, altogether, those who enjoy reading find here nearly all that they desire.

Looking about the lunch room one finds various evidences of the spirit of contentment and good-fellowship that reigns in these factories. Here is an announcement on the wall of a workmen's dance to take place in the new building, with music by

THE LUNCH ROOM.

Pope's Military Band and Pope's Orchestra, the company willingly giving the men the use of one of the buildings and furnishing light and heat. At another place on the wall one sees an announcement of the Pope Company Mutual Benefit Association, which costs each workman who joins it a small sum and pays sick members six dollars a week for a period of thirteen weeks, and pays fifty dollars to the widow or family of any deceased member.

Now the hour of rest is nearly over, and at 12:57 the electric gong sounds with a long b-r-r-r, calling the men back to their benches. Instantly there sounds the trampling of many feet over the floors and down the hall as the men answer the call, and when the one o'clock whistle sounds every man is at his work again, refreshed and willing for the labor before him.

"Educate your workmen, give them good books to read, broaden their ideas, and they will serve you faithfully and be contented with their lot." That is the idea Colonel Pope has constantly put forth and acted upon, and the result seems to have proved his wisdom, for there has never been a strike in the history of the Columbia Works. In all departments the relations of managers and workmen are marked by the best of feeling, and the work moves on without halt or conflict—as smoothly, indeed, as a Columbia bicycle.

COLUMBIA CHARACTERISTICS.

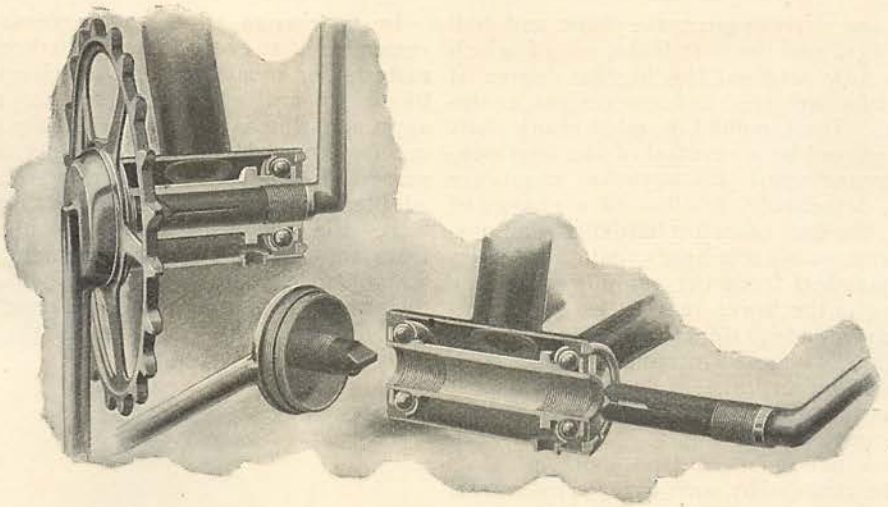
A brief review of Columbia characteristics for 1897 will prove an interesting and appropriate topic of conclusion. What is said may be immediately prefaced by the inclusive text, that in beauty of form, strength of material, delicacy of adjustment, and trial by experiment, the new models have as nearly attained perfection as contemporary conditions can allow. The 1897 Columbia bicycle is more surely and safely than ever the Standard of the World.

After indicating the character of the new models, of which there are four, we shall proceed to develop in outline the characteristics named above.

Model 45 is the regular Columbia bicycle for men, and is the embodiment of maximum strength and minimum simplicity, combined with mechanical care and ingenuity.

Model 46, the standard wheel for women, is an elegant and easy-running machine. Its graceful double-loop frame is marked by extreme strength, beauty, and convenience.

Models 47 and 48, the diamond-frame and loop-frame front tandems respectively, exhibit the practical results of all the science, ingenuity, perseverance, and prac-

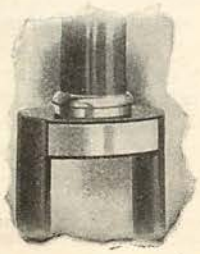


The wedge is on the gear crank end. The other end is Y shaped. The cranks are one piece, yet can be separated instantly

THE COLUMBIA DRIVING GEAR FOR 1897.

tical testing of the most advanced corps of bicycle experts in the world.

That Columbia grace and dignity have been amply considered in the new course of construction is evident, first of all, in the beautiful appearance of the new models, which elicits a general chorus of genuine admiration from examining spectators, novices and experts alike. On close inspection it becomes apparent that four of the more palpable factors deserve the major credit for this result. One is the system of flush joints, which prevents the juncture of one tube with another from showing anywhere on the frame of the machine, and ensures a smooth, clean-cut appearance. Another is the new fork-crown device, an especially distinctive part of Columbia identity, which provides a handsome nickel escutcheon for the double crown, completely encasing and protecting the interior. The third is the new aspect of the familiar name-plate, which is now made of oxidized silver with richly chased borders. The fourth point refers to the Columbia separate spoke-studs, which obviate all bending or twisting of the spoke, and present a handsome effect.



A DISTINGUISHING COLUMBIA FEATURE FOR 1897.

As regards strength of material, the attention is first directed to the frames of the new Columbia bicycles. These are now constructed of five per cent. nickel steel tubing, which is made in only one mill. The entire output this year is controlled by the Pope Manufacturing Company for exclusive use in Columbia bicycles. The tremendous strength of this material is now acknowledged to produce a frame of incomparable rigidity.

Hartford single-tube tires are still employed, as the most successful material exponents of "rubber-tire art and science." The complete tread and inner tube are vulcanized together, with the fabric between. A single compound tube results, with mutually supporting and reënforcing parts. These tires, as may readily be deduced, are strong and simple, present no problem of part friction, are light and buoyant, and peculiarly adapted to ready repair.

The rims, a third feature of strength, are built of layers of very stiff wood with non-uniform grains, which prevents splitting or warping. Their superior durability has stood every test.

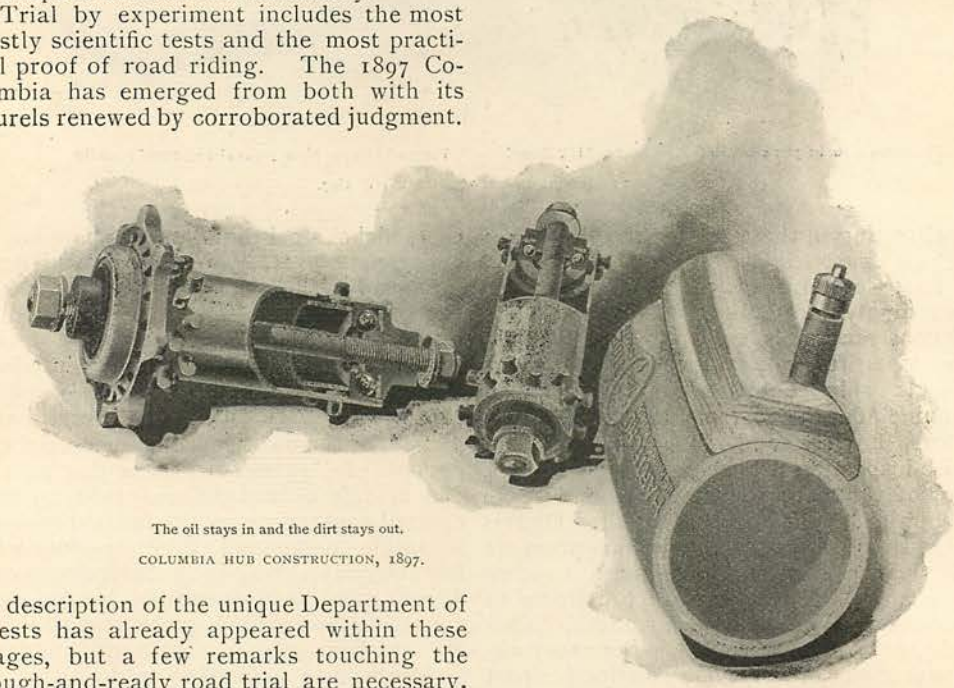
Columbia handle-bar adjustment for 1897 allows the bar to be held firmly without the help of a key. The slightest variation of angle is possible, and great strength is assured by the use of twenty-gauge nickel-steel tubing.

The choice of eight saddles is provided, all of which are strong and comfortable. The Columbia saddles are too well and favorably known to require any extended description.

The refined and delicate processes of adjustment that form the third main characteristic of Columbia construction are to be witnessed in the crank-shaft mechan-

ism, the driving-gear, the hubs and ball bearings, and the rear forks, all of which have now attained the highest degree of scientific precision and convenient equipment. The famous Columbia crank shaft is improved by a reversal of the interlocking arrangement; the sprocket wheels are made detachable, to allow of a change of gear; the ball cases are hardened, and possess removable retaining caps; all oil holes are banished from the running gear; the tubing in the lower rear forks varies uniformly in adequate circumference, and a D-shape is effected intermediately.

Trial by experiment includes the most costly scientific tests and the most practical proof of road riding. The 1897 Columbia has emerged from both with its laurels renewed by corroborated judgment.



The oil stays in and the dirt stays out.

COLUMBIA HUB CONSTRUCTION, 1897.

A description of the unique Department of Tests has already appeared within these pages, but a few remarks touching the rough-and-ready road trial are necessary. Fifteen of the new models were delivered on August 3d last to men chosen from among the factory hands who were known to be merely average riders. They were ordered to ride the models over hills and dales, rough roads and smooth, rain or shine, one hundred miles a day, and to report every day. This they did with zest and enthusiasm. The wheels were ridden more than 100,000 miles during three consecutive months, without the breaking of a single part. The proof of the bicycle is in the riding. No more rigorously practical test could have been devised, and none could have proved more satisfactory.

In conclusion it is only necessary to remember that every factor, whether of a material or mental nature, which appears likely to aid effectively the continual approach which the Columbia bicycle is making towards its ideal of mechanical perfection, is welcomed and tested, but adopted only after exhaustive and thorough trial; it is only necessary to remember this truth and the great expense incident to its maintenance, to allow of some obvious deductions. It is plain that such conditions as bring about the leadership of the Pope Manufacturing Company and the assured supremacy of the Columbia bicycle cannot result in a reduction of prices. The ratio is not inverse—that would be absurd. It is not even corresponding—that would be fair. For the notably improved Columbia bicycle of 1897 the price is just the same as before-- Models 45 and 46, $100 to all alike; tandem Models 47 and 48, $150. These four models are the bicycle exemplars in the world of business, health, and recreation.

NOTE.—While this series of articles is prepared under the direction of the editor of this magazine, and with exactly the same literary and artistic care as articles for the body of the magazine, the cost, it should be stated, is borne by the Pope Manufacturing Company.—EDITOR.