light and air as needed into the filter below. These manholes are 3 feet in diameter and 28 feet apart, and are guarded with double covers, so that they may be opened or closed as occasion demands. The filters are built in double lines, intersected by depressed roads, on which great double gates open, through which the filter may be entered for cleansing purposes at suitable times. Long aisles stretch away between rows of pillars.

As you look down at the floor of the partly completed work, you see that the groined arches overhead are repeated there inverted.

At the apex of many of these inverted arches may be seen openings leading downward, which are to carry the collected water after passing the filter into 2-foot mains that run under the floor. Lines of split tile with uncemented joints are laid with the convex side upward across the unpierced arches to reach these openings, along which the water will find its way as it does through a tile underdrain in a wet meadow.

Over the floor thus prepared is spread one foot of fine washed broken stone, and, above this fine, clean sand is laid 4 feet deep. When this has become thoroughly settled, water will be let in from the pumping house with even flow till it reaches the depth of 4 feet above the sand, at which depth it will be maintained with unvarying accuracy by an automatic apparatus in the pumping house.

The filling of the filter is a very nice undertaking. It must be filled backward. When the broken stone and sand are well packed, water is let in through the mains underneath, and allowed to soak up gradually through the mass till the whole is thoroughly wet. By this slow absorption the sand is evenly moistened and firmly packed together.

Then the water may be let in over the top. But even then it is not allowed to flow directly upon the sand lest it disturb the surface and start a washout, which the water will wear more and more, going down through it in a stream unfiltered, instead of working its way through drop by drop. So the new water is let in behind a detaining wall, the top of which rises just 3 inches above the surface of the sand, so that the incoming water flows slowly and evenly over upon the sand.

Here then we have the subterranean waters in cool dark chambers under the earth, slowly trickling down through fine, clean sand, the nearest artificial reproduction yet attained of nature's great filter that supplies the wells and springs.

The whole vast structure is built of concrete, which is really artificial stone, prepared by mixing 1 barrel of cement with 11 cubic feet of sand and 19 cubic feet of broken stone or gravel. It has been found that an arch of concrete so prepared will bear practically any weight that can be piled vertically above it. These arches are of 14-foot span, the concrete being 6 inches thick at the crown of the arch.

A visitor to the filtration plant sees vast piles of wooden forms of various shapes lying ready to be carried where they may be put in place to have the concrete masonry formed upon them. The work is necessarily slow, because the concrete is so thinly spread over so vast an area. The forms must be carried by hand from point to point, a dozen or fourteen men carrying one form, and carrying it no faster, of course, than a man can walk, to the place where it is to be set up. After the concrete has hardened, the forms must be removed and carried to a new place by the same slow process. So the inverted arches are formed for the foundation. Then the pillars or piers, monoliths of concrete 10 feet high and 22 inches square, are built where they are to stand. Looking across the partly-completed filters, one sees long rows of these roofless columns like the ruins of some newly-excavated Pompeii. When these are ready, the arched wooden forms are placed upon them, and the concrete spread above, which is to set into solid stone for the arches of the wide roof.

Over the roof is laid a level covering of earth 2 feet deep, stopping just 4 inches short of the upper rim of the manholes, so that no surface water can enter by way of the manholes. But how is the surface water falling in every rain to be kept from converting this earth covering into a swamp, and gradually working rifts, as water will, through the masonry of the roof? This is prevented by an ingeniously simple device. In the center of each pillar is set a 2-inch terra-cotta pipe, bent with an elbow so as to come to the surface of the north face of the pillar one foot above the level of the sand in the filter. Over the top of the pier, where the radiating arches spring, there is naturally a sump or depression. The terra-cotta pipe set in the stone of the pier opens upward in the center of this depression. Over the top of each of these pipes is placed a brass-wire screen, and over this 1 cubic foot of fine gravel and 11 cubic feet of sand. Thus water can never gather in pools upon the roof and become stagnant, but must work its way down through these prepared channels, and in going down must pass through sand and gravel, by which any impurities it may have gathered, as of decaying vegetation, will be mostly removed before it joins the mass of water in the filter below, again to pass through 5 feet of sand and gravel before reaching the underlying mains.

The filters are to be cleaned once a month, one filter a day, so that it will take practically a month to clean the whole plant. In cleaning, about one inch of the top surface of the sand will be carefully scraped away and removed. So carefully must this be done, that the workmen who do it will be required to wear flat-soled wooden sandals about 18 inches long by 6 inches wide, on which they go skating or sliding over the surface, where any dent of a boot heel might start a washout, through which the water would ultimately rush unfiltered. The water pressure will be very great, because each filter will contain water covering a surface of approximately 45,000 square feet and 4 feet in depth, giving 180,000 cubic feet of water, which at an estimate of 63 pounds per cubic foot, would weigh 11,340,000 pounds.

When the water has passed down through the sand and broken stone into the underlying mains, it flows through these to the "regulator houses," of which there are six, neat brick buildings, each controlling five filters. The water from the five filters is conducted into a central chamber in the "regulator house," and from this through 48-inch mains to the "filtered water reservoir."

This is a vast underground structure, 612 feet long by 162 feet wide, the roof of which is formed of arches 18 feet in span resting upon columns of monolithic concrete masonry, 2½ feet square and each 27 feet high. As one walks through the empty structure now the likeness to a vast cathedral is still more impressive than under the arches of the filters. This reservoir will hold one-third of a day's supply for the city (25 million gallons). This supply must of course be drawn off three times every day, which is to be done by five great engines in the Trumbull Street pumping station, to which the water is conveyed by four 48-inch mains from the filtered water reservoir.

The filters have been described as subterranean. They are, indeed, largely built upon excavated ground, but even so they are higher than the water in the Washington city reservoir, from which their supply is drawn. This makes necessary a special pumping station in connection with the filter plant, having for its sole work to raise the water from the reservoir and distribute it to the filters. The completion of the work is promised by September, 1905. The total cost is estimated at $3,000,000.

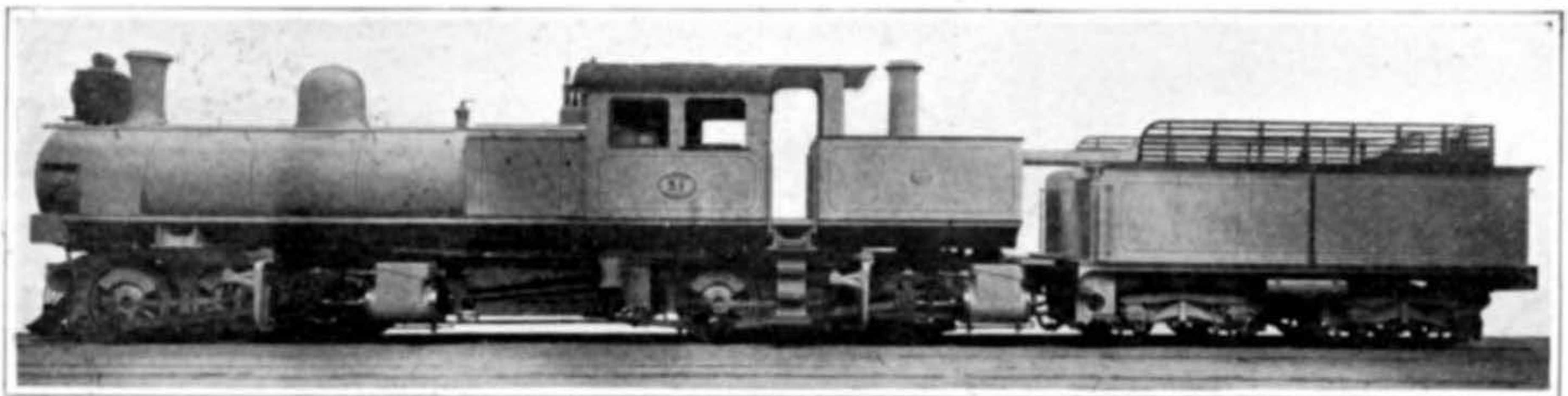
The earth covering the roofs of the filters will be sown to grass, and the intersecting streets paved and parked, so that, with the vast lake of the Washington city reservoir on the west, the wide lands of the Soldiers' Home stretching far to the north, and the Capitol, the city, and the Washington Monument full in view as one looks southward from this elevated ground, the Washington filtration plant will be an added ornament as well as a source of incalculable benefit to the beautiful and rapidly-growing capital city.

A UNIQUE LOCOMOTIVE FOR SOUTH AFRICA.

BY F. C. COLEMAN.

For working heavy freight trains over the severe grades and sharp curves encountered on the Rhodesia railway, which has now been recently extended to Kalomo, 90 miles to the north of the Victoria Falls, and which is destined to form a very important link in the projected Cape to Cairo railway, a unique type of locomotive, illustrated herewith, has been introduced into service. This engine is divided into three main portions—the superstructure and two steam-driven trucks. The superstructure consists of boiler, coal bunker, water tanks, and cab, which rest on two long girders, that are themselves carried at two pivot points on the six-coupled trucks. By this means the whole weight of the engine is upon the coupled wheels, and is, on that account, available for adhesion. It can be accurately adjusted by means of a special spring connection, introduced at a selected position away from the center of the bogie; and as the wheel-base of each engine is not more than 8 feet 6 inches, the engine here illustrated, which weighs 81 American tons, can pass round curves of three chains radius without causing the slightest injury to the road-bed. In addition to the advantage of traversing these severe curves, the line of pull from the engine itself is kept in a position which reduces the side resistance at the pulling end. Each bogie is in itself an engine, with a pair of cylinders, valve motion, brake gear, and sanding gear complete, and bears the weight of half of the superstructure on a recessed steel casting. There are bolts passing through slot holes in these castings, which form a connection between the bogie and the superstructure, and a further security against an excess of movement is provided by the addition of check chains. The mechanical details by which the power is supplied and controlled for each of the bogies have been carefully designed. The steam is carried from the front end of the boiler by means of ball-and-socket joints to each pair of cylinders. The exhaust of the front bogie is carried through the smokebox, and is sufficient to keep up a draft through the firebox, and so maintain steam. The exhaust steam of the hind bogie is passed into the atmosphere, but could be utilized either for the purpose of increasing the draft or for an exhaust steam injector, if required. The driver supplies steam to both sets of cylinders by one movement of the regulator handle, and in the same manner he is enabled to reverse both engines, put the brake on, and actuate the sanding gear by one movement of each of the handles concerned. There is no difference in the method of lookout, or of handling the engine, from the practice of ordinary locomotives. The boiler is of the "Belpaire" type, so commonly used on British railroads, and provides a specially la... steam capacity and the usual facilities for washing out, etc. The locomotive was built by Messrs. Kitson & Co., of Leeds, England, and as illustrative of its great hauling capacity, it may be stated that the engine illustrated herewith is now regularly drawing twice the train loads formerly hauled by the most powerful locomotives on the Rhodesia railroad.

Each bogie has six wheels coupled, each of 4 feet diameter, and two outside cylinders of 16 inches diameter by 24 inches stroke. Other dimensions are: Heating surface, firebox, 136 square feet; tubes, 1,590 square feet; total heating surface, 1,726 square feet. Grate area, 34 square feet. Internal diameter of boiler, 5 feet. Length of boiler, 13 feet 4 inches. Thickness of boiler, 9-16 inch. Boiler pressure, 180 pounds per square inch. Length of firebox, 8 feet 3 inches. Height from rail level to top of funnel, 12 feet 10 inches. Height from rail level to center of boiler, 7 feet 2 inches. Rigid wheel-base, 8 feet 6 inches. Total wheel-base, 34 feet. The engine tank has a fuel capacity of 3 tons of coal. The tender has a capacity of 7 tons of coal and 2,855 gallons of



Each Truck is Driven by Its Own Complete Engine. The Smokestack at Back of Cab is for the Exhaust of Rear Engines. Weight of Engine is 81 Tons.

ARTICULATED LOCOMOTIVE FOR THE RHODESIAN RAILWAY.

water and, when fully loaded, weighs 47 American tons. When in working order, the total weight of the engine and tender is 125 American tons. On a gradient of 1 in 66 combined with a curve of 10 chains radius, the engine will haul a load of 624 tons (exclusive of weight of engine and tender) at a speed of 8 miles per hour with 75 per cent cut-off.

RESULTS OF THE HILL-CLIMBING CONTEST AT MOUNT WASHINGTON.

During the stay of the Glidden tourists at Bretton Woods, N. H., the second hill-climbing contest up the 8-mile road on Mount Washington was held. The rough character of this road, and the sharp turns encountered upon it, are noticeable in the accompanying photographs, which show the winning 60-horse-power Napier car (time, 20 minutes, 58 2-5 seconds), the 3-horse-power Indian motor bicycle (which required only 4-5 second more in which to make the ascent), and the 8-horse-power double-opposed cylinder Maxwell runabout with bevel gear drive, which took second place in the class for cars weighing 851 to 1,462 pounds. The time of this machine was 51 minutes, 41 3-5 seconds, the only car in its class to beat it being a 15-horse-power Stanley steamer, which reached the top in 27 minutes, 17 2-5 seconds. A 16-horse-power, four-cylinder, air-cooled Marion car reached the summit in 1:10:57 4-5, and gained third place in this class.

In the free-for-all contest a four-cylinder, 60-horse-power Napier car, driven by W. H. Hilliard, won in 20 minutes, 58 2-5 seconds. This was 3 minutes, 41 1-5 seconds better time than that made last year by Harry Harkness on his 60-horse-power Mercedes; and the new record was made despite the fact that the car stopped at least half a minute on the way up, because of a broken battery wire. The most sensational performance of all, however, and the one which caused the greatest surprise, was the dash up the mountain of the 3-horse-power Indian motor bicycle mounted by Stanley F. Kellogg. The rider did not dismount from start to finish. Nearly 3 miles from the summit he ran into a dense fog, which made the ride all the more dangerous. But in spite of all difficulties, he reached the top of the mountain in the remarkable time of 20 minutes, 59 1-5 seconds. A second Indian machine of the same power also made the climb in 22 minutes, 42 seconds. A Stanley steamer driven by F. E. Stanley made the second best time in 22 minutes and 17 seconds.

In the light-weight class, for cars weighing from 557 to 851 pounds, the Stanley steamer was again first in 30 minutes, 34 3-5 seconds; while a 16-horse-power, four-cylinder air-cooled Cameron machine was second in 1:03:24 2-5, and a 10-horse-power Crawford car third in 1:11:35 2-5.

In the contest for runabouts selling for $650 or less, two Oldsmobiles made the climb in 56 minutes, 10 4-5 seconds and 1 hour, 20 3-5 seconds respectively.

In the class for cars listing at from $1,000 to $2,000, a Reo won in 52 minutes, 35 2-5 seconds; a Maxwell was second in 1 hour, 27 seconds; and a Columbia third in 1 hour, 7 minutes, and 14 seconds.

In the $3,000 to $4,500 class, a 45-horse-power Pope-Toledo was first in 29 minutes, 37 2-5 seconds; a Pierce second in 38 minutes, 45 seconds; and a White steamer third in 41 minutes, 35 4-5 seconds.

A 50-horse-power Richard-Brazier car made the time of 26 minutes, 38 2-5 seconds; and a 20-horse-power double-opposed cylinder Buick, 36 minutes, 25 seconds.

The day after the conclusion of the hill climb, which was held on July 17 and 18, the tourists for the Glidden trophy ran to Concord, N. H., a distance of 103 miles. Heavy thunder showers were encountered, and twice the Packard truck skidded off the road. All the machines reached Concord safely. The following day a run of 99 miles was made to Worcester, Mass., where some excitement was caused by the arrest of eight of the tourists for exceeding a local speed limit of 12 miles an hour on the outskirts of the town of Leicester when on their way to the White Mountains the week before. Two constables claimed that they timed the cars for a distance of 300 feet at the foot of a hill just before they made the ascent of another one. No warning was given that speed should be reduced, and the constables took advantage of the contestants' lack of knowledge of the local ordinance to mulct them $17 apiece. Such treatment of tourists in the State of Massachusetts, especially when they were making a reliability run under the auspices of the American Automobile Association, only goes to prove the mistake of legislators when they frame laws making possible a different speed limit for every hamlet, village, or town. The abolishment of the speed limit altogether, and the making of arrest possible only for furious or dangerous driving, is the only proper way of curbing the men with scorching propensities.

An 8-Horse-Power Maxwell Runabout Making a Turn on the Way up the Mountain.

This little two-cylinder car made the best time of any gasoline machine in the 851-1,462 pound class. It obtained second place in 51 minutes, 41⅗ seconds, being beaten only by a 15-horse-power Stanley steam machine.

Kellogg on His Indian Motor Cycle Making the Climb in 20 Minutes, 59 1-5 Seconds.

This remarkable performance, which was accomplished in only ⅘ of a second more time than that required by the 60-horse power Napier car, was made by a 3-horse-power two-cylinder motor bicycle having the cylinders placed like a letter V.

Hilliard's 60-Horse-Power Napier Ascending the Mountain in 20 Minutes, 58 2-5 Seconds.

This record, which is 3 minutes 41⅕ seconds better than that of last year, was made despite a stop to repair a broken battery wire.

RESULTS OF THE SECOND "CLIMB TO THE CLOUDS" UP MOUNT WASHINGTON.

Fast Long-Distance Trains in Great Britain.

Owing to the great success that attended the development of fast long-distance express trains by the various railroads of Great Britain last year, these services are considerably extended for this season. The feature of these trains is not only great acceleration in speed, but the absence of intermediate stops upon long distances. The most important of these new services is the introduction of non-stop expresses upon the London and North-Western Railroad between London and Liverpool, which are to cover the distance of 192 miles in 208 minutes, equivalent to a speed of 55.307 miles per hour. The distance of 196 miles between London and Leeds is to be accomplished by certain of the Midland Company's trains without any intermediate stoppage in 225 minutes—52.22 miles per hour; and 210 minutes required by the expresses of the Great Northern Railroad between the same two cities, a speed of 56 miles per hour. The Great Western Railroad is maintaining the non-stop expresses between London and Plymouth, which it successfully introduced last year. In this case the distance is 245¾ miles, and is covered in 265 minutes, which is equal to 55.64 miles an hour. This is the longest non-stop run in the world, and in view of the many difficult gradients on the road, the average speed is a creditable one. The fastest speeds, however, are being recorded upon the Great Central Railroad between London and Sheffield, 164¾ miles in 170 minutes, 58.14 miles per hour. As, however, for a distance of 38 miles this Great Central runs over the track of the Metropolitan Railroad, speed has to be limited; but between Aylesbury, where the Great Central road commences, and Sheffield, a distance of 126¾ miles, the journey is covered in 120 minutes, which represents a speed of 63.37 miles per hour. In point of distance this is the fastest express in Great Britain. Notwithstanding the speed of these expresses, extraordinary precaution is taken to insure the safety of passengers. Some idea of the extent of these precautions may be gathered from the fact that on the round trip between London and Liverpool, a train is controlled by over three hundred semaphores.

The earlier wooden and iron bridges were built very much in the same manner as the ancient Roman bridges, in accordance with empirical rules, by practical men who had no accurate knowledge of the strains produced on the various members of a structure by the exterior forces, but who were men of unusual constructive ability and sound judgment, who had to depend upon their own resources and natural instinct, experimenting with models and profiting by previous failures. Practice always preceded the science, thus the structural systems were invented before their theory was developed.