Steam engines kept in reserve in case of failure of water power were furnished by Wolff, of Magdeburg-Buckau.

The steam locomotives were furnished by the Schweizerische Lokomotiv-fabrik, of Winterthur, which firm also supplied the compressed-air locomotives now used exclusively at both sides for work in the advanced headings.

The boring of the tunnel resulted in some interesting data regarding the increase of temperature with depth. We give herewith some temperature curves made at different periods, and a description of the same, from London Engineering. The difficulties of ventilation were intensified owing to the height of mountain over the tunnel; and, in view of the important question in physics associated with the increase of temperature per unit of depth from the earth's surface, the data in connection with temperatures in the Simplon tunnel become of great interest. These data were taken in the most systematic way. But before dealing with this interesting subject, a word may be said as to ventilation. We have mentioned already that the parallel heading No. 2 was utilized for ventilation in conjunction with cross-galleries, the air supply passing up the main tunnel, and the exhaust through the gallery No. 2. The air-supply from the Brig end equaled 33.9 cubic meters (1,197 cubic feet) per second, and from the Iselle portal 27.3 cubic meters (964 cubic feet) per second. A further interesting feature was the method of supplying cool air near the face when it was some distance in advance of one of the cross galleries. This was accomplished by having a special light sheet-iron pipe carried immediately below the roof of the heading. (See cross section, page 24452.) At intervals there was formed a connection between the hydraulic pressure main placed on the floor of the heading to project into the pipe a jet of air. As the hydraulic power water had a pressure at the face of 72 to 78 atmospheres, this jet induced through the pipe a strong current, which was conducted right up to the face. The water was collected in siphons in the bottom of the air-main at intervals, and there drained off. This proved a most satisfactory method of ventilation between the last cross-gallery and the face.

The effectiveness of ventilation slightly affects the assumptions which may be drawn from the temperature data taken, so far as it reflects on the question of increase of temperature per unit of depth from the earth's crust. A series of holes were made into the side walls to a depth of 1.5 meter (about 5 feet) at distances of 1,000 meters, as the work of boring proceeded, and into each hole was introduced a thermometer, from which observations were taken periodically, showing the ranges in temperatures. The full-line curve is plotted from the thermometrical readings taken immediately the 1½-meter borehole was driven into the side, close up to the face; and thus, as there was a minimum of influence due to artificial ventilation in the workings, the readings represent approximately the temperature due to the superincumbent rock; some allowance has been made for slight ventilation influence in plotting the curve. It will be observed that for the maximum depth, 7,005 feet—far greater than any depth previously attained—the maximum temperature of the rock was found to be 54.5 deg. C. (130 deg. F.). In the course of a paper to the Royal Society on this subject, Mr. Francis Fox, one of England's leading experts on tunnel ventilation, described the investigations he had made as to the increase in temperature due to the height above the tunnel. From elaborate data collected by the engineers, he chose at random the readings in March of the four years 1901-4, to show the rapid cooling of the rocks due to the boring of the tunnel. In March, 1901, for instance, when the tunnel had advanced from Brig for 4,693 meters (nearly three miles), the readings from the face toward the portal showed a considerable decrease. This is shown by a comparison of the thick line with the single dot-and-dash line. In March, 1902, the distance driven was 6,884 meters (4¼ miles), and there was a greater decrease, the temperatures then read at the thermometrical stations—1,000 meters apart—being recorded by the line of dashes. In March, 1903, when the tunnel had been advanced 8,930 meters (5½ miles), the thermometers gave readings as recorded in the three-dot-and-dash line, while the dotted line represents the readings in March, 1904, when the tunnel had been advanced 10,140 meters (6¼ miles) from Brig.

At the southern side of the Alps—that to the right of the diagram—the temperature rise corresponded approximately to the increasing altitude of the mountains up to the point 2,200 meters (1.1-3 miles) from the portal. There was then a diminution, culminating at 4,400 meters (2¾ miles), where a great spring of cold water was tapped, yielding 10,560 gallons per minute. At first the water issued at a high pressure, estimated at 600 pounds per square inch, but it gradually decreased. The temperature fell, the ultimate minimum being 13 deg. C. (55.4 deg. F.). From this point the temperature, first ascertained at 1,000-meter stations, again rose, coinciding with the temperature in the northern part of the tunnel for similar heights. Mr. Fox, in his paper, eliminated the effect of the great spring and the estimated influence of such disturbing factors as the inclination of the strata—where horizontal or vertical, and whether synclinal or anticlinal—and took also into consideration the temperature which was to be assumed as existing near to the surface.

In Sweden the government is attempting to favor the use of peat on railways, and has instructed the Board of State Railways to utilize it wherever possible without incurring loss.

CHICAGO'S UNDERGROUND FREIGHT TRAFFIC.*

By GEORGE E. WALSH.

WHILE New York has been busy devising ways and means to accommodate its enormous traveling public underground, Chicago has been quietly tunneling under its streets to build railroads that will relieve the freight traffic congestion of its chief surface thoroughfares. With the two systems nearing completion almost simultaneously, the relative value of the two systems of underground transit may receive a test that will ultimately settle some disputed points in municipal growth and expansion. While Chicago has committed itself to the underground freight traffic system, it has not entirely decided that it will never need underground railroads for the accommodation of passengers. Indeed, in the contract for building the underground freight tunnel, the city protected itself by specifying that at no point should the top of the tunnel come nearer than 26½ feet to the street surface. This part of the contract was made for the specific purpose of making provision for a tunnel subway similar to the one nearing completion in New York. There is sufficient room between the street surface and the freight subway to build a tunnel for passenger trains.

Chicago, owing to its topographical formation, found its freight traffic congested more than its passenger. New York's problem was one that concerned the handling and distribution of enormous crowds of people, which traveled continuously along a narrow longitudinal line and not laterally in all directions. With no less than twenty-five trunk lines of railroads running into the city, Chicago's freight tonnage traffic is enormous, and this is all located within a comparatively small territory—not more than a mile and a half square. Within this district teamsters' trucks constantly block the way, and cause such congestion of traffic that business is often paralyzed for hours at a time. New York's chief thoroughfares are congested enough, and in time some relief must be obtained; but Chicago had the problem of solving the question thrown upon her so that action had to be taken at once.

It was this difference in conditions of the two cities which decided New York to place the traveling public underground, and Chicago to put the freight traffic there. At first thought it seems the ideal method to give the streets and fresh air to the people, and the underground burrows and tunnels to the freight; but it is manifestly impossible to secure rapid transit in city streets and avenues. The only alternatives are elevated structures or tunnels.

The freight congestion of city streets is one of the problems of municipal development that seriously confront all towns of rapid and steady growth. The disappearance of the horse as a dray animal in the city, and the substitution of steam or electric trucks and wagons, would reduce the street congestion nearly one-half, and writers have constantly promised such ideal conditions in the near future; but in New York more has been gained through the regulation of the traffic, the occasional widening of certain streets, and the attempt to distribute the traffic along different thoroughfares. The tendency to follow certain favorite routes has always made prominent streets and avenues crowded to their full capacity, and it has only been by wise improvements and strict regulations that a part of this has been gradually deflected to less used streets and avenues.

In Chicago this was impossible in the congested districts down town. The freight traffic of this part of the city has been increasing so rapidly in the last few years that it threatened to cause trouble. The problem for the city to solve was keenly felt, and the city authorities were at a loss what to do. It was impossible to change the termini of the trunk railroad lines, and with the city's constant growth the freight traffic promised to double within every decade.

The tunnels of the Illinois Tunnel Company have been designed to handle nearly, or quite all, of this freight traffic which centers around the loop in the great business district, carrying not only all the freight which comes in by trains and must be distributed throughout the city, but likewise the enormous quantities of coal, building materials, and ashes and garbage from the giant office buildings. It is roughly estimated that nearly half a million tons of freight, coal, and ashes must be handled every week within this narrow district. To move this enormous amount 30,000 to 40,000 horses would be required, and the work would have to go on continuously every day in the week. The removal of this number of dray animals and carts from the streets of Chicago would afford a relief to the congestion of the streets that would immediately improve real estate value in the whole region.

This is the ambition of the present supporters of the underground freight tunnel. The work has been carried on somewhat quietly, and the completion of the tunnels this year will mark revolutionizing changes that will make the business section of Chicago vastly superior to anything in the past. All the coal used in the great business houses will be carried through the tunnel, and also all the ashes, garbage, waste, and old newspapers. From a sanitary point of view this change will be of inestimable value. The coal dust and ashes that constantly float in the air to be breathed in by the lungs must be responsible for many throat and respiratory troubles that cannot be cured without the removal of the irritating cause. The streets can be kept cleaner at less expense, and the danger from infectious disorders will be greatly minimized. The garbage, even when removed every day through the streets,

always leaves a taint in the atmosphere which is certainly offensive to the senses if not actually injurious to the health. Another point that is worth considering is the actual saving to the city cleaning and street repair departments. The wear and tear on the street pavements by the continuous line of rumbling teamsters' carts have been very costly, and the street department is called upon to spend thousands of dollars every year to keep the pavements in fair condition. By removing the traffic from the streets, the tunnel company indirectly saves the city large sums of money.

The question of utilizing the underground freight tunnel for transporting the mails, and for accommodating the telephone and electric light wires, has also been adequately solved, and the removal of all these underground where they can easily be reached by repair men will simplify another problem of municipal growth. The distribution of the mails from one station to another by underground trains will not only relieve the streets of a large traffic, but will increase the prompt delivery of letters. The companies operating the telephone, telegraph, and electric light wires constantly disturb street conditions by the necessity of tearing up to repair lines. If the lines are laid in the tunnels, with proper facilities for reaching them at any point, the streets will no longer be needlessly torn up. This will represent a considerable item of saving to the companies, and will relieve the public of a nuisance and inconvenience that must appeal to all.

The new freight subway will be in partial operation before the close of the present year, and contracts have already been made to handle coal, ashes, and other freight at less than the minimum charges made by teamsters. By the first of the year the tunnels will be so far completed that the company will be in a position to handle 50,000 tons of freight a day, and by the end of another year, with the extensions projected, the total annual amount of freight that can be carried through the subway will approximate twenty-five million tons. Even this amount must soon be increased in order to keep pace with the rapidly-expanding conditions of busy Chicago.

The tunnels form a loop around the business section of Chicago, tapping each of the six freight depots where nearly all the freight tonnage of the trunk lines is received and distributed, and then spreading out to different portions of the city where freight traffic is most likely to go. There are completed about twenty miles of the subway, but eventually this will extend to include some fifty or sixty miles. As the city grows, and the freight traffic increases, provision will be made for extending the routes indefinitely. A comprehensive plan has been drawn up for present and future needs, and Chicago will as a result have her freight traffic provided for as no other city. Whether her traveling public will receive equally good facilities and accommodations in the future depends upon a number of other problems not yet solved.

The freight tunnels are of two distinct types—trunk tunnels and lateral conduits. The former follow the main routes of freight traffic, and the latter run out to the less important parts of the city. These in time will reach the suburbs and end in small conduits adapted only to accommodating telephone and other wires. The freight-carrying tunnels are built on a firm foundation of solid concrete, and are roofed over with the same material. They are made wide enough to permit trains to run in opposite directions, with accommodations on the sides for wires and cables. The trunk tunnels are 12½ feet high and 11 feet 2½ inches wide. This inside measurement is sufficient for all purposes demanded. The cars and engines to traverse the tunnels are of special design and pattern. The box freight cars are 4 feet wide, and stand 63 inches above the rail. This gives an inside measurement large enough to answer all purposes, for each car is 10½ feet long, with a weight capacity of 30,000 pounds. They are of iron and steel construction, with double trucks, and eight wheels. They are what is known as combination cars, which can be used either as a flat type or box car. Although of narrow size, they are built to accommodate almost any kind of freight, with doors wide enough to pass anything through that the ordinary type of railroad box car can receive.

TRANSPARENT IRON FILMS.—It is easy to obtain transparent iron films by the ionoplastic method, in which the iron is deposited by cathode disintegration, but in attempting to measure the thickness of such films serious difficulties are encountered. The method of iodization, though applicable to silver and copper, does not work well with iron, and the conversion of the iron into oxide does not make exact measurements possible, owing to the inconstant composition of the oxide. An accurate method consists, according to L. Houllé-vigue, in dissolving the iron film in aqua regia and comparing the coloration of the solution with that of a standard solution of a known ferric salt. This, again, has the disadvantage of destroying the film whose thickness is to be measured. The author has, therefore, worked out a purely optical method, in which the error does not exceed 25 per cent. The method consists in measuring the transparency of the film in a Lummer-Brodhuft photometer. Since the light transmitted by the film is grey it absorbs all rays equally, and the absorption is proportional to the thickness. The coefficient connecting the absorption and the thickness is determined by the colorimetric method mentioned above as involving the destruction of the film. Thus the author found for a film of 0.024 milligrammes per square centimeter a thickness of 39 μ and a transparency of 0.114. With a film of 0.056 milligramme

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT

per square centimeter, the thickness was 72μ and the transparency 0.0093; this transparency is, however, subject to a correction for reflection.—L. Houllé, *Comptes Rendus*, February 13, 1905.

COTTON GINS.*

By WILLIAM SCOTT TAYLOR, M.I.Mech.E., Author of "Cotton Spinning."

THE operation of stripping the fibers of cotton from the seeds was doubtless at first performed by hand. This must have been a very slow and tedious process, and no doubt prevented the extensive use of cotton for some considerable period after other fibers had become thoroughly established as articles of common use. A cotton-pod contains a large number of seeds, and each seed is surrounded by innumerable fibers growing from its skin or outer covering. The detachment of the

FIG. 1.—FOOT-ROLLER GIN.

fibers from the seed presents a problem which had to be solved before cotton could be used to any extent for textile purposes.

The earliest gin of which we have any record is the one known as the foot-roller gin. It consists essentially of a slab of stone or wood, and a roller. The cotton from the plant was placed on the slab, Fig. 1, and the roller pressed to and fro by means of the feet of the attendant. This action squeezed the seeds away from the fibers; and by this very crude method cotton was obtained which could be spun and woven into excellent materials. In the outlying districts of India large quantities of cotton, for local use, are still ginned by this primitive method, the production being from four to six pounds of clean cotton per day from each laborer.

The next advance was made by the introduction of the Churka gin. The same principle was used as in the foot-roller gin. Two rollers were supported in a framework, the top small one, of iron, being revolved at a higher speed than the large lower one. The fibers of cotton were carried through between the rollers, and the seeds left behind. Six to ten pounds of clean cotton could be obtained in this way per day. Large numbers of these machines are still used to-day in India and China, by villagers in out-of-the-way districts.

When cotton came to be used on a large scale in other countries than the East, the necessity for large productions to meet the demands gave rise to rapid developments in the cotton gin. Progress came from the side of those who wanted the cotton rather than from the growers; so that gins, as we know them to-day, date from the rise of the cotton industry in England and America.

Among many attempts made, the machine invented by Macarthy has stood the test of time; and at the present moment the greater part of the cotton crop of the world, outside America, is ginned by machines known by his name.

A section of the Macarthy gin is given in Fig. 3. A leather-covered roller, A, revolves as shown. Pressing against the roller is a steel blade, B, with a knife edge; springs, C, keep the blade pressed uniformly against

FIG. 3.—SECTION OF SINGLE MACARTHY COTTON GIN.

the full length of the roller. The seed cotton is fed along the table and into the hopper receptacle. The fibers come into contact with the rough surface of the leather roller, and are rapidly drawn between the steel

knife and the roller, the seeds being left sticking to the edge of the blade. A vertical moving blunt blade of steel, F, is given an upward and downward motion by the crank, R, and the blade, F, is guided in the right direction by the radial arm, G, to which it is attached. The action of F is to give a very rapid series of taps to the seeds adhering to the doctor knife, B, and to so cause them to fall away through the grid, T, on to the floor. To give some idea of the speeds at which the machine works, it may be mentioned that the leather roller runs at 150 R.P.M., and the beater knife, F, strikes the seeds at the rate of 800 R.P.M. The production of the machine is over 50 pounds of clean cotton per hour.

A double form of the Macarthy gin is made, whereby a better balancing of moving parts is obtained, as well as a greatly increased production with smaller speeds. The single machine is always used for good long-stapled cotton such as Egyptian, Sea Island, etc.; while the double action gin is chiefly used for Indian woolly seed cottons.

We now come to another type of machine called the saw-gin. The advent of this machine is often said to mark the advent of America's commercial progress. Eli Whitney was the inventor, and his first machine was brought out in 1791. Previous to this year only very small quantities of cotton came to England from America, and that which came was always long-stapled Sea Island. Uplands cotton was practically unknown before the days of the saw-gin. The short fibers were so difficult to detach from the seeds, that only about a pound of cleaned cotton could be obtained per day from an operator. The Churka gin was used in America before the saw-gin was invented, but only the long-stapled Sea Island cotton could be cleaned on it.

To illustrate the importance of the saw-gin, it may be remarked that eight bags of cotton arrived in Liverpool in 1784, on board an American vessel, and were seized by the custom house authorities, because it was not credited that the fiber was American cotton. In 1787, 108 bags were imported, all Sea Island. Two years after the saw-gin was started the cotton crop of America rose to 5,000,000 pounds, and has grown enormously since. Uplands cotton in 1791 required two operators to produce two pounds of clean cotton per day; while at present two men, in charge of six ma-

FIG. 2.—CHURKA GIN.

chines, can produce 24,000 pounds of clean cotton per day.

It is unnecessary to trace the development of the saw-gin since Whitney introduced it. It will be sufficient for the present purpose to give two sketches of it. In the first one, Fig. 4, two rows of saws are shown. Between each pair of saws is passed a plate or bar, C, the space between bar and saw being sufficient to allow fibers of cotton, but not seeds, to pass. The seed cotton is thrown into the hopper, A, and the saw teeth, revolving at a high speed, carry it round and tear the fibers from the seeds, leaving the latter behind to fall down through the grid, E. The brush, D, sweeps the cleaned cotton from the saw teeth and sends it along in the direction of the arrow at J. The bars, C, get choked with seeds at times, and when this happens the attendant presses the foot lever and lifts the bars clear of the saws, and so enables them to be easily cleaned.

A more modern form of saw-gin is illustrated in Fig. 5. The seed cotton has been considerably opened out before being brought to the gin by a machine called a seed cotton opener, which will open as much as a ton of seed cotton per hour. This opened-up seed cotton is dropped on to a traveling lattice, A, and is carried forward under a picker roller, B, which throws the cotton into a hopper, D, and so into what is called the gin breast. Here the cotton comes into contact with the revolving saws, F, between which are fixed the bars, G. (A side view of the arrangement of the saws and the bars is shown at the right of Fig. 5.) The fibers of cotton are torn from the seeds in passing through the bars, and the cleaned cotton is passed along the passage, J, being sometimes assisted by a draft from the drum, K. The fibers are carried round between the drum, K, and a roller, L, and from this point are delivered into some receptacle for making into a bale.

Students in England have only the cleaned cotton to deal with; but all practical men in responsible positions realize that the ginning operation is a very important one from several points of view. Badly ginned cotton means very dirty cotton; the skins of the seeds are torn off and broken up, and are difficult to remove in the subsequent processes in the cotton mills, thus entailing additional expense and care. The fibers of cotton are also damaged and weakened, so that the resulting yarn is of an inferior quality. Quality is of vital necessity in the textile trade, so that ginning is a factor to be seriously considered. The saw-gin is clearly a machine for giving a large output at a minimum cost, but it is equally clear that quality is sacrificed to obtain this. The long-stapled cottons are not ginned on this machine; and, strange to say, the greater

proportion of the shortest and worst cottons are not cleaned on the saw-gin. These cottons almost invariably pass through the Macarthy gin. This latter gin, however, will produce only 1,000 pounds of clean cotton per day, while a saw-gin will produce 4,000 pounds per day; so that it is only a question of time for the saw-gin to oust the Macarthy gin from the market. Sea Island cotton, and to a large extent Egyptian cotton,

FIG. 4.—THE SAW GIN (OLDER FORM).

are luxuries; and all operations through which they pass are based on this fact. Present-day students had better prepare themselves for the future by thoroughly grasping this problem of ginning, for there is no doubt that there are distinct signs of competition and labor conditions compelling the adoption of the saw-gins in other than the American cotton-fields. In conclusion, it may be said that the amount of "lint" (as the cleaned cotton is termed) is usually about one-quarter of the seed cotton put in at the gin, so that for every ton of seed cotton gathered, only 600 pounds reaches the spinning mill.

THE STRENGTH OF TIMBER TREATED WITH PRESERVATIVES.

WITH the increasing use of timber, preserved in one way or another against decay and fire, it is important to determine the effect which the preserving process has upon the strength of the preserved timber. Many engineers believe that creosoted timber is more brittle and less capable of withstanding strains than the same timber before being treated with creosote. This is particularly true with bridge timbers and piling.

Actual tests are necessary to determine what relationship exists between the preservative process and the strength of the timber. Most of the tests hitherto made with preserved timber were made by comparing results of tests on treated sticks with results on untreated sticks. In many instances these turned out in favor of the untreated timber. The reason why such tests are unfair to the preservative is that in the process of preservation two factors enter: (1) The actual process of impregnation with a preserving substance, and (2) the preliminary processes of steam seasoning,

FIG. 5.—THE SAW GIN (MODERN FORM).

in the majority of treating plants in the United States. A piece of timber subsequently treated with creosote may be steamed to such an extent that the timber becomes exceedingly brittle. This, obviously, will be the fault of the steaming and not of the creosote.

Timber preservation divides itself broadly into three stages: First, the preliminary preparation; second, the actual preservative process; and, third, the treatment of timber following preservation. The final strength of the timber may be influenced materially by each of the stages.

The Bureau of Forestry has erected an extensive plant on the grounds of the St. Louis Exposition for carrying on a series of investigations of the methods for preserving timber, and of the influence various preservative processes have upon the strength of the tim-

*Technics.