THE SIGAFOOS TUNNEL MACHINE.

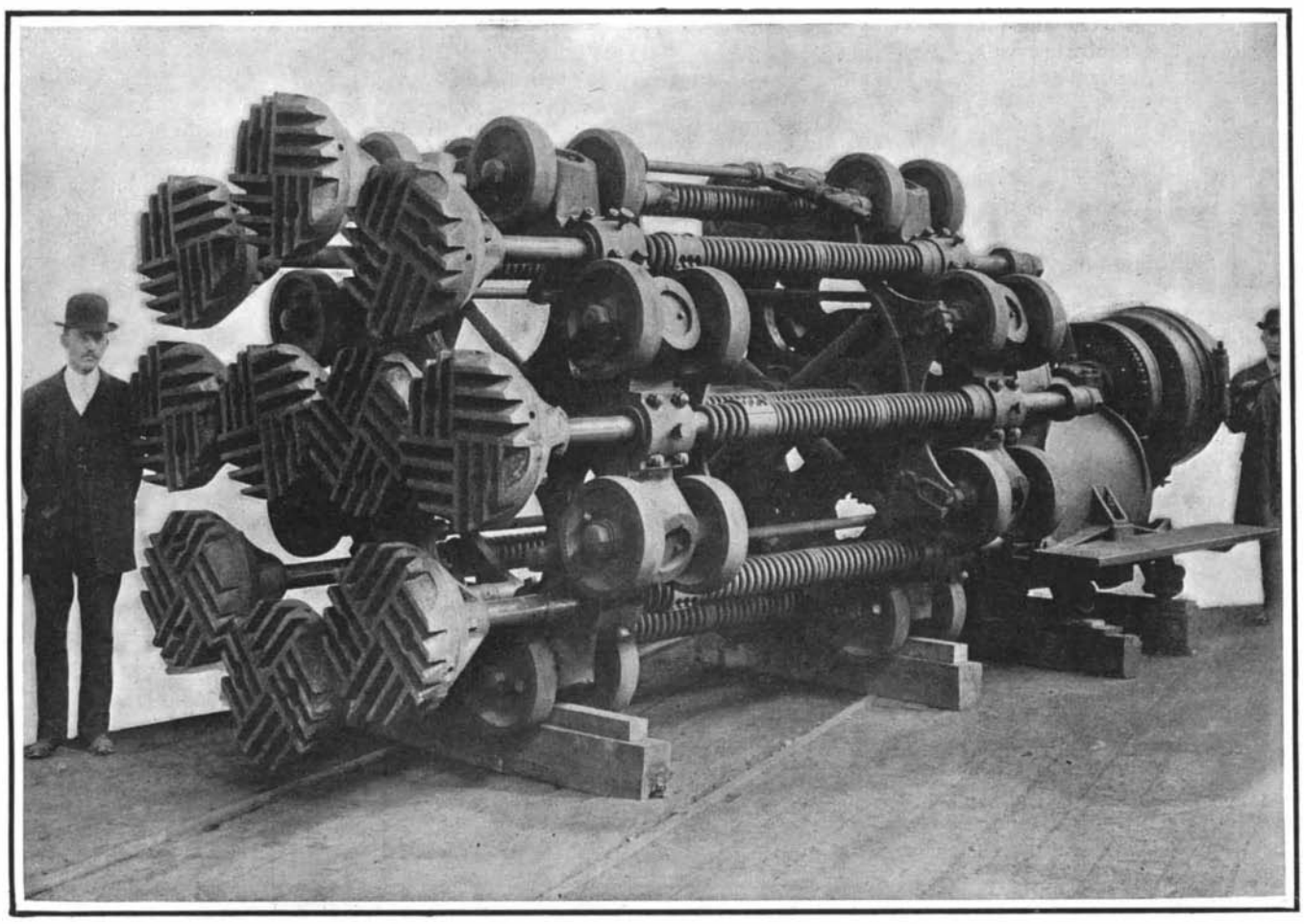
BY ROWLAND ASHFORD PHILLIPS.

Like the poor, new ideas for tunneling through rock and doing away with drilling and powder and dangerous blasting, are forever with us. Since 1853 there have been no less than sixty-nine patents granted on tunneling machines, and of this number but three have progressed beyond the blue-print stage. One was constructed and used with some slight success in the East, but owing to lack of funds or disputes among its builders, all progress was stopped. The second was built in Colorado, and at the present time is installed in a tunnel near Boulder. This machine does the work claimed for it, but the cutting is very irregular, numerous breakdowns are constantly happening, and in the course of over six months the machine has penetrated but a few hundred feet.

The third machine, here illustrated, was invented by Mr. Sigafoos, of Denver, long associated with many eastern manufacturers until of late, when he turned his mind and labor toward western mining fields. Mr. Sigafoos built his first model three years ago, and until the present day it is on exhibition in his offices. Even this little working model, barely two feet long, has eaten through solid granite quite as easily and determinedly as a hungry earthworm.

Early in January of this year the first regular-sized machine was constructed in the East and shipped complete to Georgetown, Col., where the first contract was let and its behavior eagerly watched. The utmost secrecy was observed for the first trial, and the author was extremely fortunate in being allowed to witness the test. In every instance the rotary proved its value, and came up to the highest expectations. Mr. Sigafoos stands ready to take contracts with his machine, in any and all rock, and will guarantee to cut five feet an hour, twenty-four hours a day.

The machine complete, ready for work, weighs 29 tons, and its length is slightly in excess of 18 feet. This huge frame holds ten crushing heads, as the photograph shows, each carried on a 4-inch horizontal shaft and working on the same principle as a stamp mill, with the exception that the blows are given with the aid of springs instead of force of gravity. The entire fore part of the machine revolves as it cuts, thus cutting a full, clean bore, all the muck being flushed from the tunnel by means of a 3-inch stream of water, carried directly through the machine under 40 pounds pressure, and fed through ten small nozzles, each of which sends a stream beside each crushing head. This constant revolution of the machine is its strong point, the body being run on a series of "foot" wheels, thirty-two in all. The axles of these wheels—they are set in pairs—are arranged so they may be set at will, preventing the wheels from tracking. A simple twist sets them at an angle, and thus the whole machine moves forward or backward not unlike a huge screw.



Front end view of tunneling machine showing cutting heads.

The ends of the cutter shafts carry tappets, which, as they revolve, are acted upon by a 5-foot cam. This draws back the tappets and releases them. In relation to the hardness of the rock these blows can be regulated, and the drop varied from 4 to 12 inches by substituting other sized cams.

Of these monster crushing heads there are ten, eight on the outside of the revolving front and two in the center. The cam has a long, barrel-like hub, which permits the center shafts being brought back without interfering with the others. Diametrically opposite cutters strike at the same time. The springs which lend the force to the blows are 5 feet long, 6 inches in diameter, and composed of a specially chilled inch steel. These cutting or crushing heads, as they should be called—for the machine works on the principle of pulverizing the rock instead of cutting it—are 2 feet in diameter, the face of each being composed of a series of blunt teeth. These heads revolve about the axis of the machine as they strike, thus producing a grinding motion to the surface of the breast. In this one respect alone the rotary differs from all its competitors, and in doing so proves the wisdom of the method. Mr. Sigafoos has always maintained that a sharp or edged tool is worthless in tunnel work.

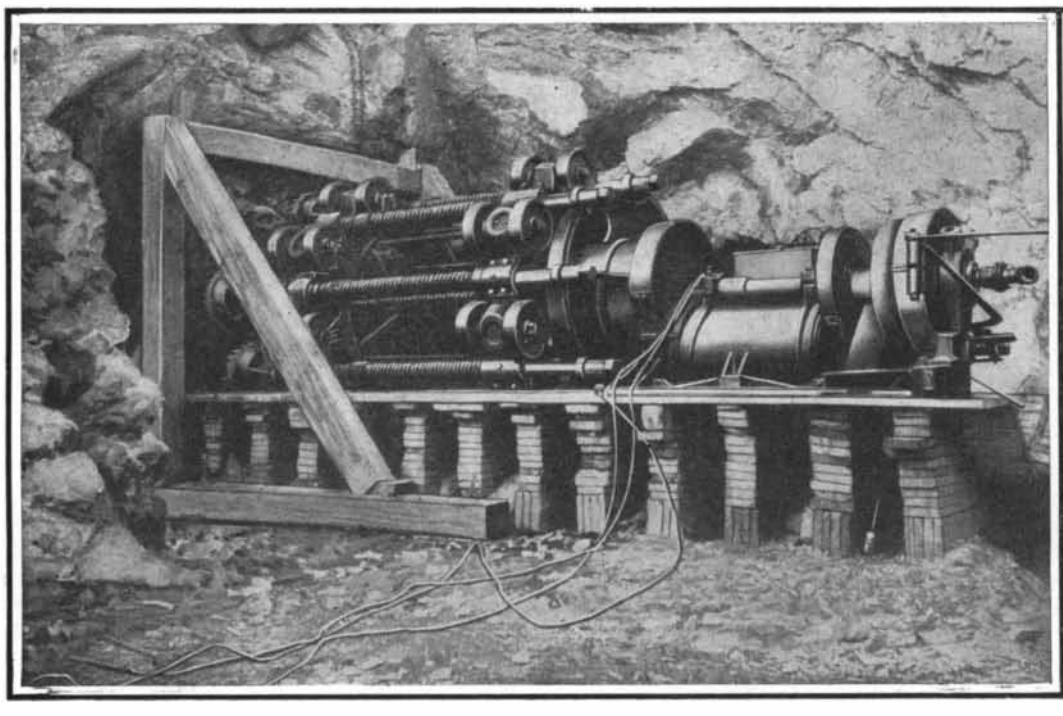
With an 8-inch drop these heads strike a blow of 4,000 pounds, two hundred times a minute. This means that a total of 8,000,000 pounds is expended against the breast of the tunnel every sixty seconds. It is claimed that if each head penetrates but the thickness of a sheet of common writing paper at a blow, it will cut in at the rate of an inch a minute.

In fact, the harder and more stubborn the rock, the more easily the machine will do the work; and it is doubtful if it would work at all in soft dirt or clay. The inventor purposely accepted this Georgetown contract because of the nature of the rock, it being long acknowledged the hardest in the State. The photograph, showing a 3-foot penetration, will in a measure give a good idea of the rock formation.

Should accidents occur, as they will in any machine, all that is necessary is to reverse the axles on the "feet" wheels, and the entire rotary will back itself out a sufficient distance to allow the men to climb through the framework—manholes are provided for this purpose—gain the space between the crushing heads and the tunnel breast, and set matters right. Here again the Sigafoos machine differs from the others, and is the only one in which the whole machine does not need to be backed completely out of the drift in order to replace or repair the parts.

The rotary is operated by a 150-horse-power motor, although one of 60 horse-power is sufficient to keep it running once it is in motion. This motor is mounted on the machine, on a sort of car, the engineer riding along with it, and controlling all movements with a single lever.

The time and money to be saved by this practical invention are inestimable. For it must be remembered



The machine set up to start a tunnel into a hillside.

Face of tunnel as punched out by the machine.

THE SIGAFOOS TUNNEL MACHINE.

that scarcely any timbering will be needed, as the machine cuts the walls as smoothly as dressed marble, instead of shattering them, as is done with powder. Then, too, all powder and fuse are done away with, and only a third as many men will be needed. And lastly, but one of extreme importance, the work is accomplished absolutely without the least danger.

A practical example may be interesting, and the inventor himself gives it. To run the ordinary tunnel, 4 by 7 feet, needs three shifts of about four men each. These men can, under ordinary conditions, cut about 12 feet in the twenty-four hours. Wages alone amount to over $65, while powder, fuse, and timbering will easily add as much expense again. Against this, the tunnel machine with three shifts of two men each can cut approximately 120 feet, at a total cost in wages of $24. There is absolutely no comparison in these two methods.

Tests have proved that light tunneling machines are impractical and worthless; and in spite of the fact that the Sigafoos machine weighs as much as any ten others put together, the inventor is increasing its weight. And in the face of this, other hopeful inventors talk of boring a tunnel with a machine of a few thousand pounds.

If, as will often be the case in boring a long tunnel, a "pay streak" is encountered, the muck washed out by the water can be run onto a large concentrating table at the mouth of the bore, a separation made then and there, and all values saved.

The machine is not limited in its work to starting into a hillside on virgin ground; it can easily be taken to pieces, carried any distance, and lowered into a shaft, to be at once set up in a drift ready for work.

At the present time, ten of these 8-foot machines are contracted for in the State of Colorado alone.

While this 8-foot machine will be sufficient for ordinary use in mining and in irrigation work, other contracts, for larger bores, such as railroad tunnels, will make it necessary to use a larger machine. This larger model is 8 feet longer than the former one, with thirty-six stamping heads instead of ten, and cutting a 12-foot bore.

It may not be amiss to state that the famous Moffat road will probably use these large rotaries in cutting its great tunnel through the mountains. In places to-day where the road ascends and descends mountains, it is expected within a short time to eventually bore through them, cutting down the time from coast to coast fully twenty-four hours. The contractors, before learning of the new machine, allowed ten years for the completion of this gigantic undertaking; but to-day, with a sufficient number of tunnel rotaries at work, two years will not be an impractical limit.

The immediate uses to which this machine can be put to work are innumerable. Subways that formerly took five years to construct can now be run for half the expense in one-tenth the time. Water in unlimited quantities can be brought through the mountain walls, and the vast arid areas of the deserts will be made to blossom as a wonderful garden.

If the claims made for it continue to be substantiated in practice, Mr. Sigafoos may well be considered a world's benefactor in giving us this marvelous rotary tunnel machine.

Dwellings in the United States.

At the First Census the marshal for the State of Massachusetts returned the number of dwellings in that State. It was not required by the federal government, nor was such a return made for any other State.

Upon tabulating the returns for Massachusetts, it appears that the average number of families to a dwelling was 1.2, and that the county averages varied but little. This fact, taken in connection with the prevalence of agriculture at that period and the practical non-existence of towns of large size, suggests the propriety of applying to the remainder of the country the average number of families to dwellings actually reported for Massachusetts. By so doing, 454,309 results as the total number of dwellings in the United States in 1790.

Analysis of the average number of persons per dwelling in Massachusetts reveals the interesting fact that the average was higher in 1790 than in 1900. The average at the later census is higher in the cities, doubtless due to apartment houses and tenements. The smaller general average in 1900, which is contrary to what might be expected, probably reflected the influence of the smaller size of family.

By a recent act of Congress the office of First Assistant Commissioner of Patents was created. Cornelius C. Billings of Brattleboro, Vt., who is now Assistant Commissioner of Patents, has been nominated for promotion to the new office, and Frederick A. Tennant of Ripley, N. Y., who is now an examiner in the Patent Office, has been nominated to take his place. The Senate has just confirmed the nominations, and on July 1st, when the new law goes into effect, the changes will be made.

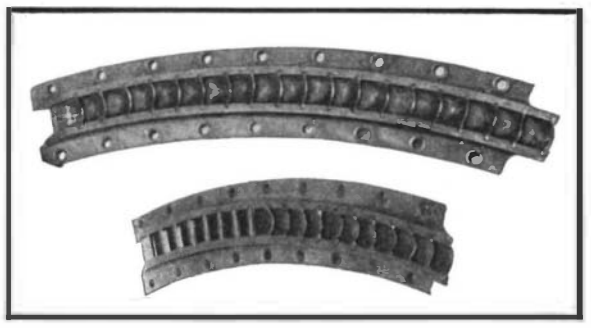
INJURY TO THE TURBINES OF THE SCOUT "SALEM."

The U. S. scout cruiser "Salem" has been sent to the builders, the Fore River Shipbuilding Company, for an examination of the main propelling turbines, which are of the Curtis marine type. During the recent competitive trials the starboard turbine, although there was no difficulty in its operation, ran considerably slower than the port, with the same steam supply, thus indicating that some internal derangement had occurred.

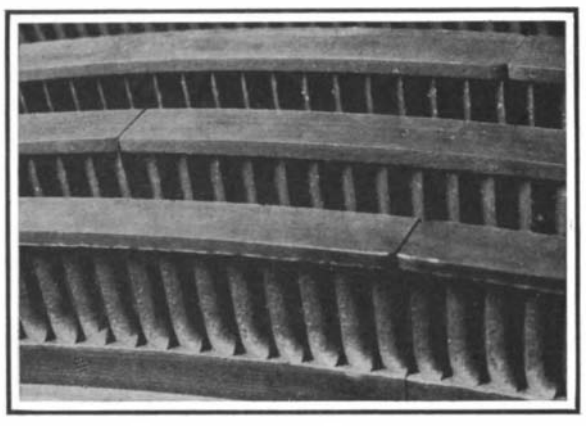
When it was opened, it was discovered that some foreign body had become caught in the fifth stage between the nozzles and first row of buckets; which had bent over the edges of the buckets so as to completely prevent any steam passing through them, and had broken about one-quarter of the nozzle division plates. The foreign body which caused this has not yet been found, but a loose ⅝-inch nut was found in the fifth stage, lying in the bottom of the casing, which did not, however, become caught in the moving parts.

Examination of the port turbine disclosed a service bolt, 2½ inches long, which was not a part of the machine, lying in the first stage against the nozzle openings leading to the second stage. The damage done here was comparatively slight.

The rotors of both machines were also found to have moved axially so as to allow the moving buckets to rub against the stationary guide blades, with the result that in the first and second stages, where the axial clearances are least, the guide blades were worn on the edges; but no blade stripping occurred. As in



Portions of turbine damaged by foreign body.



Buckets in the front row bent over by contact with obstruction, completely closing steam passages.

INJURIES TO THE BLADES OF THE "SALEM'S" TURBINES.

these stages the guide blades cover only a small part of the circumference, practically all the wear occurred on them and very little on the moving buckets. All blading was found to be entirely free from any erosion due to the action of the steam, and the surfaces were as smooth as when first installed.

This shows that the Curtis type of construction has a remarkable ability to withstand abuse and still remain in operative condition; as even in this condition the vessel made 24½ knots for twenty-four hours, and for the first eight hours made 25 knots, while the contract speed required 24 knots for four hours. Also the operation of the turbine was perfect, and except for the drop in revolutions, it would not have been known that any internal damage had occurred.

The damage is being repaired, and is expected to be finished in thirty days from the vessel's arrival at the yard.

Present Condition of the Norwegian Nitrate Industry.

The Birkeland-Eyde electric furnace, which is employed in Norway for the synthesis of nitrates, is distinguished from other electric furnaces by its strength, capacity, and durability. The water-cooled tubes of copper which form the electrodes have an average life of 1,000 hours. In addition to the magnetic deflection of the arc, there are ingenious devices for controlling the entering and issuing gases. The details of these devices are not published, but it is known that they diminish the time during which the oxides of nitrogen formed in the arc are exposed to the temperature of dissociation, and thus greatly increase production.

The methods of converting the nitrous vapors into commercial forms have been the object of careful research and, although the processes are protected by patents, their details are kept secret. The gases pass from the furnaces into oxidation towers, where the nitric oxide is converted into peroxide, and thence into granite towers 66 feet high and 320 feet in sectional area, where the nitrogen peroxide meets a finely divided stream of water. The result is the formation of a 25 per cent solution of nitric acid.

The gas which is discharged from these towers still contains one-fifth of the nitrogen peroxide. Most of this is reclaimed by washing the gas in wooden towers with a solution of lime, sodium carbonate, or potassium carbonate. The gas discharged from these towers contains less than 5 per cent of the oxides of nitrogen formed and this loss is continually being diminished by improvements in the process.

The dilute nitric acid of the granite towers is neutralized with coarsely broken limestone. The resulting solution of calcium nitrate is evaporated by the waste heat of the furnaces. The nitrate is ground and sifted for agricultural use, but is delivered to chemical factories in cakes. The liquid of the wooden towers yields, on evaporation, both nitrate and nitrite of soda (if soda is the alkali employed). Schloesing has invented a method of converting the oxides of nitrogen produced in the furnace directly and entirely into nitrates, no nitrites being formed.

Synthetic nitric acid is almost absolutely pure and is consequently very valuable for many uses, especially in the manufacture of fireworks, for the impurities of commercial nitric acid often produce chemical changes which cause serious accidents.

The most important product of the Norwegian factories is calcium nitrate, which is a far more efficient nitrogenous fertilizer than Chile saltpeter. But the Norwegian product is not likely to lower the cost of nitrogenous fertilizers, for the demand is steadily increasing; and while 1,800,000 tons of Chile saltpeter and 800,000 tons of ammonia sulphate are produced annually, the production of Norwegian nitrate is now only 25,000 tons and is not expected to exceed 125,000 tons in 1911, or 200,000 tons in 1913.

Wealth of the People of the United States.

Heretofore no estimates have been possible concerning the value of property in the United States at the beginning of the Constitutional government. It is, however, feasible to roughly compute all wealth upon the basis of the number of dwellings computed in this report as representing the number of farms or properties having an average value. A reasonably accurate estimate of the value of slaves is also available. The total value of all property in the Republic at the period of the First Census was probably not less than $500,000,000 and not more than $700,000,000. The standards of value at that time were much less than they are now. Hence, in terms of present values, it is probable that all property in 1790 was worth approximately one billion to one billion and a quarter dollars. The total per capita wealth in 1790 was about $171—in New England, $138; in the Middle States, $145; in the South, $217; but on the basis of present money tables these figures should at least be doubled.

A European Zinc Trust.

The zinc producers of Germany, Belgium, and France, with the exception of the Giesche firm, which controls only one-fifth of the Silesian product and cannot become a formidable competitor, have united to form a syndicate, which the five great English establishments will be invited to join. No attention has been given to American producers, as little American zinc is exported. The syndicate will control an annual output of half a million tons of zinc. In the provisional agreement, which is to remain in force until January 1, 1911, the output of each of the firms is determined, and it is stipulated that the production shall be diminished whenever large stocks have accumulated or the market price falls below 19 pounds sterling per ton, and increased when this price is exceeded.

A firm of patent swindlers, operating in this city under the name of Walsh Brothers & Co., has recently been found guilty of using the mails to defraud. The firm posed as an agency for soliciting patents, and those who answered the advertisement were confidentially informed that John T. Sherlock, one of the members of the firm, possessed a special influence with the Patent Department, which gave him an advantage over other agencies. The inventor was thus induced to pay a registration fee, and the only return he received for his money was a small cut of his invention. By this method the firm managed to take in from $500 to $1,000 per week. Sherlock has been sentenced to serve a term of two years in the Atlanta Federal prison and pay a fine of $500, while John Walsh, another members of the firm, must serve eight months in the penitentiary and pay a fine of $100.