Not one of the cartridges in the drill holes is connected with wires, nor is one to be exploded by electricity.

Extending from wall to wall in each of the galleries, and at intervals of about 25 feet, are timbers, 3 by 5 inches, as shown in Fig. 9. Tied side by side upon each one of these timbers are two dynamite cartridges like those already described as filling the mouths of the drill holes. Tied upon each pair of these cartridges is a mine exploder, represented in No. 5 (Fig. 7). The entire mine is divided into 24 independent circuits, each circuit representing or covering a certain section. Within each circuit are 25 fuses or mine exploders.

A wire from the surface of the rock at the mouth of the shaft leads from one fuse to the next until the 25 fuses are in the same electrical circuit, the other end of the wire, of course, returning to the surface. Each of the 24 circuits has its own wire. The wire circuit is shown at 1 and 2, Fig. 9. We now come to the electrical firing apparatus, shown in Fig. 10. We will suppose one end of each wire of each circuit to be + and the other —. All the + ends are dipped in mercury contained in a cup, and all the — ends in mercury in a second cup. It will be seen that if the mercury in these two cups be united by a wire, we shall have a complete electrical circuit embracing every fuse or mine exploder in the excavation.

Leading from the left hand or + cup is a wire secured to one pole of a battery; and leading from the opposite or — cup is a wire, C, which extends to the bottom of the middle cup, which contains only a little mercury. The wire, B, leads from the other pole of the battery, and is held suspended over the mercury in the center cup. It is evident that, when the wire, B, enters the mercury in the center cup, the circuits through the mine and battery will be completed, and the fuses discharged.

At A is a fuse held to the string carrying the wire, B, by a half hitch. One wire passing through this fuse is grounded, while the other leads to the shore, where it also is grounded; a battery on shore is placed in this circuit. The current through the shore wire explodes the fuse, A, which breaks the cord and allows the wire, B, to drop into the mercury in the cup; the mine is then exploded. It will be observed that the wire, B, enters the cup a short distance. This is in order that the mine may be exploded even if anything should happen to the shore wire or battery, or if the explosion of the fuse, A, should fail to break the string holding up the wire, B. The outlet of a vessel containing mercury is placed over the center cup. It has been ascertained by experiment just how long it will take the mercury running from this vessel to fill the cup up to the end of the wire, B. The flow has been so gauged that after all the apparatus has been arranged, there will be ample time for the boat to go from Flood Rock to the shore; then the current will be sent through the shore wire.

Should the shore wire fail, there will be nothing to do but wait until the mercury has filled the cup to the wire, B. The shore connection was devised mainly for the benefit of scientists, who will be located in the vicinity, and who wish to make observations of the vibrations of the earth caused by the explosion. The current will notify them of the exact instant of explosion. The failure of the shore wire would of course deprive them of this most important point, but would interfere in no way, as mentioned above, with the firing of the mine.

The electrical current will explode the 600 fuses or mine exploders (Fig. 9), when the dynamite cartridges projecting from the drill holes will "explode by sympathy," as it is termed, and these in turn will discharge the rack-a-rock placed behind them. Each cartridge is rendered more sensitive by the exploder embedded in it. The explosion of the 40,000 cartridges containing 75,000 pounds of No. 1 dynamite and 240,000 pounds of rack-a-rock will completely break up the 9 acres in which they are buried, so as to render easy the final operation of dredging the broken rock. The cost of the improvement is estimated at $1,000,000.

The Harlem River improvement contemplates the building of a deep water channel from the East River through the Harlem River and Spuyten Duyvil to the Hudson River, as shown in the map, Fig 11. Above the Third Avenue bridge to the entrance of Dyckman'sCut into the Harlem, the pier and bulkhead lines will be 400 feet apart. The line through rock at Dyckman's Meadows will be 350 feet wide, and from there to the Hudson 400 feet wide. From Third Avenue bridge to lower part of Randall's Island the width will be 500 feet, and from there to the East River 800 feet wide. Between Morrisania and Randall's Island the channel will be 350 feet wide.

All the work at Hell Gate was designed by Gen. Newton, to whose perseverance, industry, and skill we owe the successful opening of one of the most important entrances to New York; the last operation—blowing up Flood Rock—fittingly completes, by its great magnitude and the rare difficulties it presented, long years of well directed effort. During the past few years the work at Flood Rock has been under the supervision of Lieut. G. McC. Derby, who has without accident of any kind, or any delay, succeeded in performing one of the most arduous pieces of mining ever attempted. We wish to acknowledge the kindness of Gen. Newton and Lieut. Derby, who furnished us data.

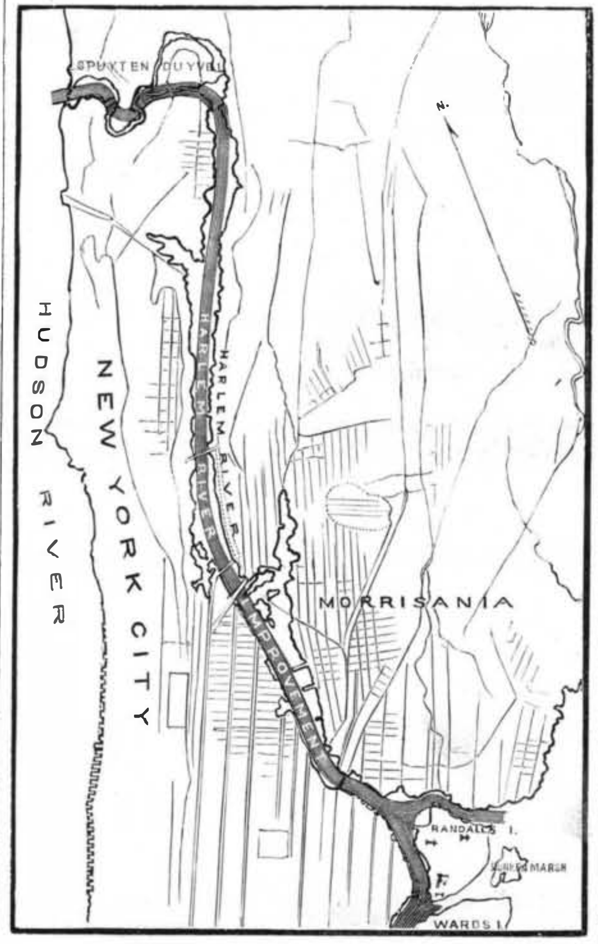
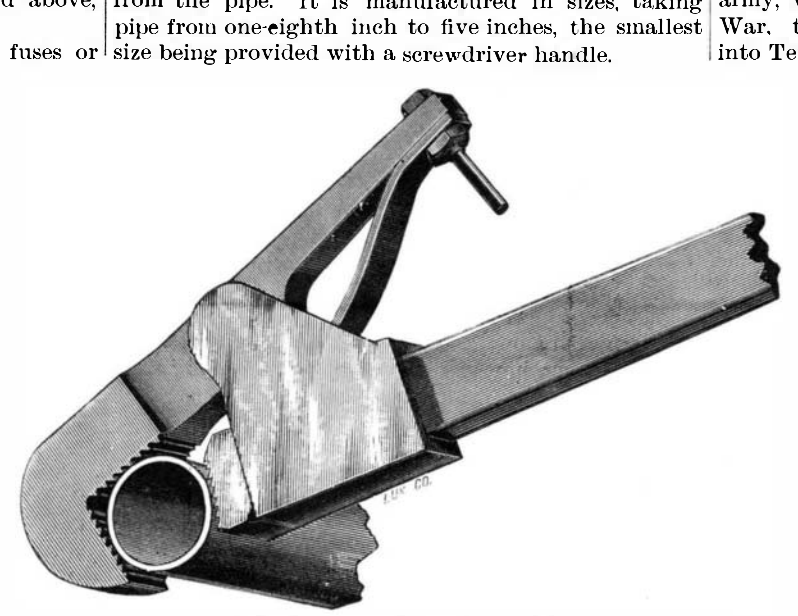


Fig. 11.—MAP SHOWING HARLEM RIVER IMPROVEMENT.

AN IMPROVED WRENCH.

The wrench shown in the accompanying cut has many admirable features—it adjusts itself to either pipe, nut, or stud; owing to the form of the forward or movable jaw, it can be used to fit corners about machinery that cannot be reached with other forms of wrenches; and owing to the fact that it has three bearings on the pipe, the latter is not liable to be crushed. The serrated or holding surfaces of the movable jaw are at right angles to each other; this jaw is pivoted in a fork projecting from the side of a fixed sleeve on the end of the handle, and a spring presses the holding portion of the jaw toward the end of the handles, which is also serrated. By pressing upon the rear end of the movable jaw bar, the jaws may be opened to their widest extent. The metal (best steel) is so distributed as to make those parts which are subjected to the severest strain exceedingly strong. The wrench is easy to handle, exerts a powerful grip, and may be instantly freed from the pipe. It is manufactured in sizes, taking pipe from one-eighth inch to five inches, the smallest size being provided with a screwdriver handle.



PORTER'S IMPROVED WRENCH.

This wrench is manufactured by the Porter Manufacturing Company, of Revere, Mass.; The Eaton, Cole & Burnham Company, of 82 and 84 Fulton Street, New York city, are sole agents.

An Electric Railway in Toronto.

The Vandepoele electric railway was recently put in operation in Toronto, in order to carry passengers from the horse cars to the fair grounds, a distance of one mile. Trips were made in two and a half minutes, and large numbers of passengers were carried over the road daily.

Rapid Steaming by the Etruria.

The Cunard steamship Etruria arrived at New York August 22, from Liverpool, having made the fastest trip in the record of Atlantic traveling. Time from Queenstown to Sandy Hook, 6 days 5 hours and 31 minutes. The fastest previous passages were made by the Oregon of the same line, and were: Westward, 6 days 10 hours and 10 minutes, just a year ago, and eastward, 6 days 6 hours 41 minutes, in December, 1884. The Etruria's previous trip eastward, reckoning to Fastnet only, was made in 6 days 5 hours and 35 minutes.

Following is a table of the runs made on the different days during the Etruria's last voyage:

Run.	Miles.
Liverpool to Queenstown	240
From leaving Queenstown to noon August 17	424
24 hours to noon August 18	464
24 hours to noon August 19	450
24 hours to noon August 20	465
24 hours to noon August 21	464
24 hours to noon August 22	465
From noon to 3:35 P. M. August 22	71
Total	3,043

The Etruria is built of steel, has a gross tonnage of 8,000 tons, and upward of 14,000 horse power; her length over all is 520 feet, and extreme breadth 57 feet 3 inches.

A Great Cargo of Lumber.

Mr. J. K. Ward, the well known Montreal lumberman, gives the following in the *Gazette* of that city:

Probably the largest cargo of sawed lumber that has ever been shipped from Canada left this port to-day per steamship Regius, Capt. Kayll, on account of Bryant, Powis & Bryant, of London, Eng. It consisted of 1,272 St. Petersburg standard three inch deals, or 2,518,560 feet board measure, equal to ten large barge loads of 250,000 feet each. If it were in one inch boards it would cover a farm of 60 acres, and require the pine product of say 1,000 acres of ordinary forest land, such as we have to depend on for our future supply. This shipment may suggest to the minds of many the great importance of the future of our leading industry. There is no questioning the fact that our country is fast being depleted of one of its most important elements of prosperity, and that it behooves not only the lumbermen and the government, who are directly interested, but also every member of the community, to do what they can by expression of opinion or otherwise to protect that that cannot be reproduced in our day.

Texas Copper Deposits.

According to a Texas newspaper, the copper region of that State is of great extent, running westward from Red River, from the line of the Indian Territory, through several counties, prominent among which are Archer, Baylor, Knox, Hardeman, and Cottle. The district is approximately in latitude 32 degrees north, with Red River to the north as well as the east, and the Brazos River to the south. The copper deposits were discovered by General George B. McClellan, in 1852. In that year, McClellan, then a lieutenant in the army, was detailed by Jefferson Davis, Secretary of War, to accompany an expedition up Red River into Texas and Indian Territory. While on this duty Lieutenant McClellan found important deposits of rich copper ore near the point where Cache Creek empties into the river, and some miles above it was discovered that Red River flowed through apparently solid beds of the valuable mineral. In the same locality rich gold bearing quartz veins and placers were found, and all the conditions pointed to the existence of a mining district of great possibilities. To complete the romantic history of the discovery of copper in Texas, it is only necessary to add that General McClellan is now, after the lapse of a third of a century, the leading spirit engaged in the development of the deposits. The Grand Belt mines, in which he is largely interested, are fifty miles from Harrold, in Wilbarger county, from which latter point forty wagons are at present engaged in hauling coke to the smelter. The smelter is an experiment, but has a capacity of forty tons per day, and is suitably provided with engine, blower, pumps, etc. All told, the McClellan company's patented claims embrace some 36,000 acres, stretching sixty-five miles along the ore belt. Upon this vast property they have made probably sixty shallow openings of an average depth of seven or eight feet. The ore is found principally in shallow pockets, and at the main point of taking out is said to average about 54 or 55 per cent metallic copper. Some of it is supposed to be very rich in silver. The most promising opening at present being worked by the company is at Kiowa Peak, the center of Motley County, some sixty miles west of Margaret, the county seat of Hardeman County.

Science Leads to Economy of Time and Labor.*

How exultant is the old Greek poet Antipater ("Analecta Veterum Græcorum," Epig. 39, vol. ii., p. 119) when women are relieved of the drudgery of turning the grindstones for the daily supply of corn! "Woman, you who have hitherto had to grind corn, let your arms rest for the future. It is no longer for you that the birds announce by their songs the dawn of the morning. Ceres has ordered the water nymphs to move the heavy millstones and perform your labor." Penelope had twelve slaves to grind corn for her small household. During the most prosperous time of Athens it was estimated that there were twenty slaves to each free citizen. Slaves are mere machines, and machines neither invent nor discover. The bondmen of the Jews, the helots of Sparta, the captive slaves of Rome, the serfs of Europe, and uneducated laborers of the present day, who are the slaves of ignorance, have added nothing to human progress. But as natural forces substitute and become cheaper than slave labor, liberty follows advancing civilization. Machines require educated superintendence. One shoe factory in Boston by its machines does the work of 30,000 shoemakers in Paris, who have still to go through the weary drudgery of mechanical labor. The steam power of the world, during the last twenty years, has risen from 11½ million to 29 million horse power, or 152 per cent.

Let me take a single example of how even a petty manufacture improved by the teachings of science affects the comforts and enlarges the resources of mankind. When I was a boy, the only way of obtaining a light was by the tinder box, with its quadruple materials, flint and steel, burnt rags or tinder, and a sulphur match. If everything went well, if the box could be found and the air was dry, a light could be obtained in two minutes; but very often the time occupied was much longer, and the process became a great trial to the serenity of temper. The consequence of this was that a fire or a burning lamp was kept alight through the day. Old Gerard, in his Herbal, tells us how certain fungi were used to carry fire from one part of the country to the other. The tinder box long held its position as a great discovery in the arts. The *pyxidicula igniaria* of the Romans appears to have been much the same implement, though a little ruder than the flint and steel which Philip the Good put into the collar of the Golden Fleece in 1429 as the representation of high knowledge in the progress of the arts. It continued to prevail till 1833, when phosphorus matches were introduced, though I have been amused to find that there are a few venerable ancients in London who still stick to the tinder box, and for whom a few shops keep a small supply. Phosphorus was no new discovery, for it had been obtained by an Arabian called Bechel in the eighth century. However, it was forgotten, and was rediscovered by Brandt, who made it out of very stinking materials in 1669.

Other discoveries had, however, to be made before it could be used for lucifer matches. The science of combustion was only developed on the discovery of oxygen a century later. Time had to elapse before chemical analysis showed the kind of bodies which could be added to phosphorus so as to make it ignite readily. So it was not till 1833 that matches became a partial success. Intolerably bad they then were, dangerously inflammable, horribly poisonous to the makers, and injurious to the lungs of the consumers. It required another discovery by Schrotter, in 1845, to change poisonous waxy into innocuous red-brick phosphorus, in order that these defects might be remedied, and to give us the safety match of the present day.

Now, what have these successive discoveries in science done for the nation, in this single manufacture, by an economy of time? If before 1833 we had made the same demands for light that we now do, when we daily consume eight matches per head of the population, the tinder box could have supplied the demand, under the most favorable conditions, by an expenditure of one-quarter of an hour. The lucifer match supplies a light in 15 seconds on each occasion, or in 2 minutes for the whole day. Putting these differences into a year, the venerable ancient who still sticks to his tinder box would require to spend 90 hours yearly in the production of light, while the user of lucifer matches spends 12 hours; so that the latter has an economy of 78 hours yearly, or about 10 working days. Measured by cost of production at 1s. 6d. daily, the economy of time represented in money to our population is £26,000,000 annually. This is a curious instance of the manner in which science leads to economy of time and wealth even in a small manufacture.

In larger industries the economy of time and labor produced by the application of scientific discoveries is beyond all measurement. Thus the discovery of latent heat by Black led to the inventions of Watt, while that of the mechanical equivalent of heat by Joule has been the basis of the progressive improvements in the steam engine, which enable power to be obtained by a consumption of fuel less than one fourth the amount used twenty years ago. It may be that the engines of Watt and Stephenson will yield in their turn to more economical motors; still they have already expanded the wealth, resources, and even the territories of England more than all the battles fought by her soldiers or all the treaties negotiated by her diplomatists. The coal which has hitherto been the chief source of power probably represents the product of five or six million years, during which the sun shone upon the plants of the carboniferous period, and stored up its energy in this convenient form. But we are using this conserved force wastefully and prodigally; for, although horse power in steam engines has so largely increased since 1864, two men only now produce what three men did at that date. It is only three hundred years since we became a manufacturing country. According to Professor Dewar, in less than two hundred years more the coal of this country will be wholly exhausted, and in half that time will be difficult to procure. Our not very distant descendants will have to face the problem —What will be the condition of England without coal? The answer to that question depends upon the intellectual development of the nation at that time. The value of the intellectual factor of production is continually increasing, while the values of raw material and fuel are lessening factors. It may be that when the dreaded time of exhausted fuel has arrived, its importation from other coal fields, such as those of New South Wales, will be so easy and cheap that the increased technical education of our operatives may largely overbalance the disadvantages of increased cost in fuel. But this supposes that future governments in England will have more enlightened views as to the value of science than past governments have possessed.

Industrial applications are but the overflowings of science welling over from the fullness of its measure. Few would ask now, as was constantly done a few years ago, "What is the use of an abstract discovery in science?" Faraday once answered this question by another, "What is the use of a baby?" Yet round that baby center all the hopes and sentiments of his parents, and even the interests of the State, which interferes in its upbringing so as to insure its being a capable citizen. The processes of mind which produce a discovery or an invention are rarely associated in the same person, for while the discoverer seeks to explain causes and the relations of phenomena, the inventor aims at producing new effects, or at least of obtaining them in a novel and efficient way. In this the inventor may sometimes succeed without much knowledge of science, though his labors are infinitely more productive when he understands the causes of the effects which he desires to produce.

* From Sir Lyon Playfair's address, British Association, Aberdeen.

An Architect's Responsibility.

An architect is the chief builder, according to the correct derivation of the word, but his responsibility for the safety, stability, and permanency of works that are being executed under his direction is a different one from that of the real builder. The builder is directly responsible, not alone for accidents which may occur in building operations (all of which he may make good financially), but also for loss of life and injury that may happen to any of the workmen in his employ, if the same occurs through negligence to provide the proper labor and material necessary to carry on the work in safety. It is not always easy to draw the line at the point where an architect's responsibility ends and that of a builder begins. There are such hazy notions prevalent in regard to an architect's superintendence, and the amount of responsibility it entails, that it is difficult to fix responsibility in any given case. The American Institute did not help matters much by their somewhat elaborate definition of superintendence. In this there was a distinct effort to define the duties of an architect as regards superintendence, and especially to show that an architect was not a clerk of works, and bound to devote an unlimited amount of time in superintending. There was nothing, however, intending to fix responsibility for poor work. This is left, wisely or unwisely, to the parties directly concerned, in case it should be necessary to determine responsibility. It seems to us that a general principle can be laid down which, if borne in mind, might prevent misconceptions. Let it be understood, first of all, that an architect by superintendence does not assume what must necessarily always be a builder's risk, *i. e.*, the risk arising from imperfect materials or poor labor. Even if an architect has passed upon a portion of the work which is afterward found defective, the builder is not thereby relieved, and in any event he cannot transfer his direct responsibility for poor work, no matter when or how detected. On the other hand, an architect is clearly responsible for the result, in case his plans and specifications are strictly followed, and the construction has been according to his directions. If it should transpire in any case where a defect was found, that it was due to imperfect design, poorly conceived planning, or bad construction, either theoretical or practical, we think an architect becomes liable for damages The trouble is, however, to prove that the defect was brought about by any such cause. We speak of legal proof—of the kind necessary to sustain action for damages—not of the conviction which every well-informed man has, after examining into a defect, as to the cause of it. For instance, suppose a building turn out when done to be poorly lighted and ill ventilated, or that the rooms are planned in an impracticable manner, or that there are various absurd and crazy features which will entail future expense in repairs, or that there are any features which will not adjust themselves to the practical requirements for which the building was built. An architect is certainly responsible for any such mistakes, and yet we have never heard of an action to recover based on them.

A case like the following will illustrate the difference between the architect and builder as to responsibility for a disaster: Suppose a high wall of masonry, where there were tall windows separated by piers, should fall down. The responsibility for this would depend, first, on the question of labor and material being all right; second, as to whether the proper precautions had been used; and third, as to whether the wall itself or through weak piers was unstable according to the plans. If on investigation it turns out that the mortar was poor, or that the stones were poorly bonded, or that the wall was not secured in any way while building—no shoring supports being used—then the builder has to bear the blame and sustain the money loss. If the builder alleges that the architect saw the mortar frequently without remark, and gave no directions concerning securing the wall, and that hence he is also responsible and liable, the claim is not good, and cannot be sustained. It is possible that poor mortar and imperfect work *may* escape the closest supervision, although, of course, this is not likely to occur with a thoroughly capable superintendent. Even the capable superintendent may be cheated, however, in the most ordinary building operations. Hence it is just to hold the builder responsible for any disaster due to imperfect work or materials, even if the superintending architect has passed upon the work that is involved. The principle at stake here is one that finds expression in many contracts, as follows: "Under the superintendence of ———, architect, who shall have full right *at any time* to reject such work or material as does not, in his opinion, conform to the true meaning of the plans and specifications." The words "*at any time*" are unmistakable in their meaning, but even without them the principle will be sustained, that the safety of the walls is at the sole risk of the builder, as far as ordinary imperfections are concerned. The architect would be responsible for the fall of the wall in case it was established that it was inherently weak in its design, and that good material and labor were not sufficient to make it stable. The wall might not be thick enough for the height to which it was carried, or the piers dividing the windows might be too weak structurally. Any such cause of trouble as this clearly lays the blame upon the architect's shoulders. Further than this, if the materials have been according to specifications, and it is established that they were inadequate to do the work they were called upon to do, the architect must be held liable.

Sometimes an accident occurs where no one is really to blame, and there is difficulty in fixing upon the person who is liable; at least, there is a disposition to waive responsibility where there is no blame attached. Suppose a truss should give way, causing the fall of a roof, and upon investigation it was found that it was owing to a defect in the iron tie rod—a defect that might have stood the test at the mill, and of such a nature that no one could be aware of it. The builder, feeling that he was not to blame for the disaster, not unnaturally seeks to evade financial responsibility, but he is liable to the owner nevertheless, and he in turn ought to recover damages from the people of whom he bought the rod.

To the earnest architect every really important building that he has charge of brings a higher kind of responsibility than the kind we have been discussing. Whether the builder is technically liable or not, the architect is morally liable, and no mishap can occur without damage to his fame. An architect literally has to entrust his reputation to the builder and his workmen, and the public will hold him strictly responsible, justly or unjustly.—*Building.*

ALFRED E. MOORE, of Winsted, Conn., made a forty-six mile journey in thirty-five minutes in a balloon, the 24th of September. The trip was made at an average of 6,000 feet above the earth, and from this altitude he could see the cities of Hartford, New London, New York, New Haven, and Bridgeport, like mere dots, through the glass. In speaking of his experience, he said: "Balloons, in descending, frighten the crows and poultry terribly. Going over farmhouses. I never heard such a racket in my life. When you are far up and above the clouds, the awful silence is terrible. You can hear the watch tick in your pocket, and the snapping of a straw hat will make you start. The rushing of blood through your whole body is an experience you wouldn't care to have lost. There is no sensation of moving along, when, perhaps, you are going at the rate of a mile a minute, and everything is as still as death.'