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SCIENTIFIC AMERICAN SUPPLEMENT

No. 759.

For the Week Ending July 19, 1890.

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COST OF THE NEW AQUEDUCT.

The new Croton Water Works for New York City have so far cost a little over twenty-three and a half millions of dollars. It is expected the water will be let on within a few days. The total length of the new aqueduct is $33\frac{1}{8}$ miles, of which $30\frac{3}{4}$ miles is in the form of a tunnel, mostly through solid rock, 18 feet diameter, lined with brick 16 to 18 inches thick, filling of concrete, interior diameter for the most part of 14 ft. The delivering capacity is three hundred and ten millions of gallons per day. The work of excavating the tunnel was begun March 7, 1885, and finished July 7, 1888. This may be regarded as excellent progress, and shows the practical advantages of using the best and most improved tools.

THE PANAMA CANAL BUBBLE.

It is now over eight years since work was first begun upon the Panama Canal, and about two years have elapsed since active operations were suspended. The total cost of the work up to the present time, including the indebtedness of the company, is estimated at seven hundred millions of dollars, and the canal is hardly half finished.

De Lesseps' estimate of the cost in 1881 was one hundred and twenty millions, and the time required to open the canal five years. The mismanagement of the enterprise has been conspicuous, and the swindling practiced upon the company fearful. Among the methods of deception the following system was at the time reported. When a ship arrived with a cargo of coal, a small portion would be landed and vouchers given for the whole cargo; the ship would then depart and return again in a short time, ostensibly with another cargo, for which new vouchers would be given; the same trick would then be performed again. Thus by the knavery of its agents, who were simply plunderers, the company paid for materials several times over. There were rumors of frauds in almost every department of the work. There seems to have been a woful lack of that rigid business organization, and close scrutiny of details, which should govern in such an undertaking, in order to secure economy and success. Much of this laxity was doubtless due to the deadly and enervating climate, which almost at the beginning of the work carried to the grave several of the ablest and most experienced chief officers and many of their valued assistants.

After the failure of the company to meet its obligations, a receiver, as we should term him, but in France he is called a liquidator, M. Brunet, was appointed to take charge of the work and the properties of the company. He named a commission, consisting of twelve independent, experienced, and prominent persons, among whom were engineers and professors, who were charged to visit Panama, examine the works and machinery, and report on the best way of completing the canal, the further costs, etc. Efforts were also to be made to obtain a renewal of the concession granted by the Colombian government, as the privilege will soon expire—having now only a little more than two years to run. The commissioners reached Panama in December last and investigated everything with much care. Their report has lately been made to the Chamber of Deputies, and is anything but encouraging.

The committee says that the construction of the canal at the calculated level would occupy twenty years and would cost 1,737,000,000 francs—$347,400,000. In the opinion of the committee the work could only be completed on the basis of an international agreement or a syndicate of the states interested.

The report further states that, taking into account the interest to be paid during so long a period without any receipts, and also the general financial charges, the capital necessary must be estimated at three milliards of francs, or say six hundred millions of dollars.

A further report deals with the defects and omissions of four plans proposed for the completion of the canal. According to the first of these plans, the canal is to be isolated, no use being made of the existing waterways. The second plan proposes to make use of such waterways. The third provides for a ship railway as a portion of the proposed interoceanic route, and the fourth for a ship tunnel through the high land at Culebra.

Meantime the unfortunate shareholders have petitioned the French Congress, asking that the liquidator shall prepare a statement showing precisely what has been done with the money received by M. De Lesseps and the directors. More than twice the sum they stated would be required has been subscribed, and the creditors now believe it was obtained upon false representations. They seek to have the directors made personally responsible for their losses, and hope in that way to recover back at least a portion of their vanished treasures.

The Plasticity of Ice.

Mr. Thomas Andrews, F.R.S., recently read a paper on this subject before the Royal Society. The experiments named in the paper form a continuation of a previous research by the author. The experiments were made to investigate the relative plasticity of pure ice at various temperatures, ranging down to —35 deg. Fah. The arrangements of apparatus used in determining the plasticity of pure ice, and also of pond ice, are illustrated in detail in the paper.

The ice for the pure ice experiments was frozen from distilled water; the coldest freezing mixture used, consisting of three parts by weight of crystallized calcium chloride and two parts by weight of snow, yielded a constant temperature of —35 deg. Fah. Other freezing mixtures were used for the temperatures above this. The cylinders of pure ice employed were 2 feet $1\frac{1}{2}$ inches long and 2 feet $1\frac{1}{2}$ inches diameter, and weighing 470 pounds. The plasticity was ascertained by measuring the relative penetration during equal periods of time of the polished steel rods into the ice, care being taken to avoid errors from conductivity. A large number of experiments were also made on the plasticity of natural, lake, or pond ice. The influence of the composition of water on the plasticity of the ice frozen therefrom was investigated, and a number of experiments were made to ascertain the proportion of the saline constituents of the lake water taken up into the ice during crystallization.

Roughly speaking, it was found that the proportion of inorganic matter in the melted ice was about 10 per cent of the total inorganic salts contained in the lake water from which it was frozen. The general summary of results of the experiments on the plasticity of pure ice at the various temperatures employed are plotted out in four curves, and the results of the experiments on the plasticity of pond ice were shown in detail. In the majority of instances it was found that if the plasticity of the ice at —35 deg. Fah. be called one, at 0 deg. Fah. it would be about twice as much, and at 28 deg. Fah. the plasticity would be about four times as great as at 0 deg. Fah., or eight times as much as at —35 deg. Fah. The comparatively great contractility in ice observed at considerably reduced temperatures—see the author's former paper "On Observations on Pure Ice and Snow," Royal Society "Proceedings," No. 245, page 544—may probably account for the great reduction in its plastic properties at low temperatures.

This is in accord with the practical cessation of motion in glaciers during the cold of winter. It was also noticed in course of the research that the plasticity of the naturally frozen pond ice was manifestly greater than that of the prepared pure ice. The comparative difference in the behavior of the pond ice was doubtless owing to a portion of the saline constituents of the water interspersing during congelation between the faces of the individual crystals of ice, thereby tending to reduce the cohesion of the mass as a whole, and increasing its plasticity.

Latent Heat.

The phenomena of latent heat were first investigated by Dr. Black, of Edinburgh, nearly 130 years ago. He was first attracted to the subject by noting that it was impossible to raise the temperature of ice until it was all melted. For instance, if a pound of ice is put over a spirit lamp, a large quantity of heat passes into the ice, but the mixture of ice and water shows no tendency to rise in temperature until all the ice has disappeared. The question then was what became of the heat. It was proved that the heat was used to melt the ice, but where did it all go to? It had disappeared and was unaccounted for.

Another experiment was tried in which a pound weight of water at 100° C. and a pound of water of 0° C. were mixed, and the result was two pounds of water at 50° C. In the mixture the pound of boiling water gave up 50°, reducing its temperature one-half, and the cold water receiving it is raised to 50°. But if instead a pound of water at 100° C. and a pound of ice at 0° be mixed, we have two pounds at the same temperature, but the mixture, when the ice is melted, would show but about 10° C. instead of 50°. Thus it would appear that 80 units of heat had disappeared and were unaccounted for. The experiment was then tried, from which it was found that this 80 units of heat reappeared when water was converted back again to ice, and this heat was manifest and given to the surrounding bodies. The question was: Where does this heat go to and where does it come from when it reappears? Dr. Black answered that heat was a kind of matter, a subtile and elastic fluid, and water had a great capacity for holding this fluid. Between the molecules of the water, it was said, there are minute spaces into which the heat finds its way, and there lies hidden as long as the water remains in the liquid state. In this condition the heat produces no sensible effect on the thermometer. But no sooner does the water begin to pass back into the solid form of ice than this heat is forced to come out from its lurking place and to make itself sensible once again. This was the doctrine that prevailed down to the close of the last century. The same action is seen in making steam, for if heat be applied to water, the temperature will rise until the boiling point is reached, and if the steam formed is allowed to escape, the water will show no higher temperature, though heat is being constantly added. This heat, it was said, was concealed between the particles of the vapor, and was squeezed out again when the vapor was changed back to water. This is what is known to-day as latent heat, just as it was called by Dr. Black, and the point for the engineer to remember is that in making steam 966 of the units of heat required to make a pound of steam at atmospheric pressure disappear and have no effect on the thermometer; also that when the steam is condensed, this heat reappears and is sensibly felt, hence is not lost.

But although it has disappeared, the modern theory of heat as a kind of motion does not allow this idea that it is hidden somewhere and can be found by shaking. According to the modern theory of heat, when we add heat to a mass, we do not pour into it a certain quantity of matter, but we impart to it a certain amount of energy. This energy goes to pull asunder the molecules of the ice against the molecular action that tends to keep them locked together in solid form. In overcoming these forces the heat expends itself, and ceases to exist as heat. Hence the term latent heat is hardly applicable. To make this theory clear, assume two blocks of lead suspended by two strings from one point. Under the influence of gravity each tends to place itself vertically below the point of suspension, and thus they cling together with a certain small force. If we wish to pull them asunder, we must overcome the force that is pulling them together, and in doing so expend a certain amount of muscular energy. If we allow the blocks to go, they will fall together and acquire an energy of motion equal to that expended in separating them. In the transformation of ice to water, and water to steam, this same process is seen, for the particles cling together and resist separation. Heat is the agent by which we overcome this attraction, and in doing so it expends its energy until all the particles are separated and the block of ice becomes the liquid water or the liquid water the vapor steam. The heat has disappeared as heat and has become energy. Hence the term latent heat is not applicable in a strict sense. It is applicable to this extent, that as the particles of water and steam are held apart they possess a certain amount of energy of motion which will cease when the particles come again in collision, and be converted into the energy of heat. It was so with the two blocks of lead on a large scale, and exactly the same on an indefinitely smaller scale in the conversion of water to ice and steam to water. The energy of motion of the steam is changed into heat by condensation. Hence all the heat that disappears to separate the particles of the water to make steam is given up and becomes sensible when the steam is condensed and becomes water. This heat disappearing and appearing again is what is known as latent heat, yet our engineer friends will understand that when it has disappeared to make steam it is no longer heat that can be shaken up and driven out of its hiding place, but energy which can be converted into heat again by condensing the steam. It is this fact that makes steam such an efficient vehicle of heat. because in condensing it so much heat is produced in its change of form. It is put into the boiler and carried in the steam as energy, but all is given up again. Therefore there is no loss.—*Bos. Jour. of Commerce.*

Files.

BY JAMES D. FOOT.

Files is a word which to the average mind conveys various meanings. Persons looking at the word associate it with newspaper files, stationers' files for properly assorting invoices, letters, etc., but to the mechanical mind it represents a tool which for centuries has been the mechanic's best friend, and sometimes the convict's in his prison cell. It is the object of this article to dwell especially on files as applied to the various mechanical arts, and it may be of interest to know the various materials used as files from the earliest ages. The first application of any article as a file we find by research to have been the dried skin of certain fish. As arts progressed, copper was treated in such a way as to produce a file sufficiently hard to work the softer metals. At a later period, when iron was largely used for armor, house trimmings, and decoration, the people of that age succeeded in forming a metal harder than iron, and practically what is known by the present generation as steel. From that time on this material has been used exclusively for the manufacture of files.

Jumping from this early period several centuries forward we find in Switzerland, Germany, and France files being made of all grades of cut, both fine and coarse, large and small; most of the work being done by families in their houses, their work being afterward assembled by one large factory and in turn placed on the market with dealers and large consumers. It is not necessary to mention the various manufacturers of these files. Those which are perhaps best known in the market to-day are manufactured in Switzerland, and known by the maker's name as the "Grobet" files. The common shapes of these files are flat, hand, half-round, round, triangular, and square, and at the present time this special brand of file is principally used by jewelers, silversmiths, etc., on the finer class of work—files being cut with teeth so fine as to finish to a polish gold material without showing a scratch on the surface. Formerly these files were cut entirely by hand, but for the past twenty years part of them have been cut by machine and part by hand. To cut most of the shapes by hand a chisel and hammer are used. Where cut by machine the chisel is used in connection with a plunger or hammer worked by a machine. On the finer grades of round files and the backs of half-round, the cutting is done by what might be called a system of etching, that is rubbing in the teeth by the use of a large file. Persons sometimes ask how it is that a tooth can be raised on a file which is so hard as to file or cut other hard material. The answer to this is that the blank before being cut is annealed so as to be as soft as the softest iron. After it is cut and goes through the various processes it is then tempered, or in other words the carbon restored to it, and the needle-like points are thereby made extremely hard and tough. Space will not permit the writer to give an extended account of the manufacture of files at the present day. If brief, where twenty-five years ago all files made in this country were virtually cut by hand, to-day over 90 per cent of the files used are cut by machines; in fact, most of the work necessary to produce a file is to-day done by the operation of the machine.

The process of making the files of to-day, briefly, is as follows: The manufacturer of files first secures his steel rolled to proper shape and size from the steel manufacturer in bars about eight feet in length. After the steel is received it is cut into proper lengths to make the various size files, and then passed under power hammers, where the shape and tang of the file is produced. The file is then known as a black file blank, and this process is known as forging the blank. From the forging it goes to what is known as the annealing department, which consists of large ovens in which the files are stacked or placed in a mass surrounded by a hot fire. At the proper time, when files are at the right heat, the fire is allowed to burn out and the files cool gradually, being kept entirely from contact with the outside air, this cooling process taking perhaps two or three days. When the blanks emerge from this fire they are then known as annealed blanks, that is the carbon has been extracted from them without destroying the quality of the steel. After these blanks are straightened on an anvil and put in shape for grinding they are then taken to large machines, where several are inserted at a time and brought with great force against the surface of a revolving grindstone. This produces an abrasion on the surface of the blank, it being necessary to remove the scale or what is known as the "skin" of the steel. These stones are about 6 feet in height, 12 inches face, and weigh something over two tons, and it requires about 25 horse power to run one of these machines in which the stones are used, the stone revolving about 200 revolutions a minute. When the blanks are finished on these stones they have a bright, polished appearance, and are known as ground blanks.

Where, owing to the shape of the file, as in round and half-round, it is not possible to grind by use of the machine, what are known as hand-stones are employed, the work being accomplished by hand instead of by machine, the result being the same. These blanks are now supposed to have a true surface and be ready for cutting; that is they are soft and free from scale, or what is known as the "skin" of the steel. From this point they go to the department where cutting machines are used, and here, by the blow of chisels, very short in length but as to edge and shape very much like the ordinary chisel of carpenters' use, ridges of metal are raised on the blank, producing what are known as the teeth of the file. Where the lines of ridges intersect they form a diamond-pointed tooth and make files such as are used for general machinists' use.

For filing hand saws and mill saws they are cut with what is known as a single tooth, or only one long line or ridge extending across the face of the file. This ridge may be coarse or fine, according to the class of work the file is to accomplish (this also applies to the other form or diamond-pointed tooth previously mentioned), some of them being so fine as to necessitate the use of a magnifying glass to be seen, while others have from 10 to 14 to the inch.

Passing from the cutting shop, files then go through several processes, finally being ready to temper. When the tooth of the file is properly protected by what is known as pasting, the file is immersed into a bath of hot lead, commonly called "tempering pots," where it remains until it becomes what would ordinarily be called red hot, but what would be called by the practical man as "low cherry red." It is then taken from the bath and immersed in a tub of water more or less chemically prepared, and in this transformation takes back its carbon formerly given up in the annealing and becomes the hard-tempered file, ready for use to file anything from moderately hard steel to the softest metals or wood. After tempering there are several other processes, such as scouring, oiling, packing, etc., and the file is then ready for market, being placed in neat boxes, 10 inches and under a dozen in a box, 11 inches and upward one-half dozen in a box.

About two thousand tons of grindstones are used in the manufacture of files yearly, while probably from 4,000 to 5,000 tons of steel are annually cut up and made into files. The larger concerns of this country manufacture or have the capacity to manufacture from 800 to 1,500 dozen a day, and over 90 per cent of the files now used are cut and almost entirely made by the use of machinery. To a very small extent for making a few special files, or for recutting old files, the work is still done by hand, but this process of manufacture is fast becoming a thing of the past.

Artificial Emeralds from Gas Retort Refuse.

Owners of precious stones were surprised a short time since by the announcement that a method of producing artificial emeralds and other gems from the refuse of gas retorts had been discovered by Mr. Greville Williams, F.R.S., the chemist of the Gaslight and Coke Company, London. According to a contemporary, the gem which Mr. Williams has modeled is composed of about 67 to 68 per cent of silica, 15 to 18 per cent of alumina, 12 to 14 per cent of glucina, and minute proportions of magnesia, carbon, and carbonate of lime. The intensely green color for which the jewel is valued is believed to be due to a slight dash of sesquioxide of chromium, though this tint has by some chemists been attributed to vegetable matter—the analyst having to proceed warily when dealing with such costly stuffs as diamonds and emeralds. It may, therefore, be presumed that Mr. Williams has turned out his artificial emerald by skillful fusing and crystallization of these ingredients. It seems, however, that there is nothing very new in the artificial production of precious stones—these having been made upward of sixty years ago. In 1837 Gaudin produced rubies by heating ammonia, alum, and potash by means of the oxy-hydrogen blowpipe; the intense heat developed by this apparatus volatilizing the potash and the alumina, then crystallizing in rhombohedral forms identical with those of the natural stone, and having the same specific gravity and hardness. The artificial production of precious stones is interesting from the standpoint of the chemist and mineralogist, and in the present case the gas manufacturer may be included; but the cost entailed is too great to allow of the operation being a commercial success, and therefore the dealers in these adornments will probably not have to close their shops as the result of Mr. Williams' discovery.

Remarkable Electrical Invention.

"The woods are full" of wonderful electrical inventions, some good, some bad, and some so supremely foolish as to make one wonder that any man of average intelligence should waste a second thought on them. But turn the ordinary newspaper reporter loose on anything which has a suspicion of electricity or magnetism about it, and he will see, if not "sermons in stones," at least some wonderful manifestations destined to overturn all previous conceptions of force, power, and mechanical theory. "Heat as a mode of motion" is nowhere as compared with the deductions of these modern Tyndalls. The latest instance of reportorial credulity we find in a daily exchange. It is so good, and so far from being true, that it merits special mention. The invention described consists of two twenty horse power boilers to which is temporarily connected a ten horse power boiler, engine and dynamo. Steam is raised in the small boiler, the engine drives the dynamo, the wires from which are connected with the ends of the tubes in the larger boilers, the tubes being filled with asbestos. The current of electricity is turned on and, *presto!* the asbestos becomes red hot, the water in the large boilers is converted into steam and forty horse power is the result. This process can be multiplied without limit, and it is only a question of a string of boilers, engines and dynamos a mile or two long to put Niagara totally in the background. Shades of Carnot, Joule, and Watt, what will come next! exclaims the editor of *The Stationary Engineer*, from which paper the above is copied.

William L. Gilbert.

William L. Gilbert, aged 84, of West Winsted, Conn., died recently near Toronto, Can., whither he went several weeks since on business. He had been fifty years president of the Gilbert Clock Company, of Winsted, very prominently identified with many large factory interests in Winsted, and with railroad interests of Connecticut, as well as banking interests of the State. His fortune is estimated at $3,000,000. He built and endowed the Gilbert Home, of Winsted, a few years since, at the expense of $500,000. He was also the promoter of a project to tunnel the mountain so as to connect the waters of Crystal Lake with Mad River, with a view of giving increased power to about twenty Winsted factories. His promised donation to that project was $50,000, and it is thought some provision has been made in his will so that the project can be consummated. Mr. Gilbert was extensively known from Maine to California.