On the contrary, the machinery of the *Algonquin*, in those parts which govern the making, using, and condensing the steam, is full of novelties. Accordingly, a very mediocre result may be looked upon as a tolerably respectable performance. The contractor of the *Algonquin*, of course, relied on running his engine with a very short cut-off, against another engine cutting off at the point which Mr. Isherwood asserts is the most economical, viz: $\frac{7}{10}$ ths of the stroke. On the contrary, as will be seen by inspection of the indicator diagrams, he failed to put his theory to the test.

The diagrams marked Nos. 1 and 3 were taken from the *Algonquin's* cylinder during the dock trials with the *Winooski*; diagrams No. 2 were taken at the same time from the *Winooski's* cylinder, and diagrams No. 4 were also taken from the *Winooski* during a "dock trial" which occurred a few days previous to the trial on Long Island Sound.

By comparing these diagrams with such a diagram as would have been given if the steam had been expanded during but $\frac{3}{10}$ ths of the stroke, it will be seen how very far the measure of expansion shown by the *Winooski's* diagrams is from the theory of Mr. Isherwood. Of course, the *Winooski* would have given such a diagram, (*i. e.* one showing the steam to have been expanded during but $\frac{3}{10}$ ths of the stroke,) if the $\frac{7}{10}$ ths cut-off theory, which Mr. Isherwood claims to have established, at the expense of the government coal yard to be the point of maximum efficiency, had been put to the test. If this had been done, it is very plain what the result would have been; of course, the *Winooski* would have been beaten worse than she really was.*

The trial was, therefore, between an engine with a very short cut-off and of novel construction, and an engine constructed on old and well established plans, cutting off at the usual point. But, nevertheless, as has been shown, it has proved that Mr. Isherwood's conclusions in relation to his innumerable government expansion experiments are fallacious.

Notes on the Origin of Several Mechanical Inventions, and their subsequent application to different purposes. By J. C. DYER.

From Newton's London Journal of Arts, January, 1866.

The Employment of Steel for Transferring Engravings.—At the beginning of this century, upon the death of Washington, medals to commemorate that event being called for, Mr. Jacob Perkins (then a silversmith at Newburyport, near Boston,) undertook to supply them, and, as they were required in large numbers speedily, he devised a summary process of transferring the engraved design, from prepared steel dies, or stamps, by which he obtained several from one original die, and thus a vast number of medals were rapidly produced. Shortly after, Mr. Perkins applied the same principle of transferring engravings for bank notes, on which very elaborate designs were printed, to prevent or render their being forged very difficult by the hand of the engraver. To effect this, he procured cast steel plates, and de-

* The pressures opposite the ordinates in the diagrams were measured from the original. The diagrams are two-thirds the original size. "Position of throttle valve 8," diagrams No. 4, means, wide open.

carbonated their surfaces to the depth of about one-sixteenth of an inch, which were thus converted into *very soft* and *pure iron*; the letters and designs for the notes being then engraved upon them, they were case-hardened and tempered for *use*, but in lieu of printing from these plates they were used as dies for making others to print with. His next process was to prepare a cast steel cylinder, which, in like manner, was decarbonated at the surface, and then, under a strong traversing pressure, it was rolled over the letters and figures engraved on the hardened plate, and these engravings were taken up in relief on the surface of the soft cylinder. This cylinder being then hardened and tempered, was used to transfer, by means of the same traversing pressure, the entire work upon its surface, to any number of copper or soft steel plates for printing with.

The adoption of this plan by several banks, for having very elaborate engravings on their notes, turned the counterfeiters upon other banks, whose notes would be so much more readily forged, which led to an extended demand by the other banks.

In the year 1809 Mr. Perkins communicated to me the details of his process of transferring engravings, with a view to having the invention patented in England for our joint account. From the success of his plan in America its adoption here was anticipated, and still further development of it looked for from the higher state of the graphic arts in London. With this view I took out patents, and minutely specified "the method of carrying the invention into effect." A very beautiful design was then obtained from the classic pencil of the late Sir R. Smirk, R. A., which was engraved by Reimback, on prepared steel, for printing bank notes. But I could not succeed at that time to induce the Bank of England or any other bank to adopt the plan, nor could the booksellers then be made to perceive the importance of the transferring system for illustrating books, for which it has since been so extensively used. The time had not arrived when public attention could be drawn to the bank note forgeries as a national evil, and the disgrace of hanging men for a feat so readily performed as that of forging the one-pound notes then in general circulation. If any excuse can be offered for this apathy, it may be said that the passions and interests connected with the war, together with those yet more embarrassing that arose from the transitions from war to peace, caused such disturbances in the circulating medium and in the general interests of commerce and industry, that it became very difficult to awaken public attention to the great scandal of relying solely upon the gallows for preventing forgeries.

It has been above shown that Perkins' invention was not for engraving on steel plates for printing, nor for engraving upon steel at all, but rather for engraving on soft iron of homogeneous structure. It was found that all wrought iron is more or less fibrous and unfit to receive delicate engravings, and that by decarbonating the surface of cast steel a pure iron surface was obtained, and this being engraved on, was case-hardened and used for transferring and printing as before stated. This should be kept in view, because many persons have supposed that the invention of Perkins was merely the substitution of

steel in the place of copper for engraving upon; such a substitution of the one metal for the other would not be an invention in any fair sense of the word. But his method of obtaining soft surfaces to receive the work, converting these surfaces back into steel, and then transferring the engravings to other plates for printing, comprised together a series of novel processes which confer lasting honor upon the inventor.

After the transition period, having better hopes of success, I recommended Mr. Perkins to come over himself and explain his system, and aid the artists here in putting it into operation. Accordingly, in the year 1820, Mr. Perkins came to England, and, being over sanguine, brought a large staff of able artists, mechanics, &c., but he could not bring any money to aid in establishing his intended works in London. He had assumed that capital could always be obtained in England for conducting any safe and profitable schemes. Now, the matter of proving his to be such was not easy to establish with the *moneyed class*; so to me alone, not of that class, he had to look for the entire expenses of his mission, and this I could only bear for a few months. After some time, the late Mr. Charles Heath, the eminent engraver, was induced to join Mr. Perkins and become a partner in the engraving works which were then commenced in Fleet Street, and are still continued by their successors.

Besides the printing on paper, Mr. Perkins' system of transferring has been since very extensively employed for calico printing, and in later years we have also seen his process employed to a vast extent in many other departments of the graphic art, such as post-office and receipt stamps, and other prints that are required in greater numbers than could be produced by other means than steel plates or stamps. His system of engraving on steel has at length become a great artistic power, the wide-spread increase of which has given employment to labor and capital to a vast extent in the several branches of art before stated, and from which I believe many large fortunes have been made, but little other than "toil and trouble" ever accrued to the inventor of them.

When any important discoveries in physical science are made they never die, whatever may chance to their authors. The new facts brought before the public go forth like seeds cast upon a fertile soil, yielding the fruits of continual progress among the families of men who seek improvement. It seems only just, then, that each generation should transmit to the next some record of the names of those contemporaries to whose genius and talents all nations are indebted for such discoveries. Wherefore, in addition to the four distinguished inventors brought to the notice of this Society in my former papers, I have in the present one aimed to place that of Jacob Perkins as a worthy contributor to the advance of those branches of art to which his inventions have been applied.

On the Compression of Water.—In tracing the progress of steel engraving, I had no thought of giving a general account of Mr. Perkins' researches in physical science, yet it may not be out of place to notice one or two other of his discoveries.

1. His experiments on the compressibility of water (made some time before he left America) were to test the correctness of the doctrine founded on the Florentine experiments, that water was a non-elastic body, which was then generally taught in the schools and elementary works. At that time Mr. Perkins had never heard of the experiments of Canton (made some fifty years before) which had established the compressibility of water. Although by Mr. Perkins' experiments its discovery was not *strictly new*, yet they were of high scientific value, because of the widely different compressing forces employed by him and by Canton, the latter having applied the pressure from half an atmosphere to two atmospheres, say from seven and a half to thirty pounds a square inch, whilst that employed by Perkins was from fifty to four hundred atmospheres, or from 750 lbs. to 6000 lbs. per inch. The same rate of compression appeared in all his experiments, which corresponded with that shown by Canton's experiments, and in all of which the water was compressed in volume directly as the compressing forces.

The apparatus employed by Perkins was first a cast iron cylinder, about three inches thick, with a movable top of equal strength; this, filled with water, had a force pump (as in the hydraulic press) to measure the pressure within by the leverage and size of the induction pipe. 2d. A small brass cylinder, with a piston to slide in it, water-tight, about three-quarters of an inch diameter, and to have a column of water ten inches long under the piston. The piston rod, graduated to divisions of a hundred to the inch, had a sliding ring on it, to be pressed upon the rod as it was forced down upon the enclosed water, thus marking in the hundredths of an inch the descent of the rod; the brass cylinder being under the same pressure inside and out, was not subject to any strain to alter its capacity. 3d. When the external pressure was removed, the water in the brass cylinder expanding to its original length and raising the piston rod, would, of course, mark the greatest compression effected. In each experiment the diminished bulk of water was directly as the pressure applied, and under the pressure of 100 atmospheres, the bulk of the water was reduced one part in a hundred, and, as before mentioned, this rate proved to be the same as that shown by the experiments of Canton. Some time after Professor Oersted made similar experiments, by employing a stout glass vessel and using a column of mercury to give the pressure, having the like inside cylinder of Perkins to mark the result, which confirmed the same rate as that shown by Perkins and Canton.

On Perkins' Steam Gun.—Mr. Perkins conceived the idea of employing steam at a very high pressure for discharging projectiles with greater rapidity and effect than could be done by the common use of gunpowder. To effect this object, he devised a plan for heating water more intensely than could be done by any boilers then known, viz: that of employing a great number of iron or copper tubes, with their ends fastened into plates, with chambers, or cavities, for receiving the water at one end and emitting the steam at the other.

This apparatus was placed in the midst of a furnace for the heat to

act directly on the water in the tubes, and thus, as Mr. Perkins phrases it, the water could be made red-hot, and flash into steam with a force exceeding that of gunpowder. Then a gun barrel, with its breech opposite the valve opening from the steam chamber, and an apparatus for conducting the balls into the space between the breech of the barrel and the outlet of the steam, and the valve opening at the same time, the steam issued and propelled the balls through the gun in rapid succession with a force about equal to common powder, which could be continued as long as the heat of the furnace could keep up the pressure. He found that from fifty to one hundred balls per minute were shot forth about one hundred yards to a target, with a force nearly equal to that of a common musket, and, of course, by having ten such guns fixed to the same furnace, from 500 to 1000 balls might be discharged per minute. His experiments were witnessed by the Duke of Wellington and many other eminent men, who took much interest in them.

The non-adoption of his system arose from several radical defects in it—first, the danger from fire of having such a cumbersome furnace on a ship; second, the time required to get up the steam in case of sudden encounter with an enemy, which might lead to a surrender before a shot could be thrown from the steam battery; third, by unequal heating, the tubes sometimes gave way, allowing the water to escape, and though the quantity being small would not cause explosions, leaks would deaden the fire and stop the action of the guns, and any suspension in the midst of action must be fatal to the ship using such a weapon. Still, the after interest attached to the plan of the tubular boilers came from reversing the scheme used by Perkins, viz: employing the tubes as flues for the fire, to convey the heat through the tubes to the water surrounding; then, in an outer boiler, by this method, without damaging the tubes, it is found that high-pressure steam can be employed with safety and advantage, so that Mr. Perkins' invention was not barren to the outer world, since his tubular boilers led to their extended employment in railway and steamboat engines, and were, I believe, first employed by Stephenson a few years after the steam-gun experiments had been put *hors de combat*.

NOTE.—Although it is needless to describe the process of case-hardening, so generally known, it may be as well to explain that of decarbonizing the steel plates for engraving. This process is as follows: The prepared steel plates are placed in a cast iron box, and covered about an inch deep with an oxide of iron, prepared by subjecting iron filings to an alternate wetting and drying until they are mostly converted into red oxide. Over this covering a clay luting is placed, so as to exclude the air, and the box is then placed in a furnace and kept at a red heat for about sixty hours, when the oxide in contact with the steel will have taken up the carbon from its surface to the depth of about one-sixteenth of an inch, and thus converted the surface into pure iron, as mentioned in the text.

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Fire-damp in Coal Mines.

From the London Chemical News, No. 309.

Mr. G. F. Ansell has sent to a contemporary the following account of his mode of applying the law of diffusion to the indication of the