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Contents:

(Illustrated articles are marked with an asterisk.)

GAIN FROM THE APPLICATION OF CONDENSERS TO STEAM ENGINES.

In the early days of the steam engine, very low pressure was ordinarily employed for engines with condensers, while, on the contrary, what was considered a very high pressure was adopted for engines that exhausted into the atmosphere. Hence arose the terms high and low pressure engines, the former being engines with, and the latter without, condensers. At present, a high pressure of steam is ordinarily carried in both kinds of engines, so that the terms do not describe the two varieties as well as formerly. Many engineers prefer to class engines as condensing and non-condensing, rather than as high and low pressure; and we recommend this classification to our readers, as the more correct of the two. One who regards economy puts in a non-condensing engine, if he has plenty of water in the locality; and many old non-condensing engines are being fitted with condensers, under the more enlightened engineering practice of the present time. Many more steam users would doubtless make the change, if they realized the gain that would probably result; and though this cannot be predicted exactly, for any given case, it can generally be estimated with tolerable accuracy.

It may be fairly assumed that a non-condensing engine has, on an average, at least two pounds per square inch back pressure on the piston. Some have much more than this, and first class engines have less; but two pounds can be considered a fair example of ordinary practice. By the application of a condenser, it might be expected that there would be a negative pressure of ten pounds per square inch on the back of the piston, so that the piston pressure would be increased by twelve pounds. In this assumption, an allowance is made for the power required to work the air pump, and the engine is supposed to be at seventy-five horse power. For an engine smaller than this, it would be better to allow an increase in the positive pressure of not more than ten pounds per square inch. As the condenser, by decreasing the back pressure on the piston, adds just as much to the positive pressure, it is plain that a lower pressure of steam can be used, or what is better, the steam may be cut off at an earlier point of the stroke. The gain in either case can be approximately calculated. If the gain in positive pressure produced by the reduction in back pressure be multiplied by one hundred, and divided by the mean effective pressure on the piston, it will give the *per centage* of gain in pressure due to the condenser.

Thus, if the mean effective pressure on the piston is thirty pounds per square inch, the gain in pressure will be 100 times 12, or 1,200, divided by 30, which is 40 per cent. Now suppose that before the condenser was attached, the steam was cut off in the cylinder at half stroke; under the new conditions the required mean effective pressure can be obtained with a lower boiler pressure than before. Before the condenser was in use, it would be necessary to maintain a pressure in the boiler of about 58 pounds per square inch by gage, to give a mean effective pressure of 30 pounds on the piston; while with an increase of 12 pounds in the effective pressure, by the application of the condenser, a boiler pressure of about 39 pounds would suffice. As the weight of steam per cubic foot at 58 pounds pressure is 0·17481 pounds, and only 0·132 pounds at 39 pounds pressure, there would be a saving of about 24·5 per cent in the amount of steam required to run the engine. Instead of reducing the steam pressure after attaching a condenser to an engine, it would be better to maintain the same pressure in the boiler, and cut off the steam at an earlier part of the stroke. In the case under consideration, the increase in 12 pounds of the effective pressure would permit of closing the steam port a little before the completion of one third of the stroke; and supposing that the clearance space in the cylinder amounts to five per cent of the capacity of the cylinder, the quantities of steam required per stroke, before and after the use of the condenser, would be in the ratio of 550 to 363, so that there would be a saving of 34 per cent.

The example given represents a case in ordinary practice. By varying the data, of course a greater or less amount of saving would result; but with an engine in good condition, it is generally safe to estimate that a saving from 20 to 25 per cent of the amount of steam used, and, consequently, of the consumption of coal, will be realized by the application of a condenser. Indeed, it is not unusual for manufacturers to guarantee this amount of saving, in converting a non-condensing into a condensing engine. Those of our readers who think of having their engines changed in this manner can generally, by consulting a reliable engineer and giving him full details, obtain a pretty correct estimate of the advantage that will probably be derived. Matters of this kind are strictly professional, requiring so much experience and technical knowledge for their proper consideration, that nothing but general hints can be given in a popular article.

It occasionally happens that no saving, or one of very small amount, is effected by the use of a condenser. This almost invariably indicates that there are leaks about the engine, which are so much increased by the reduction of back pressure as to balance the increase in effective pressure due to this reduction. Of course, all calculations of probable gain are rendered useless by the introduction of this element. The question of leaks is purely a matter of fact, and is not subject to calculations until experimental data have been obtained. This should be remembered by users of steam power, and we repeat the statement, frequently given before, that it is true economy to have steam machinery examined sufficiently often to enable leaks and derangements to be discovered and remedied. This is especially important in cases where the vacuum in the condenser may magnify leaks that were trifling when the engine was non-condensing.

IMPRACTICABLE INVENTORS.

"It is one thing to construct a machine on paper, but a very different affair to make it go," remarked a friend to us recently, as he ruefully regarded a roll of elaborate drawings, which represented the fruitless labor of a year or so of his earlier life. "If friction and gravity were only out of the way, what a great inventor I should be!" and with this sententious observation, the plans were reconsigned to their dusty shelf.

It certainly does seem an extremely difficult matter to convince mankind in general that the same operation, when it is plainly impracticable by simple means, through its variance with some natural law, is just as impossible with the most elaborate combination of machinery. Moreover, as a corollary to the above proposition, and as a general rule, if we set about a piece of work wrongly and make errors (through negligence, through forgetfulness, or through ignorance) in its course, losing sight of the pitfalls in our road while regarding only the brightness of the goal, it is equally certain that the grand result we seek will not be reached. This neglect of detail, impracticability of design, in brief, appears to be one of the commonest difficulties in which inventors are prone to involve themselves; and the reason is that they become so completely imbued with the single grand idea that they fail to see anything of apparently minor importance, utterly oblivious of the fact that perfect parts alone constitute a perfect whole.

It is related that Brunel, the great English engineer, was constantly visited by inventors desirous of submitting their designs to his expert judgment. Although frequently wasting time of the utmost value, in the examination of impracticable schemes, he would patiently listen to the description, and then point out the fallacies in the chimerical projects. An enthusiastic individual came to him one day with a plan for sweeping chimneys; it would totally obviate the cruel employment of the small boys who were sent up the flues; it was simply a broom—a mere broom—which, worked from above, swept every minute crack perfectly.

"Excellent," gravely said Brunel, "but you have not told me how the rope is to be got to the top."

"Why, nothing is more simple," replied the sanguine inventor, "of course a boy will go up with it first."

At another time, the same celebrated engineer was interrupted in his labors by an Irish gentleman, who was burning to tell him all about a portable hood, which was to be stowed away under an open carriage in fine weather, ready for immediate use in case of a storm.

"But you cannot stow away such an enormous thing as that in so small a space," objected Brunel.

"Certainly not," ejaculated the unabashed inventor, "it's not that that I mean to do. It's at home the thing is to be left when the weather is fine; of course it won't be wanted, then, you know."

It is this looking only at results, more especially when coupled with ignorance, not merely of principles but of what others have already proved useless, that has led many an inventor to despair, oft-times to ruin.

A simple incident in point came to our notice recently in the course of our weekly stroll through the American Institute Fair: Among the entries for exhibition was that of a rotary engine, which in due time was brought to the building by its constructor; and the inventor, with the aid of the proper officials, proceeded to set it up. The inventor—an old man whose dress and general appearance betokened a hard struggle with the world in days past—grew quite garrulous over his pet, and told how he had worked upon it for years, how he had spent every cent to get it built, and how he had now brought it from the far West to show the Eastern people what it could do. Then the blood would crimson his cheeks and his eyes glisten, while he would stop and gaze fondly on the insensate metal. When the placing of the machine was completed, the throttle was opened. Two turns were made, then another slow one, and then everything stopped. A second trial did no better. It was the first practical test, and the machine had never before existed except on paper. Then the inventor, with trembling fingers, moved a wheel here, a nut there; for some time he worked, but in the end he threw down his tools, and sinking despairingly into a seat, buried his face in his hands, and great tears stole slowly down his wrinkled cheeks. He saw that his treacherous fondling could never be made to run, and yet for three days he returned again and again to its side, wistfully gazing at it as if he hoped to gain some inspiration which would, after all, set everything right. But none came; none could come, for the very principle of the machine had long ago been exploded. Finally, heart-broken with disappointment, the old man started alone for his far-off home—not altogether penniless, however, for before he left his worthless engine was purchased from him at a good price by one upon whose labors in the same path fortune had abundantly smiled. Then others contributed their mites, and a sufficient sum was collected to enable the man to pay his passage home, without touching the little capital derived from the sale of his machine. That was a genuine and a noble charity, and, while the names of the generous givers are known to but few, the deed is one which an all-wise Providence will not allow to pass unrewarded.

RAILROAD EMPLOYEES AND THEIR PAY.

It seems to us that the course taken by the managing powers of our public conveyances, relative to the payment of their employees, is far from the wisest that could be adopted. The plan appears to be not to encourage a feeling of common interest, or to impress upon the employee that so long as he studies the benefit of his employers his own will not be neglected, but rather to create a species of antagonism between the parties, in which any over reaching of one by the other is considered legitimate. Upon our city omnibus and car lines, it is perfectly well known that the pay of the employees is far below that to which their arduous labor would seem justly to entitle them. As a consequence, the positions are filled principally, not by a respectable and reliable class of men, but by persons either unfit for any business, or by those whose characters prevent their obtaining other employment, or by unfortunates whom reverses of fortune have driven to accept any means of support, however slender. It would be unreasonable to suppose that the majority of such individuals would or could refrain from peculation, and hence the "knocking down" system, as it is termed, has been carried on, year after year, until it has assumed such proportions that the street conveyance owners have at length become alarmed; and inventors of ingenious contrivances, which force stage drivers and conductors to be honest, are reaping a harvest. Natural honesty, then, is at a discount, and machine integrity rules the hour. As a mere matter of money, it would appear that it costs less to employ a scamp, *plus* a punch or a fare box, than to encourage upright service by the payment of a fair salary. The same policy is extended, on railroads and steamboats, to positions in which experience, judgment, forethought, and skill are all required. The traveling community, for its personal safety, is directly interested in the latter, and it seems to us a shortsighted policy on the part of the managers of our steam conveyances, whether carriers of passengers or freight, to pay only the lowest minimum of wages to their employees.

The average railroad car conductor is paid about as miserably, proportionately, as his brother of the street conveyance; and where the latter carries a bell punch to support his moral rectitude, the former is looked after by means of the duplex ticket system. And yet, with inexplicable inconsistency, a great corporation will commit to the fidelity of that individual, whom it tacitly admits it cannot trust with a few dollars, the care and management not only of valuable property, but the safety of human lives.

Not content with carrying out these peculiar notions as regards those on whom they depend for their money, several of the railroad companies are now manifesting a disposition to extend their demoralizing system, or a modification of it rather, into the ranks of the engineers. We do not mean that any checks on the honesty of these men are proposed, for of course none such are necessary; but it seems to us that a perpetual tinkering with their hardly earned salaries, and a series of onslaughts thereon with a view of reducing their wages down to those of an ordinary day laborer, are about as well calculated to drive all good and reliable men out of the trade, and replace them with incompetent persons, as any plan which could be well devised. If the project has worked to this effect with one class of men, there is no reason why it will not act similarly as regards another; and we tell the railroad companies thus plainly that no investment is so poor a one as that in cheap skilled labor in any form.

No mechanic in any branch of trade has to face such responsibilities as the locomotive engineer. In none are such qualities of judgment, coolness, skill, and heroism, even, required. Few professions are more arduous or more physically exacting; none exist in which strong mental power is more certainly needed; and to suppose that men uniting in themselves all these conditions, and who, besides, have learned to discipline their faculties, with that unerring accuracy which every one on whose shoulders the weight of the existence of others falls must sooner or later attain, can be got to work for a pittance, or can be replaced by mechanics gathered at random from shops and founderies, is criminally foolish.

We notice that a meeting of engineers, from a large number of railroads, recently took place in this city, in order to protest against the proposed reduction of their wages, contemplated on many principal lines. The session was an orderly and decorous one, and the protest, embodied in the resolutions, earnest and emphatic. The men are clearly in the right, and, besides having their own excellent organization, they will find themselves amply supported by the traveling public; for when it comes to making us ride in trains managed by men whose ignorance or incapacity may put abrupt ends to our mortal careers at any moment, because of the niggardly arrangements of our railroad managers, it is time for the public to protest.

IMPROVISED APPARATUS FOR STEAM BOILER TRIALS.

In the course of his professional work, the engineer sometimes finds himself confronted with practical problems which only an exceptionally extended experience, or a remarkably ingenious mind, can satisfactorily solve. The marine engineer, who has charge of the machinery of a steam vessel on a long voyage, is often driven to adopt most singular expedients when a breakdown at sea makes important repairs necessary; and he sometimes succeeds, hundreds of miles from the shop, with but the few tools usually carried on shipboard, and with the ship rolling and pitching so violently that it is with difficulty that his men can keep their feet, in doing work which would be considered decidedly formidable even on land, where a stable footing and all needed appliances make the task a comparatively easy one. Such instances of difficulty seldom occur on shore; but in the course of his practice, every engineer occasionally finds exercise for his ingenuity, and for the application of such knowledge or experience as he may have acquired, in similar but usually less important matters; and he is always pleased to learn from the experience of others how to proceed, and what success to anticipate, in any specific case. The following will perhaps prove interesting and useful to others who may find themselves situated as was recently our occasional contributor, Professor Thurston, the Director of the new Mechanical La boratory of the Stevens Institute of Technology.

It had become necessary to determine very carefully the evaporative power of a set of steam boilers. A large amount of money and important interests were involved, both directly and indirectly, in the case, and it was essential that the total amount of heat evolved from the fuel should be precisely ascertained. It was equally important that it should be learned how that heat was distributed. It was necessary to determine the temperature of the escaping gases in the chimney, and the percentage of water primed over with the steam. To determine the first point, it seemed necessary to use a pyrometer; but none had been provided, and there was not sufficient time to obtain one by sending to New York or Philadelphia, the nearest cities in which they were probably obtainable. The only reliable pieces of apparatus at hand which could be used in improvising a pyrometer were a very good platform scale and one of those excellent thermometers which were made some years ago by the Novelty Iron Works. A careful search in the scrap heap brought to light a conveniently shaped mass of iron, which, being weighed, was found to balance the scale at precisely sixty pounds. This was placed in the flue at the point where it was desired to measure the temperature of the products of combustion. A small tub was placed on the scale, and into it was carefully weighed fifty pounds of water. After a time, when the iron had remained in the flue long enough to have attained fully the temperature of the gases flowing past it, it was suddenly removed and immersed in the vessel of water, and the increase of temperature of the latter was very carefully observed. The estimation of the initial temperature of the heated iron, and that of the furnace gases, was then an easy matter. In one example, the water rose in temperature from 65° to 119° Fah., a range of 54°. Fifty pounds of water raised 50° in temperature had, consequently, received from the iron 50×54 $=2{,}700$ units of heat. This having been communicated by 60 pounds of iron, each pound of metal had parted with $\frac{2700}{60}=45$ units of heat. The specific heat of iron, as given in the SCIENTIFIC AMERICAN recently by Mr. R. H. Buel, is 0·113, or, very closely, one ninth. Each thermal unit abstracted from a pound of the iron, therefore, reduced its temperature nine degrees, and its total loss of temperature must have been $9\times45=405°$. The final temperature being 119°, the temperature before reduction was $119°+405°=524°$, and this was the temperature of the flue. In another instance, the water was heated by the pyrometer ball from 63° to 122° Fah. The temperature of the flue was in this case $\frac{(122-63)\times50\times9}{60}+122=564°$. With a good thermometer and accurate scales, the results thus obtained are probably more reliable, at high temperatures, than those usually obtained by the common pyrometer.

The determination of the proportion of water contained in the steam leaving a boiler is often, as in the case here considered, a matter of vital importance. It often happens that a pound of water takes from the fuel hardly a tenth as much heat as a pound of steam, and at least one instance has been given by our contributor in which more water left the boiler unevaporated than was actually made into steam. It is seen at a glance that, where the feed water only is measured, the most worthless of boilers may appear to compete successfully with the best; and the greater the amount of priming or foaming, the better is the apparent result. Makers of peculiar forms of boilers have actually guaranteed an evaporation (!) of *nineteen* pounds of steam, from cold water, per pound of coal, a performance to which the best boilers ever yet made do not approximate, and one half of which amount is never fairly obtained, except with heated feed water. The guaranty has *apparently* been fulfilled, because the guaranteed boilers carried over (by priming) a weight of water exceeding that of the steam by which it was transported. Every intelligent engineer would recognize in such a guaranty an evidence of inefficiency, rather than of economical steaming.

The first successful attempt to determine, with precision, the quality of steam made, and to obtain a trustworthy measure of the value of competing steam boilers, was probably that made by Professor Thurston at the exhibition of the American Institute in 1871, when conducting, for a committee of judges of which he was chairman, a trial of five competing steam boilers, which had been entered by as many different makers. In that instance, all of the steam made by each boiler was condensed in a surface condenser, and the total quantity of heat transferred carefully and accurately measured. At a subsequent trial, a neat form of apparatus, invented by Mr. Leicester Allen, was used for this purpose with quite satisfactory results. In the case about to be described, it was impossible to condense all of the steam. The Allen calorimeter was not to be had, as there was but one in the country, and that was the property of the American Institute, and could not be promptly obtained.

An ordinary oil barrel was obtained and mounted upon the platform of the scale. Precisely two hundred pounds of water was weighed into it. A three quarter inch gas pipe was tapped into the main steam pipe, and fitted with a stop valve. From a short piece of pipe projecting from the valve, a piece of rubber hose, some twenty feet long, led to the barrel, its extremity being lashed to a wooden pole for convenience of handling. The temperature of the water in the barrel was carefully determined, and an additional weight, indicating ten pounds, was placed on the pan of the scale. The valve was then opened, and steam was allowed to blow through the hose until it was warmed up, and condensation in the pipe was thus prevented. When the hose seemed as well cleared of water as it could be, the extremity was plunged into the barrel, and the issuing steam was condensed until the rising of the scale beam proved that ten pounds of steam had been added to the two hundred pounds of water originally placed in the barrel. The water was then thoroughly stirred with the thermometer, and the temperature noted. The following are the data obtained in one experiment:

Weight of water, 200 pounds; weight of steam, 10 pounds; original temperature of the water, 62°; final temperature of the water, 115° Fah; pressure of steam per square inch by gage, 75 pounds. Steam at 75 pounds pressure has a temperature of 320° Fah., and to raise it from 0° Fah. to 320°, and to evaporate it at the latter temperature and the given pressure, requires $1{,}178\cdot6°+[0\cdot305(320°-212°)]=1{,}211\cdot5$ units of heat. Each pound of steam, therefore, communicated to the water which condensed it, in this example, $1{,}211\cdot5-115=1{,}096\cdot5$ thermal units. Each pound of water suspended in the steam, and primed over into the condensing water, transferred only $320°-115=205$ units of heat. The total heat transferred was $(115-62)\times200=10{,}600$ thermal units. Then the product of the number of pounds of steam condensed multiplied into 1,096·5, *plus* the product of the number of pounds of water multiplied into 205, will be equal to the whole sum, 10,600. A simple algebraic equation will give the proportion of priming.

Let W = the total weight of steam condensed, together with the suspended water; then X may be taken to represent the weight of pure steam, and W—X will be the weight of water carried over with it. Let the total amount of heat transferred be called U, the heat transferred by a pound of steam, H, the heat transferred by a pound of water, *h*. Then

$$HX+(W-X)h=U;\ \text{or,}\ X=\frac{\frac{U}{h}-W}{\frac{H}{h}-1}$$

In the example above given, $X=\frac{\frac{10600}{205}-10}{\frac{1096\cdot5}{205}-1}=9\cdot59$ pounds of steam, and $10-9\cdot59=0\cdot41$ pounds of water suspended in the steam. The priming, therefore, amounts to 4·1 per cent.

Now, suppose 100,000 pounds of water to have been apparently evaporated, under similar conditions, from feed water at 200° Fah., by 10,000 pounds of coal. Of this quantity, 95,900 pounds would have been steam, and 4,100 pounds would have been water. But each pound of steam requires for its evaporation under the assumed conditions $1{,}211\cdot5-200=1{,}011\cdot5$ thermal units, while each pound of water takes up but $320-200=120$ units of heat.

$$95{,}900\times1{,}211\cdot5=116{,}182{,}850$$
$$4{,}100\times120=\quad492{,}000$$

Total heat from fuel, 116,674,850
" " per pound coal, 11,667·5 thermal units.

Engineers are accustomed to reduce results obtained on such tests to evaporation from 212°, at atmospheric pressure. The amount of heat required to convert one pound of water into steam at atmospheric pressure, when already at the boiling point, is well known to be 966 6 thermal units. Hence, $\frac{11667\cdot5}{966\cdot6}$ $=12\cdot07$ pounds of water, per pound of coal, represents the performance of the apparatus tested.

In another example, with steam at 50 pounds, the water was raised from 70° to 118°, and he obtained $X=\frac{\frac{9600}{180}-10}{\frac{1145\cdot6}{180}-1}$ $=8\cdot07$ pounds steam, and the priming amounted to 19 3 per cent. In this case, had the steam been perfectly dry, and the evaporation equal to 12 pounds of water per pound of coal, the occurrence of priming to the extent just calculated, while causing an *apparent* increase of the evaporation to 14·31 pounds, would have really produced a very serious loss of efficiency, and even great pecuniary losses, by causing accidents which so commonly arise from serious priming.

It is evidently extremely important, therefore, in all trials of the economical performance of steam boilers, to determine carefully not only the quantity of water entering as feed, but also the quality of the steam leaving the boiler. This necessity, which was first exemplified in 1871, and which has become a usual feature of trials at the exhibitions of the American Institute, is becoming well understood. At the approaching exhibition of the Franklin Institute, at Philadelphia, competing boilers will be compared as to quality of steam, as well as to apparent, but fictitious, evaporative capacity.

Where expensive and elaborate apparatus cannot be afforded, the simple apparatus above described will often be found quite satisfactory.

SCIENTIFIC AND PRACTICAL INFORMATION.

ENGINEERING IN PERU.

The Pacasmayo railroad has just been finished from the Pacific to La Vina, a distance of 75 miles. The eastern termination is 3,469 feet above the ocean. Leaving Pacasmayo at 8 A. M., one can now reach Cajamarca—the famous city of the Incas—at 8 P. M. The most wonderful part of the road is the great iron mole, which is to extend 2,190 feet into the ocean. There will be 146 bays, each 15 feet; 101 are completed. There is to be a head over 90 feet wide by 300 long. The bottom of the Pacific here is mingled sandstone, conglomerate, and limestone, so hard that three turns on the top of the iron pile, with steel-pointed drill, makes very little headway. The tide rises four feet; and the prevailing wind is S. W. Mr. Meiggs builds the road for $7,000,000.

KAURI GUM.

Professor M. M. P. Muir shows, as a result of his experiments on the Kauri gum of Australia, that it is a mixture of resins and true gum, classable among the gum-resins, as shown by distillation. One half of its weight consists of water and a heavy oil. The residue solidifies to a brittle, transparent, solid mass.

RANGE OF TORPEDOES.

From recent experiments conducted by an English Torpedo Committee against the iron hulk Oberon, with the view of ascertaining the maximum distance within which the engines of an enemy's vessel might be rendered useless, if not the ship herself destroyed, by the explosion of a submarine torpedo, it appears that the hull of an ironclad is practically safe from danger at a range of 100 feet from a 500 pound charge of gun cotton, exploded in 48 feet of water, but that her engines are liable to derangement at that distance.

IMPROVEMENT OF THE MISSISSIPPI.

The Commissioners, appointed by the President to report upon the best plan of improving the mouth of the Mississippi river, recently sailed from New York for Europe, where they purpose to examine the Deltas of the Danube, Rhine, and other rivers. The party consists of W. Milner Roberts, General Alexander, General Wright, General T. S. Sickels (of the Union Pacific Railroad), Professor Mitchell, Mr. H. W. Whitcomb, and General Coombs. They return in November.

ACTION OF CHROMIC ACID ON TEXTILE MATERIALS.

In the presence of oxidizable substances, chromic acid loses a portion of its oxygen and passes to the state of green sesquioxide. With other substances, especially wool and silk, M. Jacquelin finds that it gives a bright yellow color, whence he concludes that the acid may be advantageously used to detect vegetable fibers from those of animal derivation in mixed stuffs, the former not yielding the yellow color. Chromic acid is also a good test to show the presence of cochineal in artificially colored wine.

ENGRAVING ON COPPER.

M. de la Grye reports a new process in the above named art which consists in first covering the plate with a thin coating of adherent silver, which is in turn covered with colored varnish. The lines are then drawn with a sharp point, after the fashion of using a diamond for stone engraving, and subsequently sunk into the plate by means of the action of perchloride of iron.